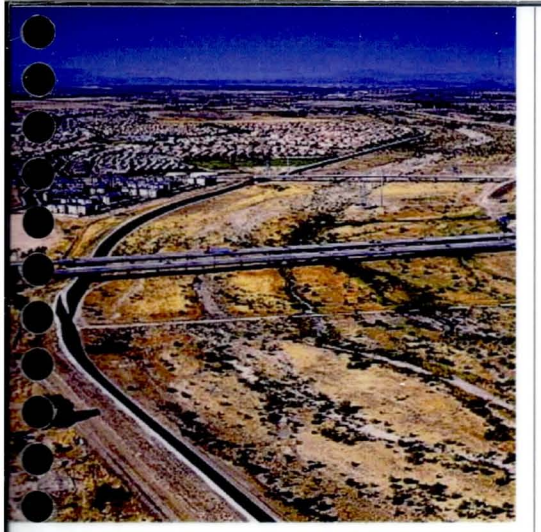

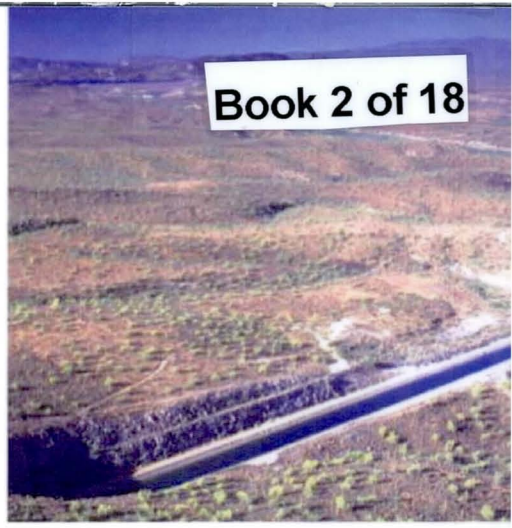

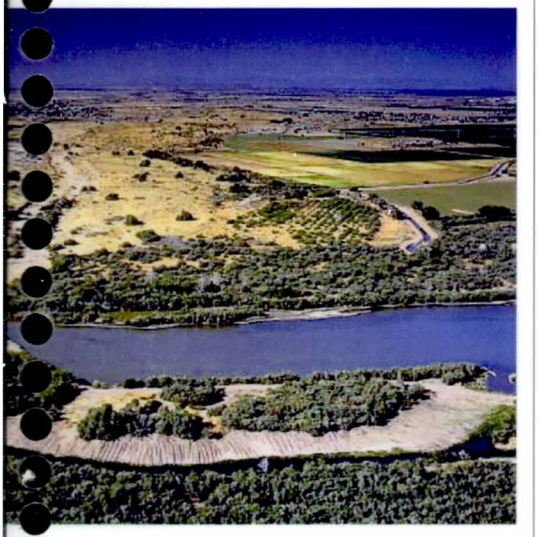

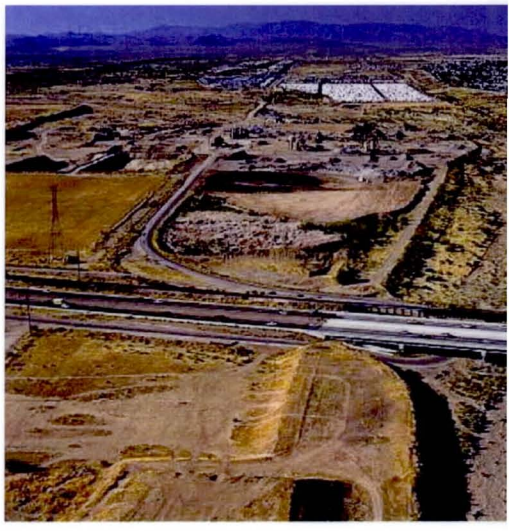

AGUA FRIA
WATERCOURSE MASTER PLAN

Final Implementation and Maintenance Report

Prepared for

Flood Control District

A109.202

December 2001

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Acknowledgements

This watercourse master plan was prepared by a group of Maricopa County and Consulting professionals dedicated to improving the way we protect people and property from flood damages while meeting the multiple use needs of a growing population. The commitment to this ideal was demonstrated throughout this project by the Maricopa County Board of Supervisors and by leaders of the Flood Control District of Maricopa County. Finally, the plan for the West Valley Recreation Corridor captures the vision of John F. Long — a man who has spent his entire life trying to improve and promote quality of life for families in the West Valley.

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TABLE OF CONTENTS

1. INTRODUCTION AND PURPOSE 1

2. FLOODPLAIN MANAGEMENT - NO ADVERSE IMPACT STRATEGY 2

2.1 FINDINGS 2
2.2 ACTIONS 3
2.2.1 Watershed Impacts 3
2.2.2 New Waddell Dam 4
2.2.3 Floodplain Storage 4
2.2.4 Expanding Floodplains 4
2.2.5 Induced Lateral Migration and Degradation 5

3. LATERAL MIGRATION ZONE 6

4. SAND AND GRAVEL MINING 7

4.1 CURRENT CORPS OF ENGINEERS RECOMMENDATIONS 8
4.2 ANTICIPATED IMPROVEMENTS 8
4.3 RECOMMENDED GUIDELINES FOR PIT DESIGN 8
4.4 CHANNELIZATION ALTERNATIVE 32

5. RECOMMENDED PLAN COMPONENTS 33

5.1 INTRODUCTION 33
5.1.1 Confluence of Gila River to Broadway Road 33
5.1.2 Broadway Road to MC 85 33
5.1.3 MC 85 to I-10 33
5.1.4 I-10 to Indian School Road 37
5.1.5 Indian School Road to Confluence of New River 37
5.1.6 Confluence of New River to Glendale Avenue 37
5.1.7 Glendale Avenue to Olive Avenue 37
5.1.8 Olive Avenue to Cactus Road 37
5.1.9 Cactus Road to Grand Avenue 43
5.1.10 Grand Avenue to Bell Road 44
5.1.11 Bell Road to Beardsley Road 47
5.1.12 Beardsley Road to Pinnacle Peak Road 47
5.1.13 Pinnacle Peak Road to Jomax Road 50
5.1.14 Jomax Road to Dixileta Drive Alignment 50
5.1.15 Dixileta Drive Alignment to the CAP Canal 53
5.1.16 CAP Canal to Cloud Road 53
5.1.17 Cloud Road to New Waddell Dam 53

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Date Signed 12/20/01
ARIZONA, U.S.A.

6. OPINION OF PROBABLE CONSTRUCTION COST OF FLOOD CONTROL COMPONENTS 57

6.1 OPINION OF PROBABLE CONSTRUCTION COST OF RECREATIONAL COMPONENTS 61

LIST OF TABLES

Table 6-1– Opinion of Probable Construction Cost of Flood Control Components 59

Table 6-2 - Opinion of Probable Construction Cost of Recreational Features 62

LIST OF FIGURES

Figure 4.3-1 – Schematic Mining Plan 10

Figure 4.3-2 – Schematic Mining Cross Section 11

Figure 4.3-3 – Implementation and Maintenance Plan – Confluence of Gila to Broadway Road 13

Figure 4.3-4 – Implementation and Maintenance Plan – Broadway Road to MC 85 14

Figure 4.3-5 – Sand and Gravel Mines – MC 85 to I-10 15

Figure 4.3-6 – Implementation and Maintenance Plan – I-10 to Indian School Road 16

Figure 4.3-7 –Implementation and Maintenance Plan – Indian School Road to Confluence of New River 17

Figure 4.3-8 – Implementation and Maintenance Plan – Confluence of New River to Glendale Avenue 18

Figure 4.3-9 – Implementation and Maintenance Plan – Glendale Avenue to Olive Avenue 19

Figure 4.3-10 – Implementation and Maintenance Plan – Olive Avenue to Cactus Road 20

Figure 4.3-11 – Implementation and Maintenance Plan – Cactus Road to Grand Avenue 21

Figure 4.3-12 – Implementation and Maintenance Plan – Grand Avenue to Bell Road 22

Figure 4.3-13 – Implementation and Maintenance Plan – Bell Road to Beardsley Road 23

Figure 4.3-14 – Implementation and Maintenance Plan – Beardsley Road to Pinnacle Peak Road 24

Figure 4.3-15 – Implementation and Maintenance Plan – Pinnacle Peak Road to Jomax Road 25

Figure 4.3-16 – Implementation and Maintenance Plan – Jomax Road to Dixileta Drive Alignment 26
Figure 4.3-17 – Implementation and Maintenance Plan – Dixileta Drive Alignment to the CAP Canal 27
Figure 4.3-18 – Implementation and Maintenance Plan – CAP Canal to Cloud Road 28
Figure 4.3-19 – Implementation and Maintenance Plan – Cloud Road to New Waddell Dam 29
Figure 5.1-1– Confluence of Gila River to Broadway Road 34
Figure 5.1-2 – Broadway Road to MC 85 35
Figure 5.1-3 – MC 85 to I-10 36
Figure 5.1-4 – I-10 to Indian School Road 38
Figure 5.1-5 – Indian School Road to Confluence of New River 39
Figure 5.1-6 – Confluence of New River to Glendale Avenue 40
Figure 5.1-7 – Glendale Avenue to Olive Avenue 41
Figure 5.1-8 – Olive Avenue to Cactus Road 42
Figure 5.1-9 – Cactus Road to Grand Avenue Figure 45
Figure 5.1-10 – Grand Avenue to Bell Road 46
Figure 5.1-11 – Bell Road to Beardsley Road 48
Figure 5.1-12 – Beardsley Road to Pinnacle Peak Road 49
Figure 5.1-13 – Pinnacle Peak Road to Jomax Road 51
Figure 5.1-14 – Jomax Road to Dixileta Drive Alignment 52
Figure 5.1-15 – Dixileta Drive Alignment to the CAP Canal 54
Figure 5.1-16 – CAP Canal to Cloud Road 55
Figure 5.1-17 – Cloud Road to New Waddell Dam 56

APPENDICES

APPENDIX I – Management of Sand and Gravel Operations 64
APPENDIX II – Example Calculation 93
APPENDIX III – Sources of Funding 97
APPENDIX IV – Erosion Monitoring Procedure – Grand Ave. to Peoria Ave. 120

1. INTRODUCTION AND PURPOSE

The Agua Fria Watercourse Master Plan was prepared for the Flood Control District of Maricopa County (District). The purpose was to provide the District with a plan that examined the cumulative impact of existing development and future encroachments on flooding within the Agua Fria River, and to develop technical criteria for the management of the watercourse so as to minimize potential flood damages.

Authority for the Watercourse Master Plan can be found in A.R.S. 48-3609.1, including provisions for development and adoption of technical management criteria that meet or exceed those criteria published by the Director of the Department of Water Resources.

Due to the lack of existing flood damage problems in the Agua Fria River, the District opted to emphasize non-structural flood protection solutions in order to prevent the need for future structural projects that are costly to both construct and maintain. Additionally, the District considered development impacts associated with traditional land development practices, in channel sand and gravel operations, and development associated impacts related to multi-use trails or channel restoration.

The purpose of the Implementation and Maintenance Report is to provide agency staff with a "go to" document that summarizes potential projects, management actions, and sources of project funding.

2. FLOODPLAIN MANAGEMENT - NO ADVERSE IMPACT STRATEGY

Nationally, it is becoming recognized that current floodplain management strategies may be leading to escalation in flood damages due to lack of consideration given to the adverse impacts that construction can cause to other properties. With the Agua Fria Watercourse Master plan, for example, it was identified that continuous encroachment to the floodway boundary would lead to an approximate 15% increase in downstream flow rates in the 100-year flood event.

The fundamental goal underlying the recommendations of the Agua Fria Watercourse Master Plan is to reduce or eliminate adverse impacts due to human activity within the watercourse. To meet this goal, it is recommended that the District adopt a management strategy termed No Adverse Impact (NAI). Whether the activity is providing flood protection, recreational use or sand and gravel mining, it is desired to limit the impact of the activity to the immediate vicinity of the activity.

First, it must be recognized that "no impact" may not be achievable or measurable. However, moving towards a goal of understanding potential impacts and taking actions to mitigate for adverse impacts, is expected to greatly reduce the need for future flood control on the Agua Fria River.

2.1 Findings

Through the development of the Agua Fria Watercourse Master Plan, the following was determined:

- **Watershed Impacts** – Current storm water retention policies, when fully enforced, effectively prevent increased flood peaks in the Agua Fria River
- **New Waddell Dam** – The regulatory flows on the Agua Fria River are premised on New Waddell Dam attenuating flood flows. It should be noted that there is no dedicated flood storage behind New Waddell Dam. In a very wet year, there could be less storage available for flood flow attenuation, meaning that the resulting release may be higher than what would have been released in a dry year. The Corps has evaluated the joint probability of reservoir level and flood inflow in order to develop an estimate of the 100-year outflow.

- **Floodplain Storage** – Encroachment (filling/construction) of the floodway fringe area (the area from the floodplain boundary to the floodway boundary) will lead to significant increases in downstream peak discharges. Sand and gravel mines located within the same zone however, can provide significant flood storage.
- **Expanding Floodplains** – Current floodplain strategies do not consider the potential for floodplains to be expanded if development on one side pushes water onto the other side of the floodplain.
- **Induced Lateral Migration and Degradation** – Construction of bank stabilization or levees can upset the sediment balance within the river, leading to bank and bed erosion in other locations. Sand and gravel mining within the floodplain also interrupts the sediment flow, and may promote the creation of headcuts, both of which can lead to offsite impacts to channel elevations or can undermine infrastructure.

2.2 *Actions*

The No Adverse Impacts (NAI) Management strategy consists of taking steps to eliminate or mitigate adverse impacts on river stability, floodplain elevations, and peak discharges. To meet this goal, it is necessary to develop definable, multi-level management policies. A Level 1 policy has the lowest cost, but is most restrictive in terms of use. A Level 3 policy is less restrictive, but may require higher costs for engineering analysis and investment in mitigation measures. It may not be feasible or necessary to define three levels of management policy in all aspects of watercourse management.

2.2.1 *Watershed Impacts*

Level 1 – The District should notify all communities along the Agua Fria River that current retention standards are meeting the goal of not increasing future flow rates to the river. Further, the District should urge the communities to resist granting variances to the retention policy. Allowing the use of pre- versus post-detention for large developments should only be allowed following a watershed analysis that demonstrates no adverse (cumulative) impact to the river system and other properties.

Level 2 – The District should move towards updating watershed models being developed, as part of the ADMS/ADMP program, to better monitor watershed flows and trends.

2.2.2 *New Waddell Dam*

Level 1 – The District should establish regular contact with CAWCD (the operators of the Central Arizona Project) regarding operating rules for the dam. While seemingly unlikely at this time, modifications to the operating rules could require the redevelopment of regulatory flow rates for the Agua Fria River. The District should continue its program of monitoring pool levels within Lake Pleasant. The District should consider showing flood maps depicting the area of inundation if New Waddell Dam were not in place. In this way, developers and the public would understand that they are within a historic floodplain. New subdivisions within these boundaries should disclose this fact in their real estate reports. The same applies to the area behind the Corps levees in the lower reach.

Level 2 – Current Emergency Action Plans (EAP) for the dam only require notification of local officials. The EAPs should be refined to allow for more site-specific mitigation actions. In addition, the EAPs should include an analysis that considers reservoir level, season, and a rating of low, moderate or high potential for flood flow release.

Level 3 – Current levels of flood protection are highly dependent on the incidental storage behind the dam. In order to reduce the chance that the incidental storage is reduced, the District may want to consider entering into an agreement with the CAWCD to protect the incidental storage.

2.2.3 *Floodplain Storage*

Level 1 – Prohibit new encroachment within the floodway fringe.

Level 2 – Require flood storage be provided within one mile of the site to offset the loss of storage due to a proposed encroachment. The storage area is to be located outside of the floodway but within the floodplain.

Level 3 – Creation of a regional offline storage facility.

2.2.4 *Expanding Floodplains*

Any method of floodplain encroachment must also consider the goals for floodplain storage.

Level 1 – Allow encroachment to floodway line to the extent that the floodplain top width, as depicted on flood maps, is not significantly expanded by a single sided encroachment. Expansion would be defined both in terms

of cross-river impacts or upstream impacts generated by backwater. By FEMA practice, an expansion in top width is considered significant if:

A. The expanded floodplain line would be moved out a distance of more than 1/20th of the map scale. On a map with a scale of 1:2000, a significant increase is 100 feet total, or 50 feet each side.

B. The expansion of the floodplain impacts an existing building.

C. The expansion of the floodplain exceeds more than 10% of the existing top width of the floodplain.

D. The expansion of the floodplain leads to more than 0.2 feet of depth within the expanded zone.

Level 2 – If Level 1 is exceeded, require the developer to obtain a legal agreement (easement) from landowners affected by the expansion to allow flooding on the property.

Level 3 – If it is not possible to obtain an easement, then the expanded floodplain width would be contained via structural controls.

2.2.5 *Induced Lateral Migration and Degradation*

Level 1– Hard banking not allowed within the lateral migration erosion hazard zone.

Level 2- In the event that the LMEHZ extends outside of the mapped 100-year floodplain, the hard bank may be established at the floodplain boundary. Additionally, a protected bank may be allowed within the floodplain if the depths and velocities are determined to be non-erosive along the proposed bank line.

Level 3 – Hard banking allowed to the extent that sediment continuity can be demonstrated for low flow and high flow events for both the channel bed and channel bank. The proposed hard bank would not lead to the redirection of the channel flow path or meander to the detriment of other properties.

3. LATERAL MIGRATION ZONE

As part of the Agua Fria Watercourse Master Plan, the limits of the Lateral Migration Erosion Hazard Zones (LMEHZ) were established. The following criteria are to be utilized for the management of this zone.

- Construction of residential, industrial, or commercial buildings to be prohibited unless adequately protected by bank protection that conforms with the No Adverse Impact policy; or the foundations are designed to withstand erosion.
- Construction of temporary buildings related to specific events, the construction of recreational facilities and restrooms, and the construction of pole barns or other similar agricultural buildings may be permitted.
- Public and private utilities and roadways may be constructed within the zone. The following guidelines are suggested to minimize the need for relocation or future protection efforts.

    1. Water, sewer, natural gas, power, power pole foundations and other critical infrastructure should be set back as far from the bank as practical, and buried to a depth that is lower than the long term scour line for the channel section.
    2. Future utility crossings should be concentrated in areas that are already disturbed with bridges or other channel and bank disturbances.
    3. Consideration should be given to constructing future bridge openings at least as wide as the LMEHZ.
    4. Arterial roads, or roads that serve as a sole source of access to a development, should cross the LMEHZ perpendicular to the river to minimize disturbance and reduce roadway length within the LHEHZ.
    5. Care should be taken to avoid areas of channel bends, channel expansions and contractions, areas of historic channel avulsion, or other areas that may be at higher risk as compared to the rest of the zone.

4. SAND AND GRAVEL MINING

Sand and gravel mining continues to play a vital role in the Valley's economy. The Agua Fria River is a source of abundant, high quality sand and gravel materials; that can not readily be replaced. Properly located pits have also provided significant flood storage that has been shown via modeling to provide flood peak attenuation in the 100-year flood.

The challenge for the District associated with sand and gravel mining is to develop strategies that would isolate potential adverse impacts associated with flooding, and erosion to the site. Mining of sand and gravel is considered an acceptable use of the floodplain, but miners would not be exempt from policies related to the No Adverse Impact management strategy. Adoption of the NAI management strategy is expected to lead to increased infrastructure requirements for mining operations located within the floodplain. Miners will need to demonstrate that their operations do not disrupt the sediment balance of the river; that they do not cause expansion of the floodplain; that they do not cause reflective erosion; that they do not propagate headcuts; and that they do not reduce channel storage.

The No Adverse Impact Policy is premised on truly limiting the impact of mining operations to the boundary of the property being mined. The policy would be implemented when mine operators renew their Floodplain Use Permits. In order to renew the permit, a mine operator would have to show that the engineering design of the pit limits the impact of the 100-year storm to his property boundary. By definition, levees and protective works placed to protect mining activities would not fall under the NAI policy for expanding flood widths, providing structures are designed with controlled drown out features and the top elevation is no higher than the 100-year flood level. It is assumed that due to additional off line flood storage being created by the mines, that adverse impacts are being mitigated by reducing peak flow rates. The miner's levees would need to comply with the NAI policy in regards to reflective erosion and the propagation of headcuts.

It is anticipated that the implementation of the NAI policy will lead to movement of mining activities away from the floodway; mitigation of reflective erosion; construction of protective works to separate mines from the river; and incorporation of features that would allow mine pits to drown out during major floods to replace channel storage.

4.1 *Current Corps of Engineers Recommendations*

The LA District of the U.S. Army Corps of Engineers published the *Sand and Gravel Mining Guidelines, 1987*, to provide recommendations related to in-stream mining near Corps structures within the regulatory floodway. These include:

- Incorporation of set back from bridges and utilities of 500 feet, and maximum pit depths no deeper than that allowed by a 1% slope (a pit initiated 500 feet downstream from the structure would be no deeper than 10 feet deep at a point 1,000 feet downstream from the bridge or utility).
- Pit depths would not be lower than the existing thalweg elevation.
- Pits would be set back from channel banks 500 feet, and pit depths would be limited to being no deeper than a 10:1 slope as measured from the setback.
- Mining operations should be continuous and not be set up to promote skipping over land areas.

It is recommended that similar guidelines be adopted to minimize riverbed degradation due to mining, providing the floodway boundary line is considered equivalent to a bank line.

4.2 *Anticipated Improvements*

Mine owners would be expected to provide the infrastructure necessary to limit mining impacts to their property line. Miners are not currently required to isolate mine pits from the floodway with engineered levees. Adding this requirement would increase the capital improvements required to operate a mine. In order to offset this cost increase, it is proposed that the District pursue a river-wide 404 Permit from the Corps. The permit would encompass the entire reach from New Waddell Dam to the confluence of the Gila River. The District would then assist individual miners to obtain site-specific 404 Permits for their mines.

4.3 *Recommended Guidelines for Pit Design*

Levees and drown out features are not necessarily required for all mines within the floodplain, but it is up to the designers to show that the impact of mining activities is limited to the boundaries of the parcel being mined. In addition to the Corps' guidelines, it is recommended that the District adopt the

following guidelines for design of mining pits within the Agua Fria floodplain unless a qualified engineer submits a plan and documentation demonstrating that adverse impacts are limited to the applicant's site.

1. **Pit Configuration** – Pit configurations and locations within the floodplain are shown on Figure 4.3-1 and Figure 4.3-2. Designers should note that a pass-through channel is provided. The pass through channel is located within the floodplain boundaries. This channel must accommodate at least the 50-year design flow. This flow has been established as part of the Agua Fria Watercourse Master Plan.

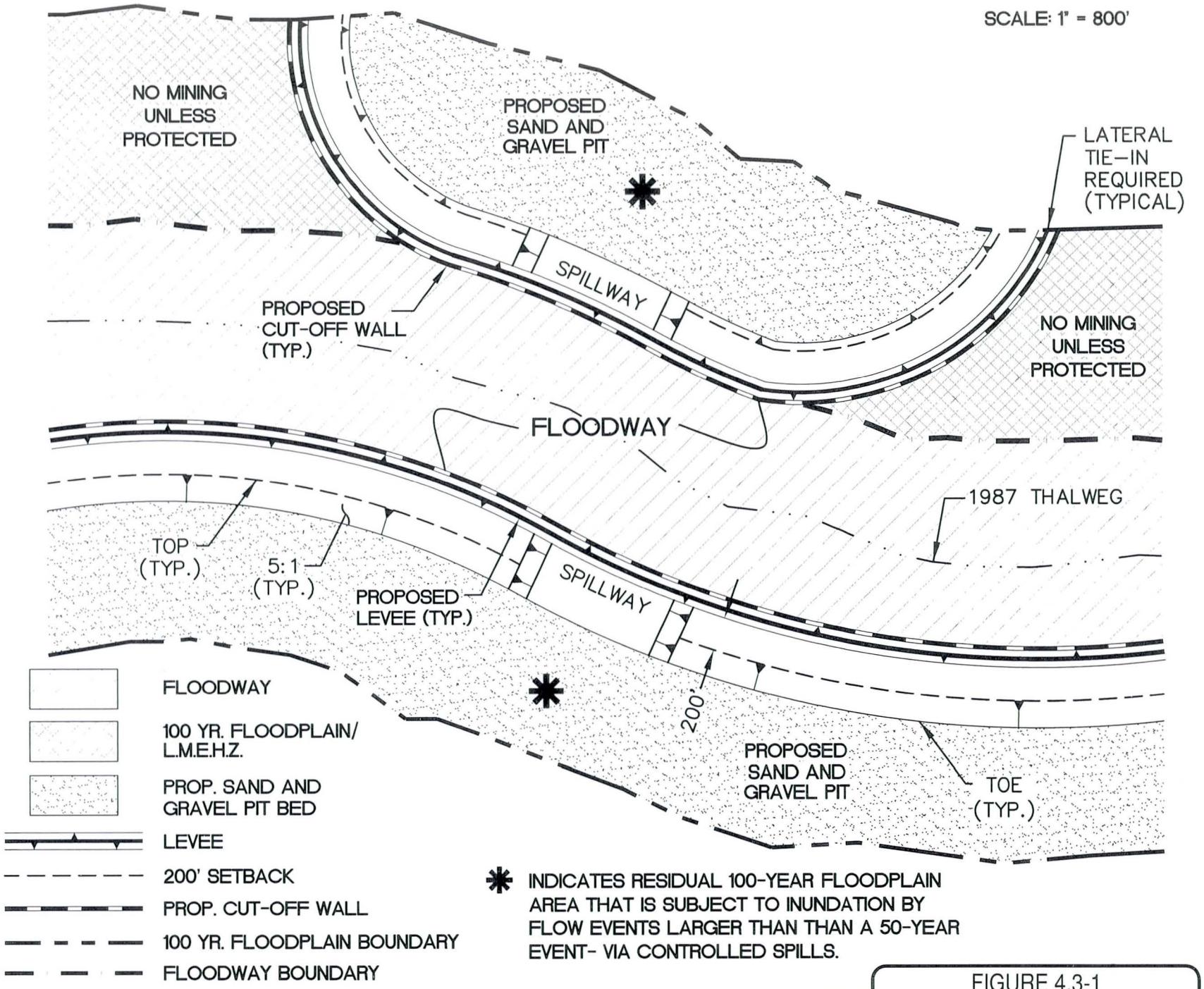
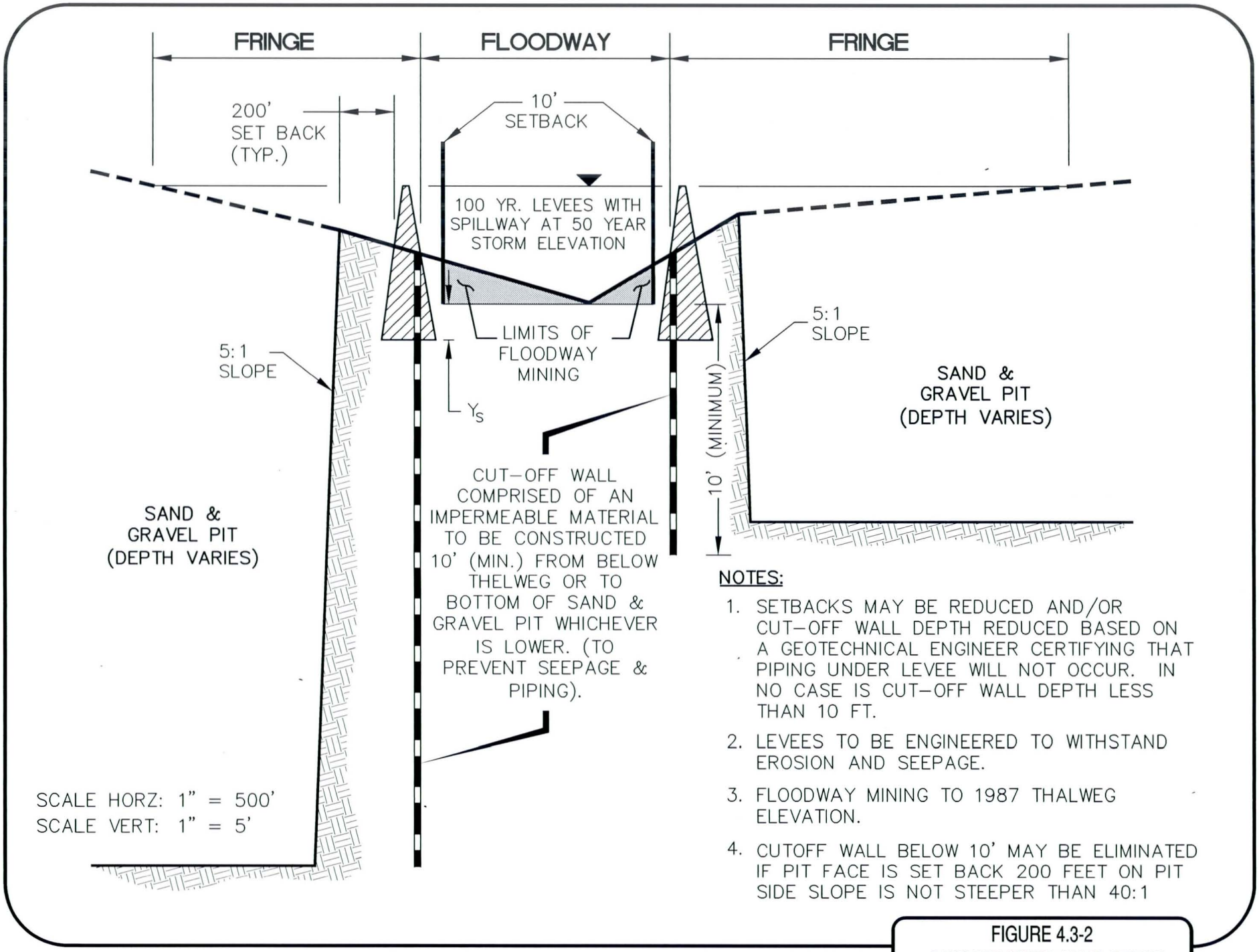


FIGURE 4.3-1
SCHEMATIC MINING PLAN



NOTES:

1. SETBACKS MAY BE REDUCED AND/OR CUT-OFF WALL DEPTH REDUCED BASED ON A GEOTECHNICAL ENGINEER CERTIFYING THAT PIPING UNDER LEVEE WILL NOT OCCUR. IN NO CASE IS CUT-OFF WALL DEPTH LESS THAN 10 FT.
2. LEVEES TO BE ENGINEERED TO WITHSTAND EROSION AND SEEPAGE.
3. FLOODWAY MINING TO 1987 THALWEG ELEVATION.
4. CUTOFF WALL BELOW 10' MAY BE ELIMINATED IF PIT FACE IS SET BACK 200 FEET ON PIT SIDE SLOPE IS NOT STEEPER THAN 40:1

FIGURE 4.3-2
SCHEMATIC MINING CROSS SECTION

Water surface elevations associated with this flow are found in Appendix I. The HEC-RAS model used to calculate the water surface elevations is included in the back of this report on a compact disk

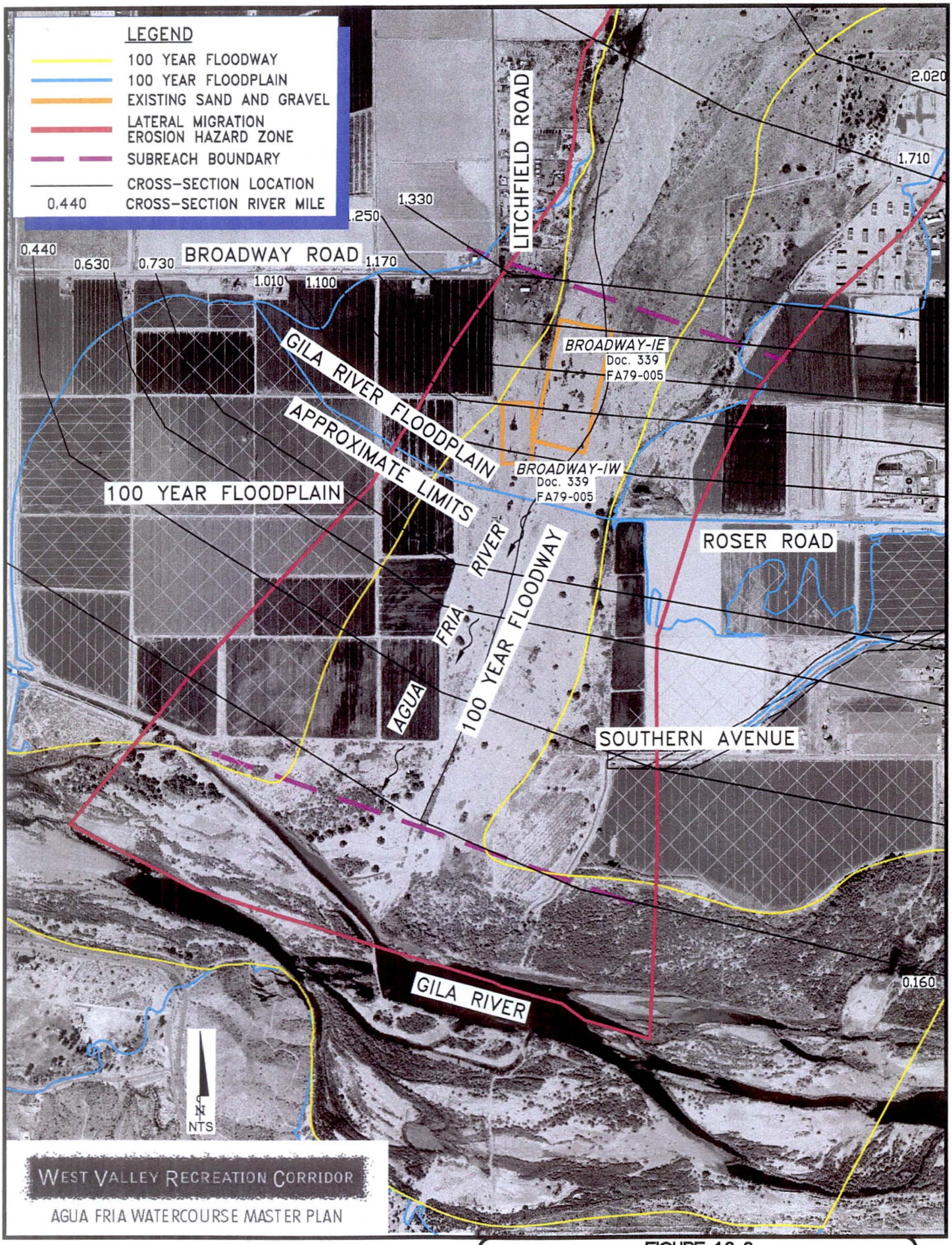
2. **Floodway Mining** – Limit depth of pit to existing thalweg elevation. The thalweg elevation was established in 1987 as part of at Flood Insurance Study. The thalweg elevations are included in Appendix I. The use of levees or bank hardening within the floodway must be evaluated for reflective erosion. Mining operations within the floodway must comply with FEMA regulations.

3. **Levee Height** – Provide levees to isolate pit from low flows, up to the 50-year design storm. Levees should be no higher than the 100-year water surface elevation. Water surface elevations associated with the 100-year design storm are included in Appendix I and in the HEC-RAS model on the compact disk.

4. **Reflective Erosion**– The operator will be responsible to assure significant reflective erosion does not occur. Check change in channel velocity due to introduction of levee. As a guideline, if channel velocities increase more than 10 percent or more than 1.0 feet per second, further investigation is required to determine if reflective erosion will be caused. Further investigation may include development of 2-D flow models or analysis of the soil condition of the opposite bank.

5. **Volume Calculations** – Allow storage behind the levee to accommodate the volume of water that would occupy the floodplain if the levee were not in place. The volume of storage is to be calculated based on the undisturbed (pre-mined) condition. Use the topographical mapping associated with the 1987 Flood Insurance Study. The mapping is shown on the CAD files on the compact disk included with this report. The files are Auto CAD R14 format.

   Calculate volume of entire site (including area behind and upstream of proposed levee) based on average end area. Develop cross sectional areas along the river cross sections used in the HEC-RAS model included with this report. Figure 4.3-3 through Figure 4.3-19 show some model cross section locations. Complete cross sections are shown on the Auto CAD drawings. Parcel boundaries of active mines and mines with pending mining permits are also shown on Figure 4.3-3 through Figure 4.3-19 and the electronic CAD drawings.



WEST VALLEY RECREATION CORRIDOR

AGUA FRIA WATERCOURSE MASTER PLAN

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FIGURE 4.3-3
IMPLEMENTATION AND MAINTENANCE PLAN
CONFLUENCE OF GILA RIVER TO BROADWAY ROAD

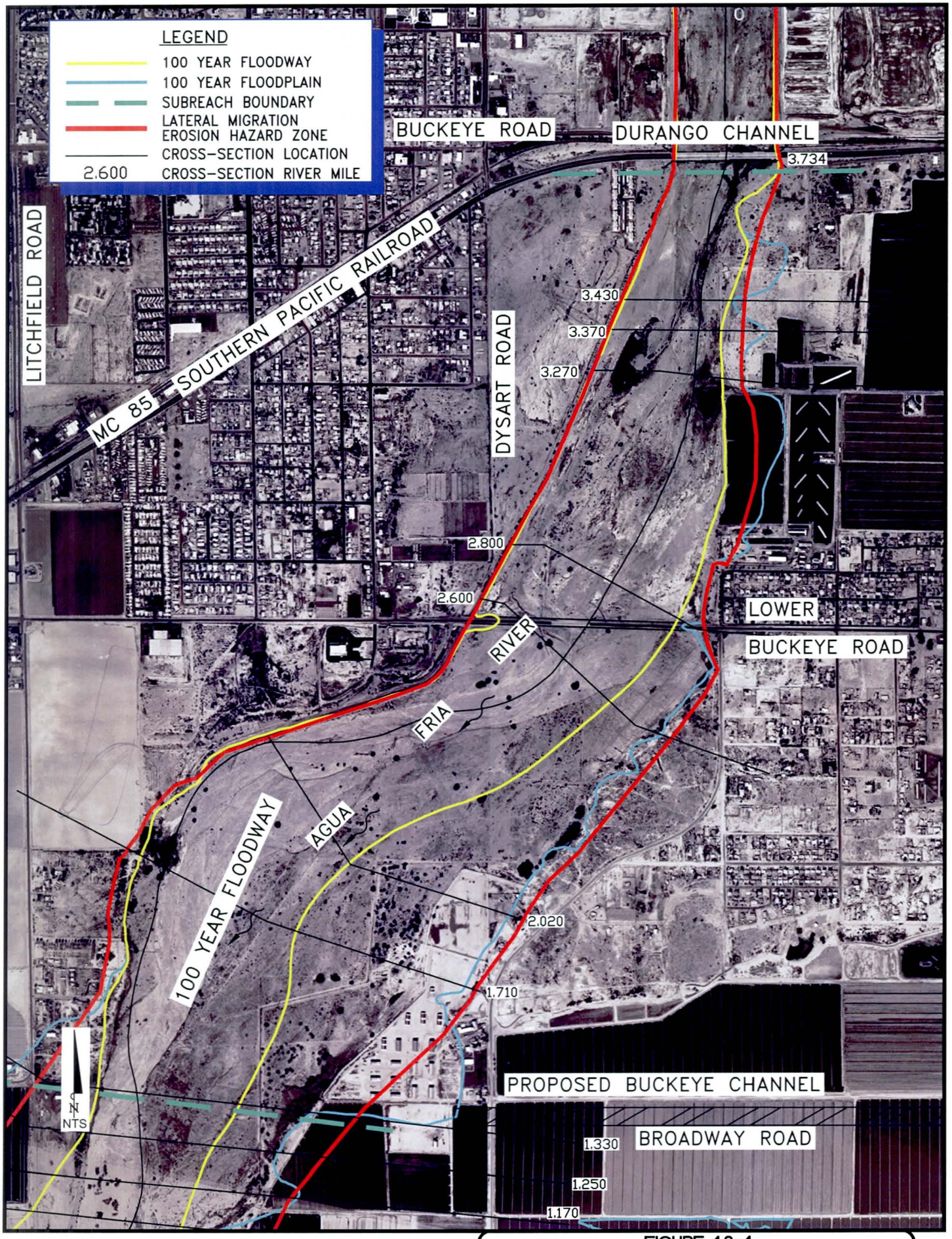

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FIGURE 4.3-4
IMPLEMENTATION AND MAINTENANCE PLAN
BROADWAY ROAD TO MC 85

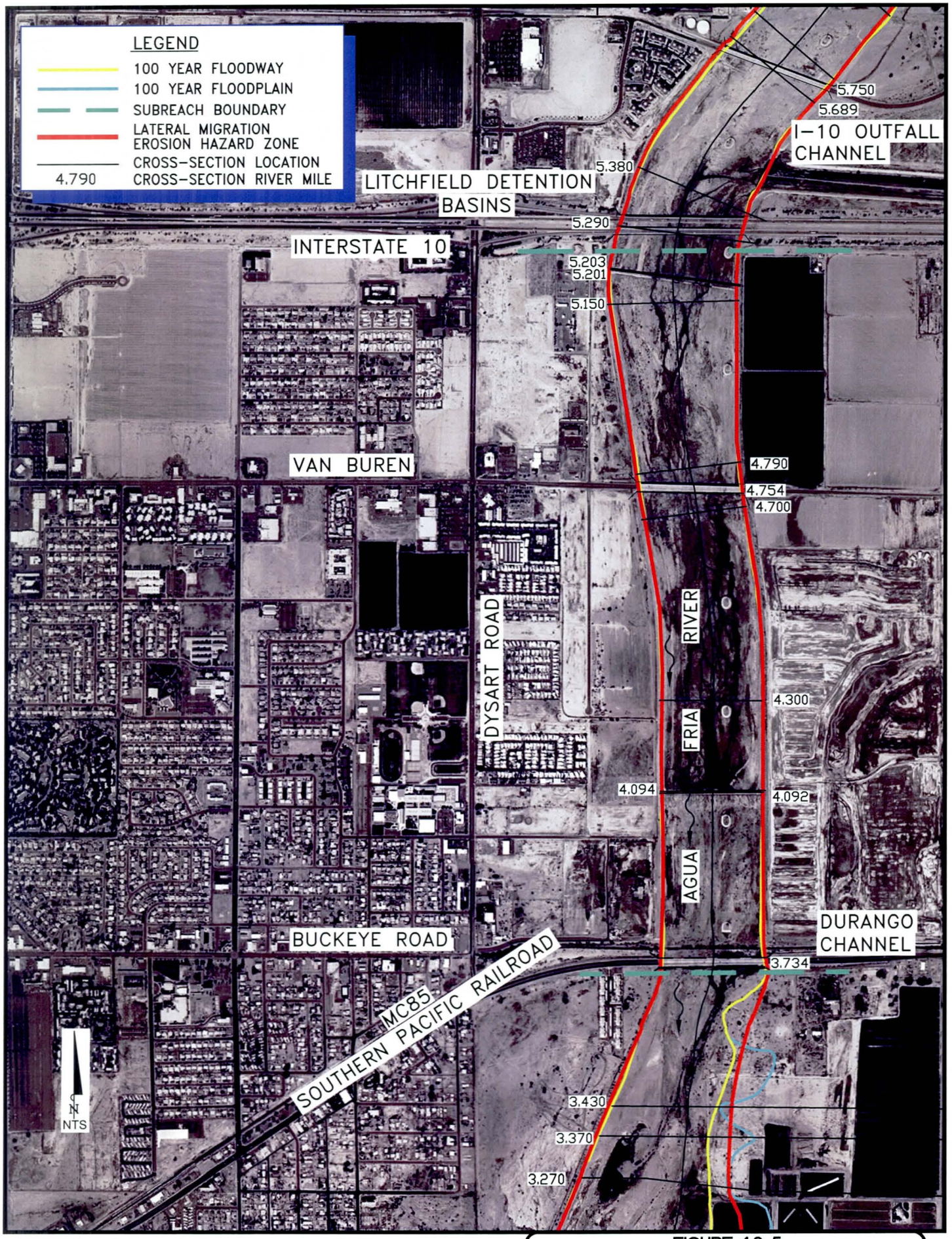

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FIGURE 4.3-5
IMPLEMENTATION AND MAINTENANCE PLAN
MC 85 TO INTERSTATE 10

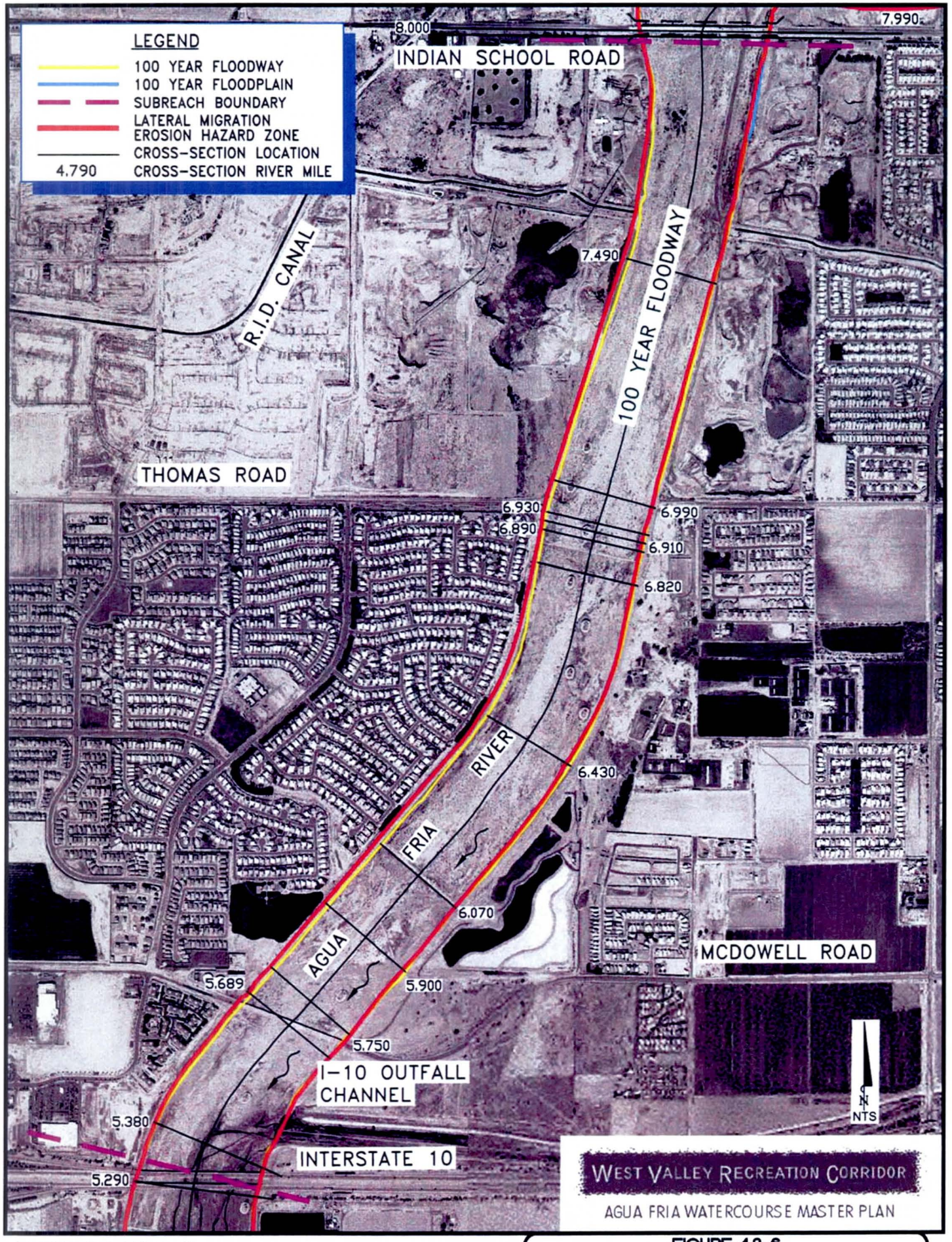

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FIGURE 4.3-6
IMPLEMENTATION AND MAINTENANCE PLAN
INTERSTATE 10 TO INDIAN SCHOOL ROAD

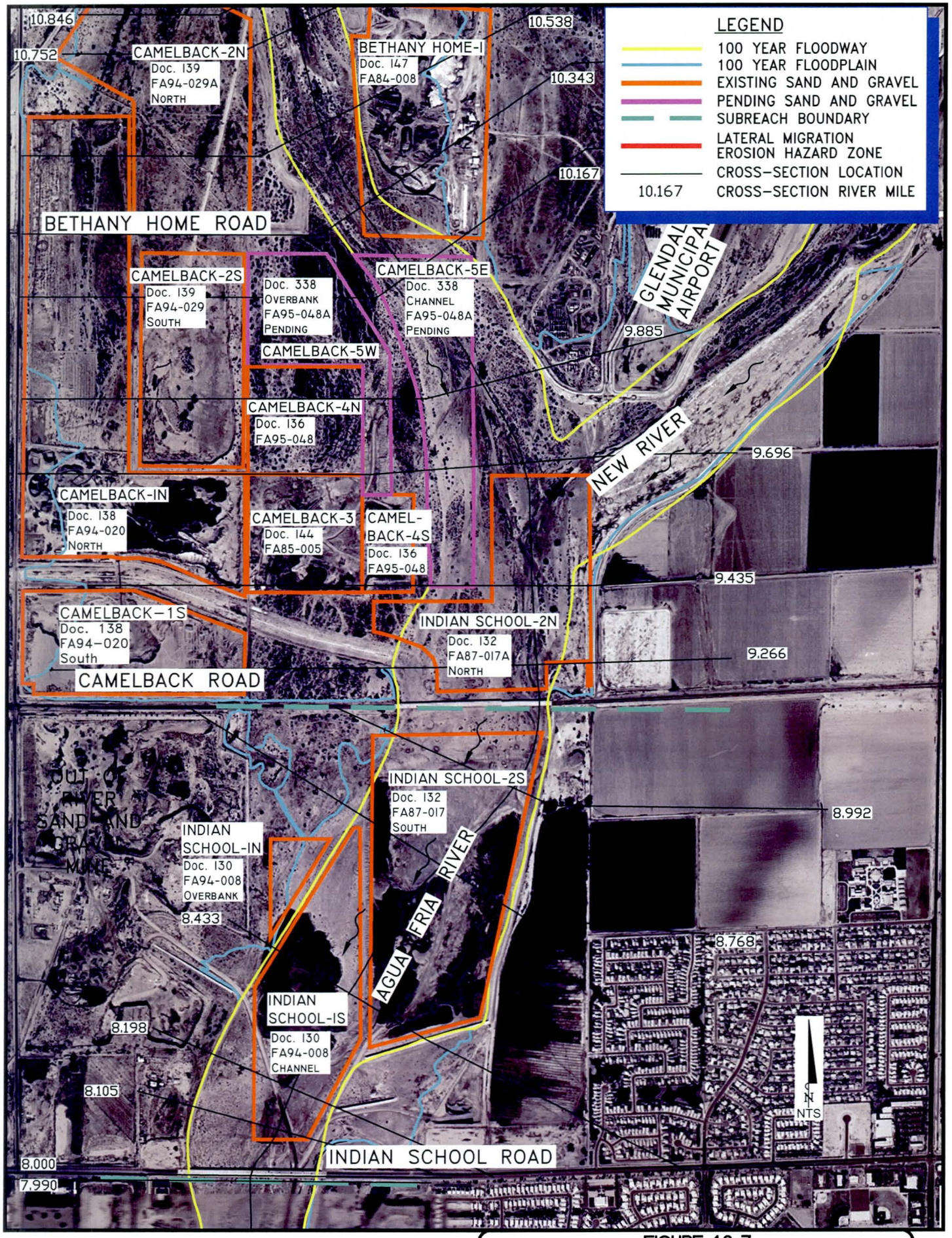

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FIGURE 4.3-7
IMPLEMENTATION AND MAINTENANCE PLAN
INDIAN SCHOOL ROAD TO CONFLUENCE OF NEW RIVER

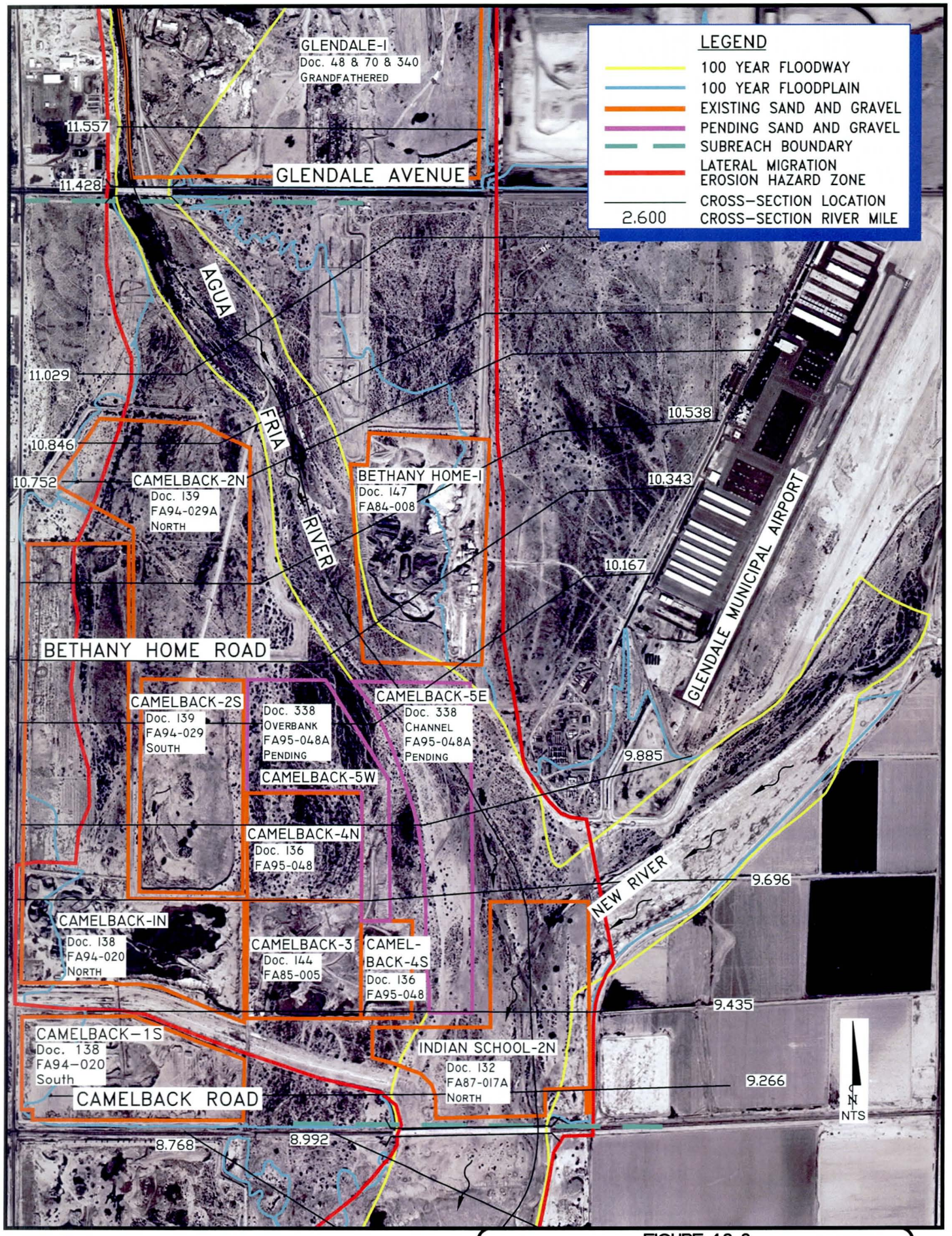

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FIGURE 4.3-8
IMPLEMENTATION AND MAINTENANCE PLAN
CONFLUENCE OF NEW RIVER TO GLENDALE AVENUE

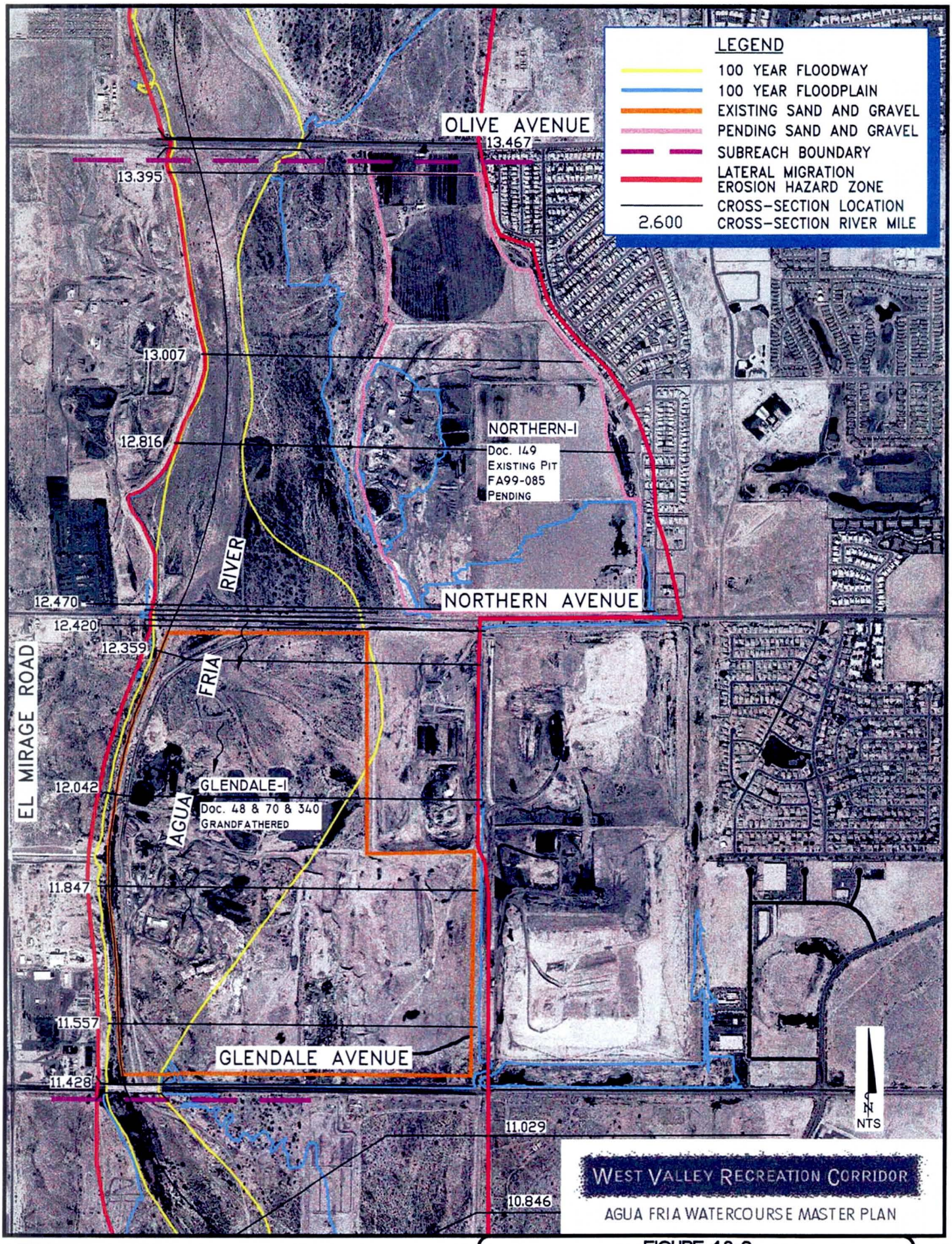

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FIGURE 4.3-9
IMPLEMENTATION AND MAINTENANCE PLAN
GLENDALE AVENUE TO OLIVE AVENUE

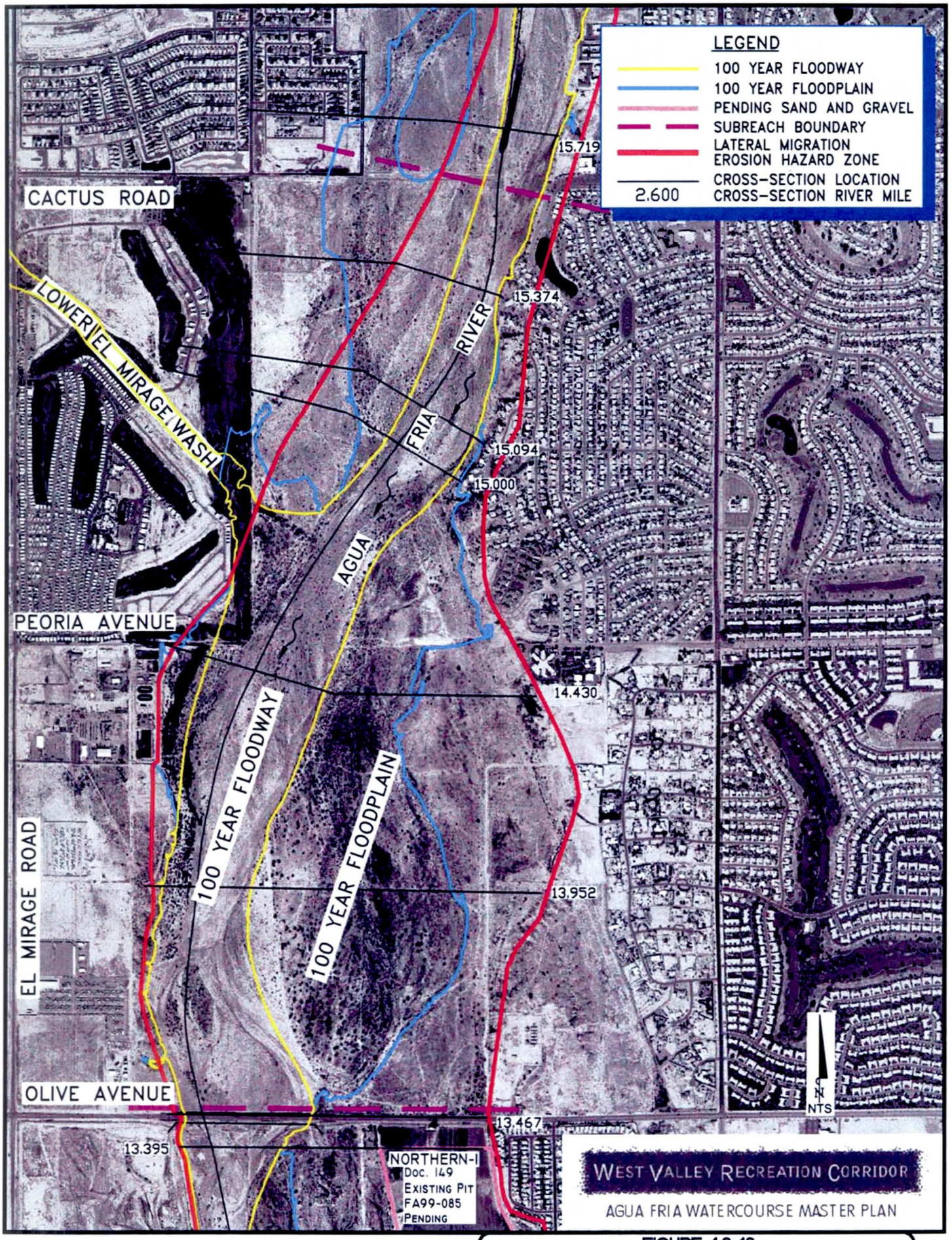

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FIGURE 4.3-10
IMPLEMENTATION AND MAINTENANCE PLAN
OLIVE AVENUE TO CACTUS AVENUE

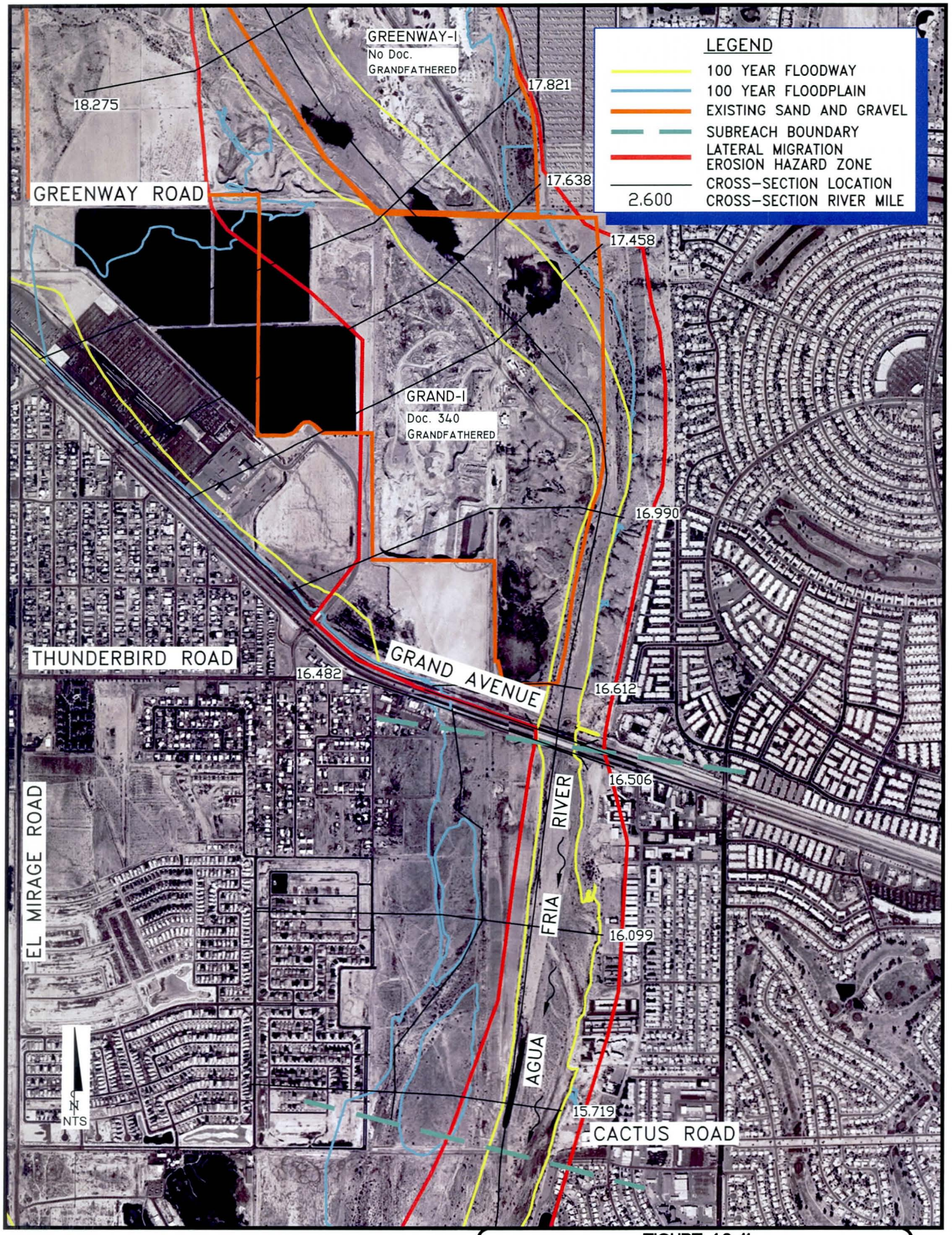

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FIGURE 4.3-11
IMPLEMENTATION AND MAINTENANCE PLAN
CACTUS ROAD TO GRAND AVENUE

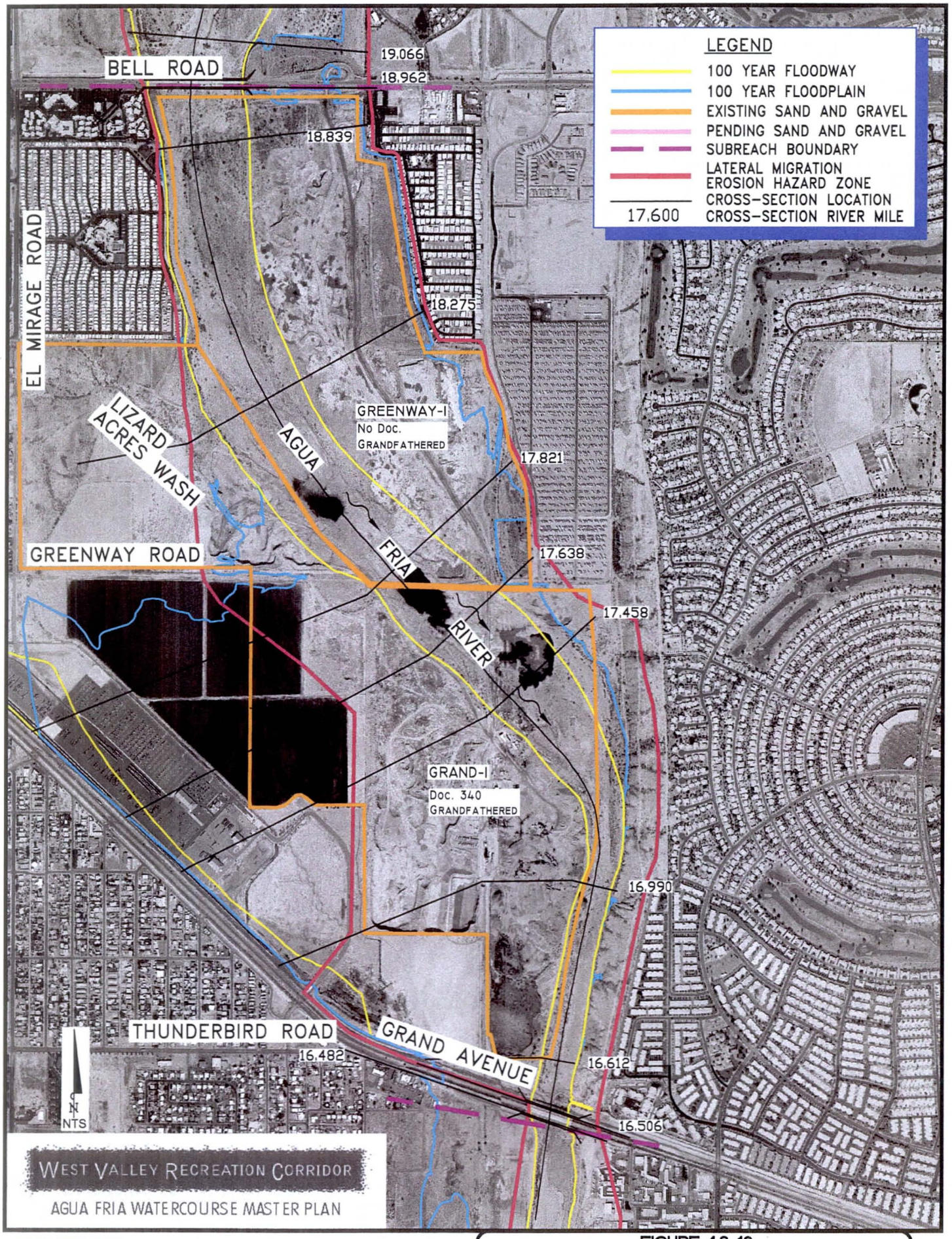

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FIGURE 4.3-12
IMPLEMENTATION AND MAINTENANCE PLAN
GRAND AVENUE TO BELL ROAD

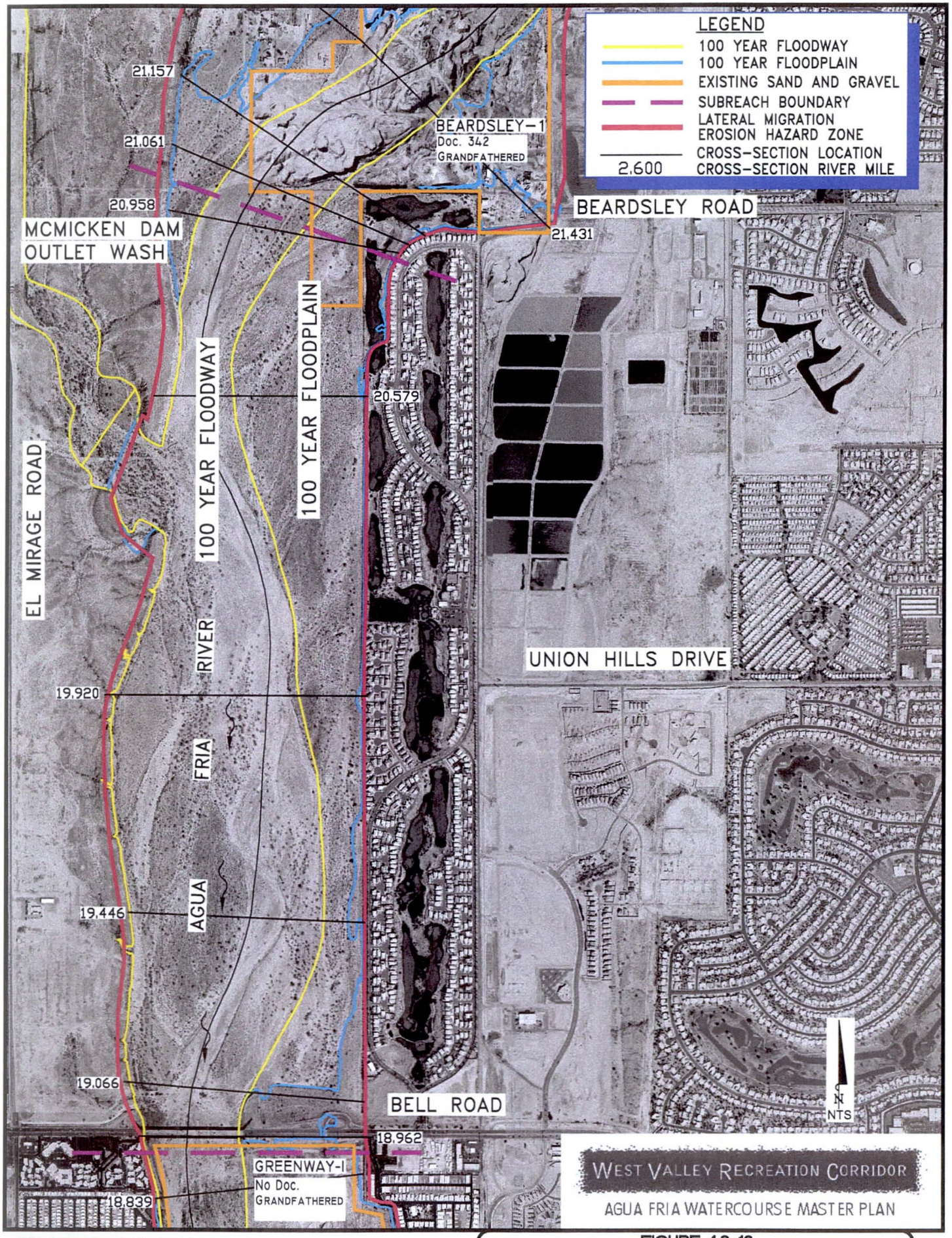

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FIGURE 4.3-13
IMPLEMENTATION AND MAINTENANCE PLAN
BELL ROAD TO BEARDSLEY ROAD

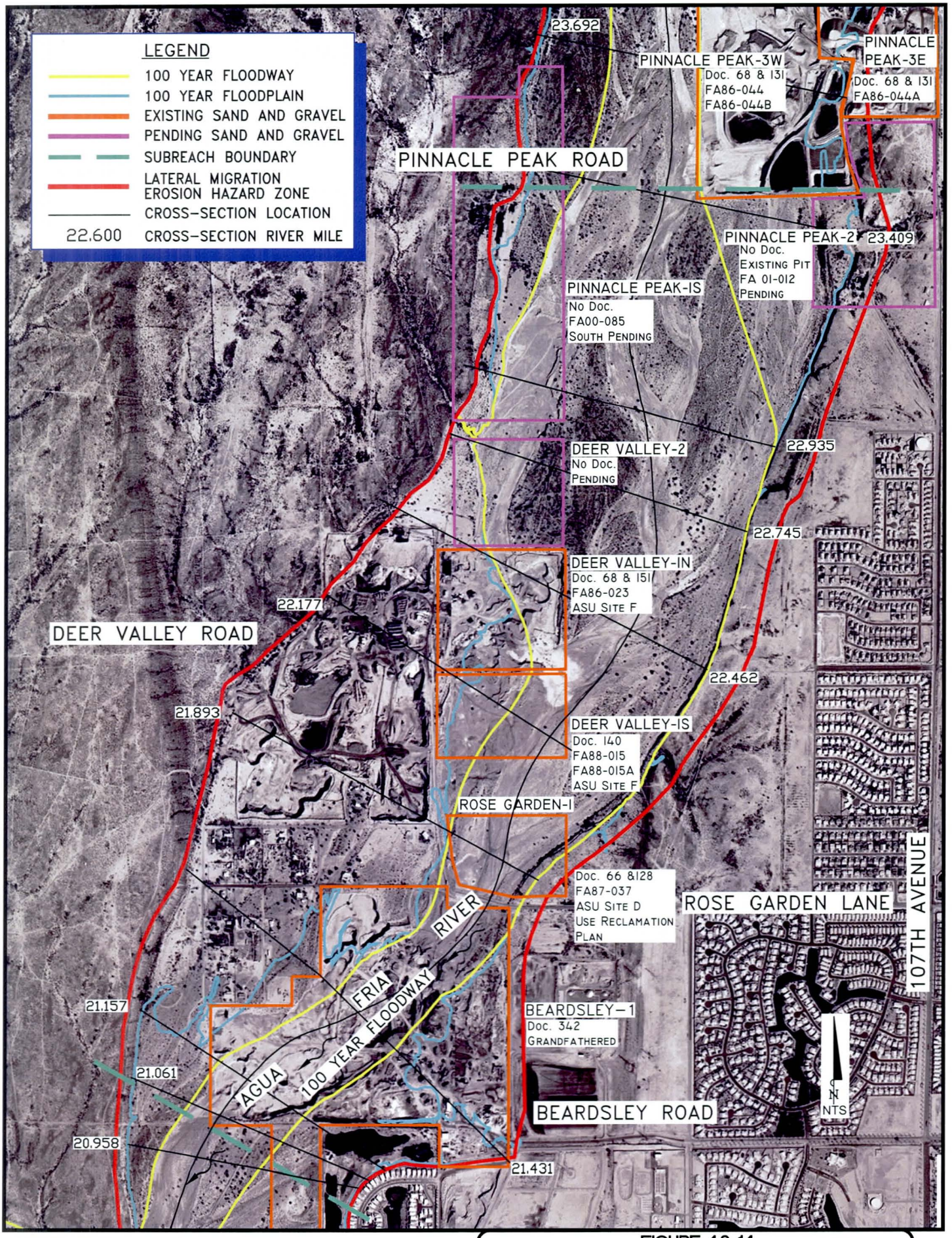

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FIGURE 4.3-14
IMPLEMENTATION AND MAINTENANCE PLAN
BEARDSLEY ROAD TO PINNACLE PEAK ROAD

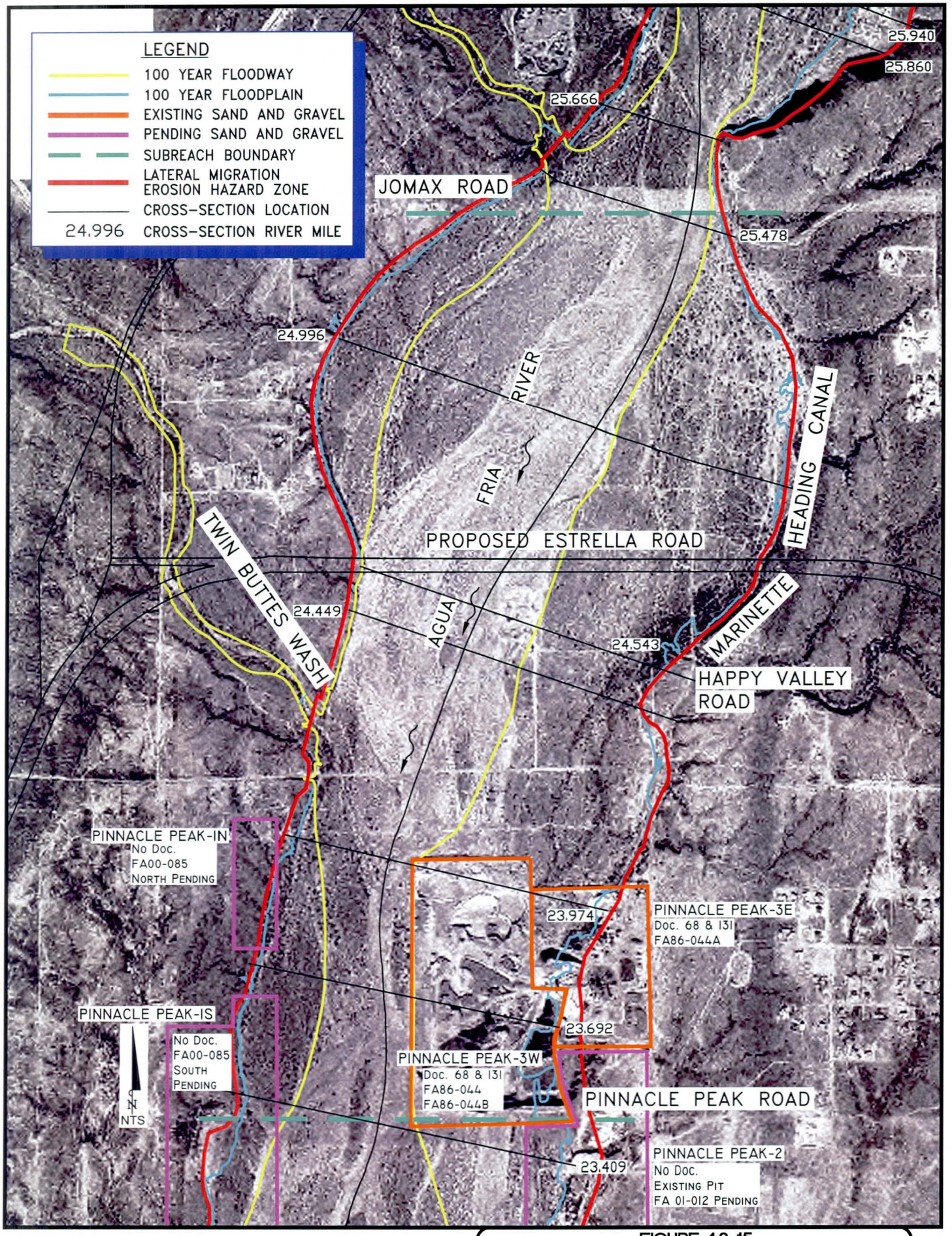

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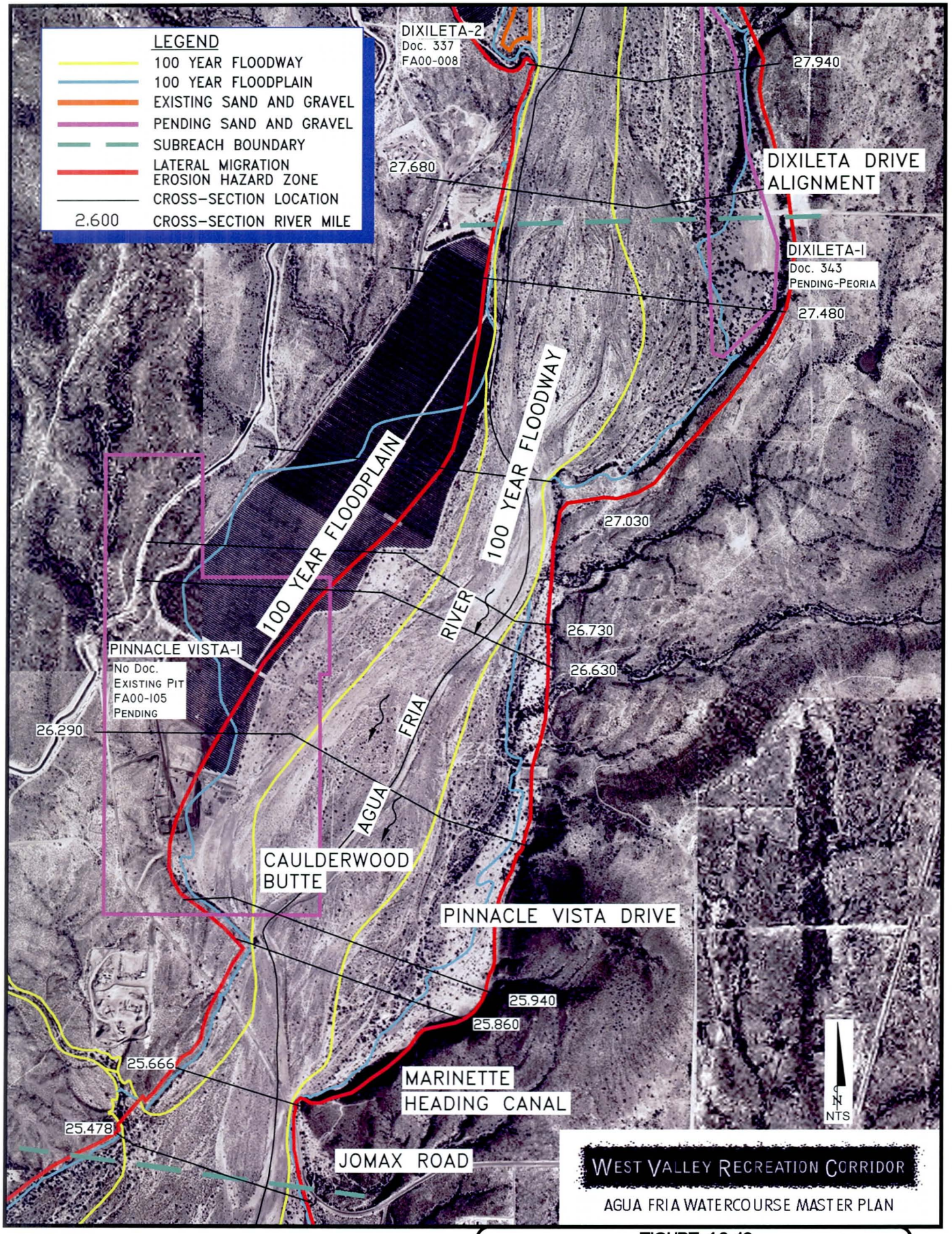
FIGURE 4.3-15
IMPLEMENTATION AND MAINTENANCE PLAN
PINNACLE PEAK ROAD TO JOMAX ROAD



WEST VALLEY RECREATION CORRIDOR

AGUA FRIA WATERCOURSE MASTER PLAN

Kimley-Horn and Associates, Inc.

FIGURE 4.3-16
IMPLEMENTATION AND MAINTENANCE PLAN
JOMAX ROAD TO DIXILETA DRIVE ALIGNMENT

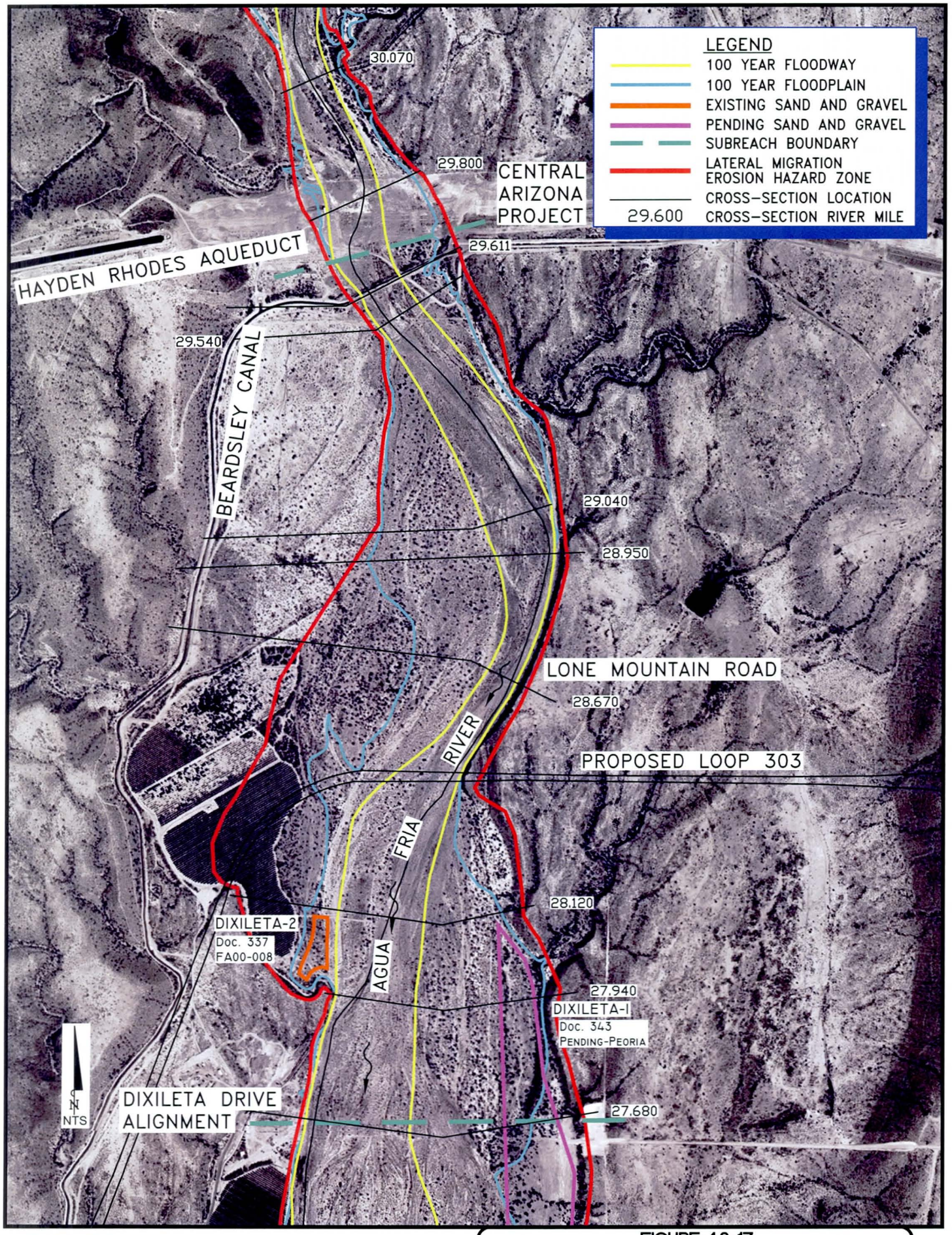


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FIGURE 4.3-17
IMPLEMENTATION AND MAINTENANCE PLAN
DIXILETA DRIVE ALIGNMENT TO CAP CANAL

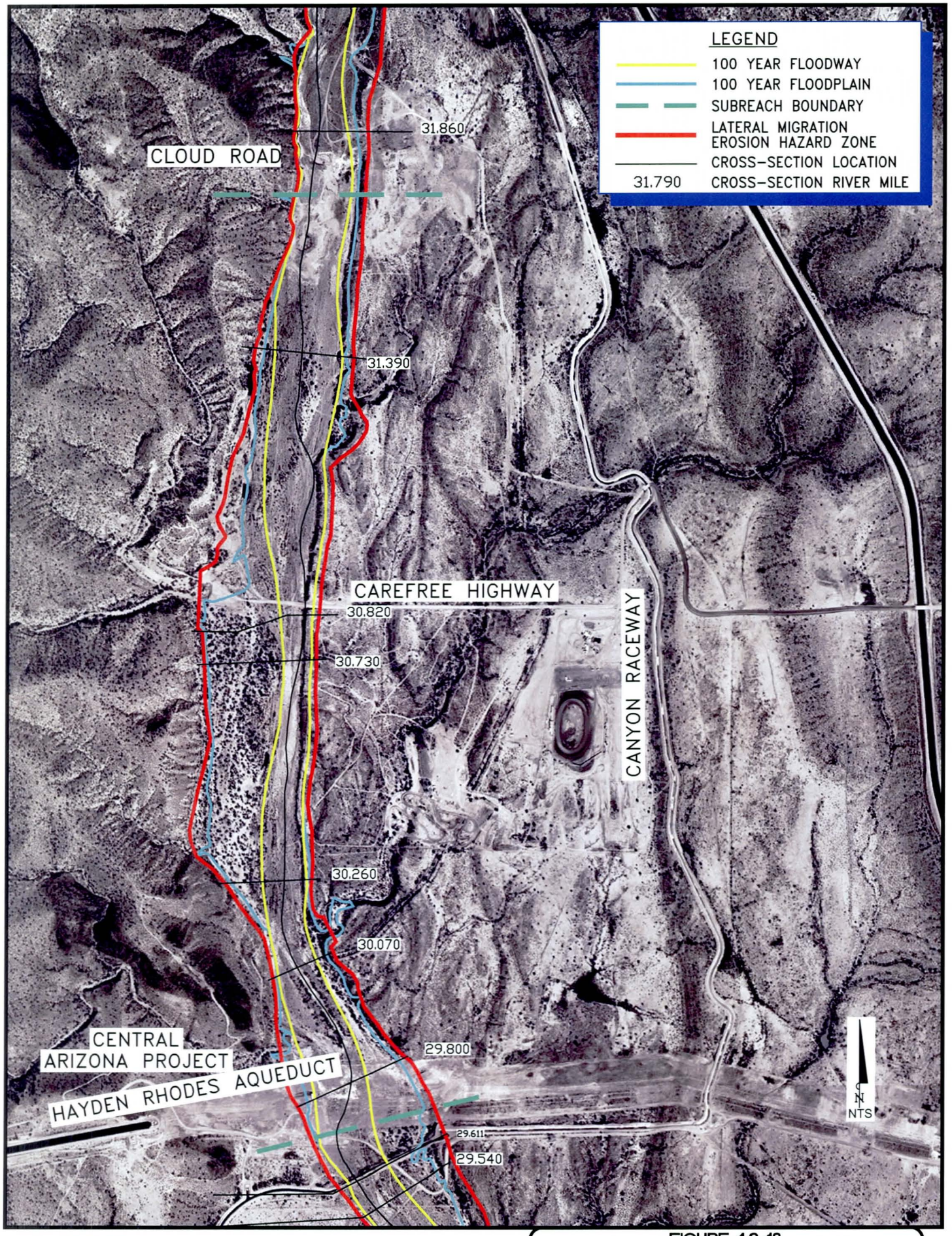

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FIGURE 4.3-18
IMPLEMENTATION AND MAINTENANCE PLAN
CAP CANAL TO CLOUD ROAD

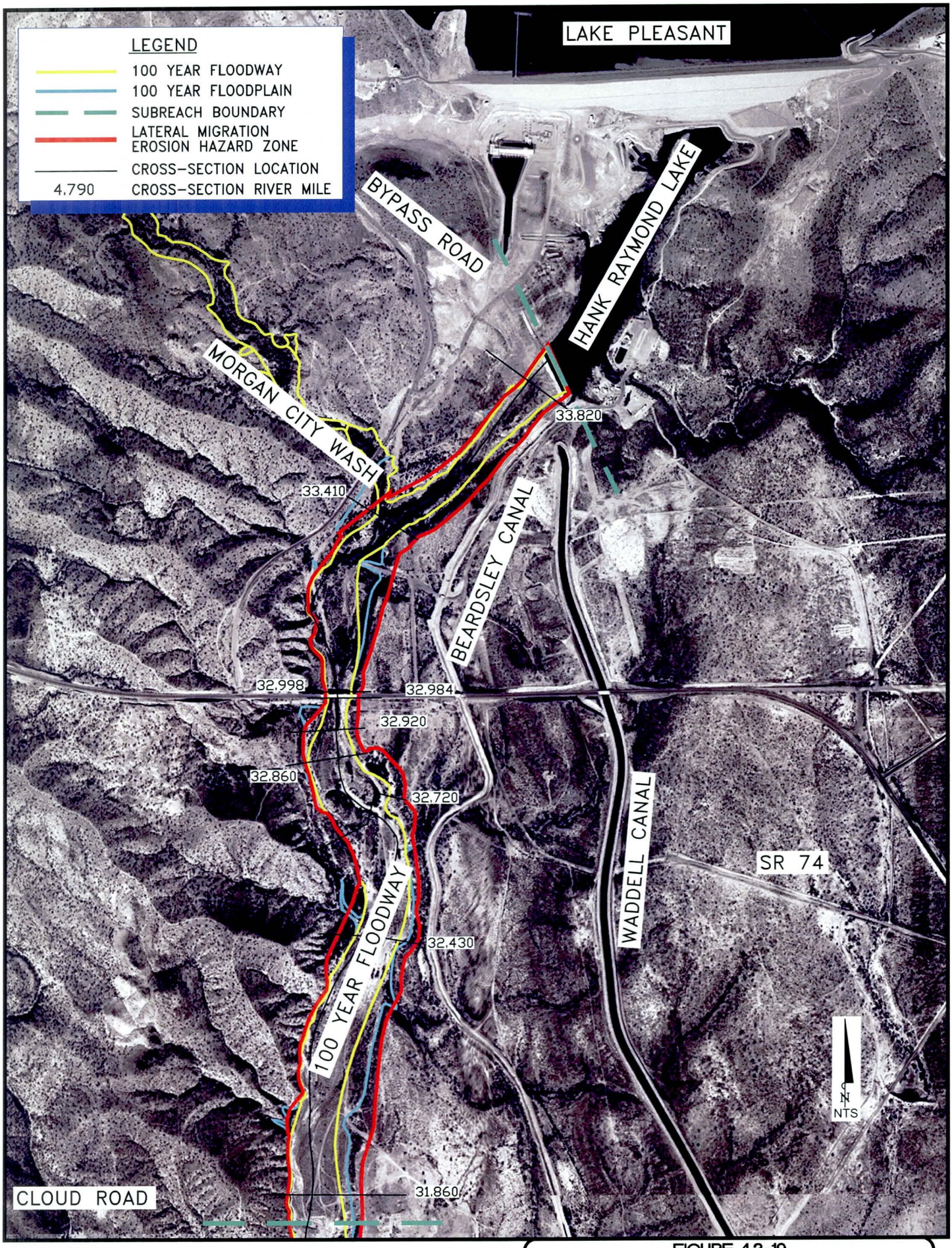

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FIGURE 4.3-19
IMPLEMENTATION AND MAINTENANCE PLAN
CLOUD ROAD TO NEW WADDELL DAM

Develop cross sectional areas for all cross section lines that cross the proposed pit area. A minimum of three cross sections shall be used at all sites. Use interpolated cross sections if HEC-RAS cross sections do not cross the site. Interpolated cross sections shall be drawn in areas that are representative of average pit topography.

The boundaries of the cross sectional areas used to calculate volume shall be:

- Top: 100-year water surface elevation (Appendix I)
- Bottom: Undisturbed ground elevations per 1987 topographical mapping. For mines that were in existence before 1987, approximate the "existing" ground line using representative topography from cross sections near the pit. Do not include the volume of mined areas
- In-stream: Levee around mine pit
- Outboard: Floodplain boundary line

The top of the levee elevation will decrease in the downstream direction. Therefore, it is recognized that the actual storage volume behind the levee will be less than the volume calculated by the method described above. However, the volume calculated using this method shall be used to calculate the length of the drown out weir as described below.

6. **Drown Out Features and Weir Lengths** – Design pits to drown out during storm events that exceed the 50-year design storm. This replaces the channel storage lost by constructing levees. Miners shall provide a weir along the upstream end of in the levee that allows flow to enter the pit. The entire weir shall be located in the upper one-forth of the levee as measured from the point the levee ties into the floodplain boundary. Total length of the levee shall be measured from upstream tie in point to downstream tie in point.

   Alternate weir locations will be permitted if it can be shown that the volume of storage created by mining either equals or exceeds the volume that would have been provided if the weir were located in the upper one-forth of the weir length. Volume calculations for alternate weir locations shall be performed as described above. Provide calculations showing:

A. The volume between the downstream end of the alternate weir location and the one-forth point of the upstream end of the levee.

B. The volume of the excavated portion of the pit downstream from the downstream end of the alternate levee location. Consider excavated volume only- not volume above undisturbed ground line.

The weir shall be long enough to allow sufficient water to enter the pit that the channel storage found in the existing condition is filled. It is recommended that these assumptions be adopted for weir design:

Weir is considered as a broad crested weir. Use the following equation to calculate capacity-

$$Q=2.5LH^{3/2}$$

The weir shall be no higher than the 50-year water surface elevation found in Appendix I.

Examination of various hydrographs for both the 100-year and 50-year design storms shows that flow from the 100-year storm can be expected to exceed the flow from the 50-year storm for a period of 2 hours.

The maximum elevation of flow over the weir shall be based on the 100-year water surface elevation found in Appendix I. The water surface elevation used for the calculation shall be the elevation established at the HEC-RAS cross section closest to the proposed weir location. The cross sections are shown on the CAD files on the compact disk included with this report. The files are Auto CAD R14 format.

The calculations may be based on an average flow rate over the weir. The average flow rate occurs when the height of flow over the weir is one-half the 100-year water surface elevation minus the top of weir elevation.

The top of the weir should not be level, it should slope downstream at a rate that corresponds to the changes in water surface elevation along the length of the weir. In other words, the elevation of the top of the weir should decrease in the down stream direction to match the water surface elevation associated with the 50-year storm.

Pits shall be configured so that weirs are not blocked by berms, haul roads or other features that would prevent water from entering the site or occupying a storage area at least equal in volume to the volume calculated above.

4.4 *Channelization Alternative*

A technically viable alternative that may bear further examination is the development of a flood control channel that would contain a flow event equal to, or larger than, the 100-year flood event. This channel, in essence, would allow for sand and gravel extraction in areas that would be protected from direct inundation. As part of the alternative analysis for the Watercourse Master Plan, a benched channel that included opportunities for multi-use trails was technically feasible, but the cost associated with its construction was significant, therefore, justifying construction of this feature solely using public funds was difficult. In the event that a private partner, such as the sand and gravel industry, private land holders, or other public entities that would benefit from the channel were to participate in the implementation of a channel facility, then this alternative should be reexamined. In order for this alternative to be consistent with the rest of the Watercourse Master Plan, it will be essential that incorporation of offline channel storage facilities be included so as to not cause excessive increases in downstream flood peak. It is also essential that the management plan developed with this alternative consider management strategies that would prevent the piping of waters from the channel into adjacent sand and gravel pits. Finally, it would be recommended that land use zoning within the historic floodplain adequately consider access and emergency evacuation of lands adjacent to the channel. Due to the landforms of the floodplain, unlike most other areas, a channel failure or flow event slightly larger than the design will lead to the inundation of significant areas, and potentially, the temporary displacement of significant populations.

5. RECOMMENDED PLAN COMPONENTS

5.1 *Introduction*

The Agua Fria Watercourse Master Plan recommends flood/erosion control measures to protect the public. Both structural and non-structural means of flood control are recommended to meet the goals of the master plan. The recommended structures and management policies are to help protect against inundation or avulsion due to flood flows, arrest bed degradation, and reduce the cumulative impact of mining operations within the river system.

5.1.1 *Confluence of Gila River to Broadway Road*

Existing buildings are within the LMEHZ along the west bank at Broadway Road. The buildings are over 100 feet from the existing bank. It is proposed to monitor the location of the existing riverbank. Future action may be required in the event of bank loss due to erosion.

The area south of Broadway Road is affected by flood flows in both the Gila River and the Agua Fria River. The confluence area is shown in Figure 5.1-1. It is proposed that future buildings in this area be protected by elevating them two feet above the regulatory (100-year) water surface elevation.

5.1.2 *Broadway Road to MC 85*

Much of the west bank and a subdivision on the east bank are protected by existing levees, therefore, implementing non-structural management policies within the remainder of the subreach is proposed. Additional flood control structures or monitoring do not appear to be warranted within this subreach.

5.1.3 *MC 85 to I-10*

The entire subreach is protected by existing levees. Additional flood control structures or monitoring do not appear to be warranted within this subreach. The addition of wetland vegetation/habitat is being considered at the I-10 Outfall Channel. Preliminary hydraulic analysis shows this to be a potentially viable use of the river if an isolated riparian palate is implemented. A more dense hydric riparian palate would not be suitable due to freeboard constraints of the levees.

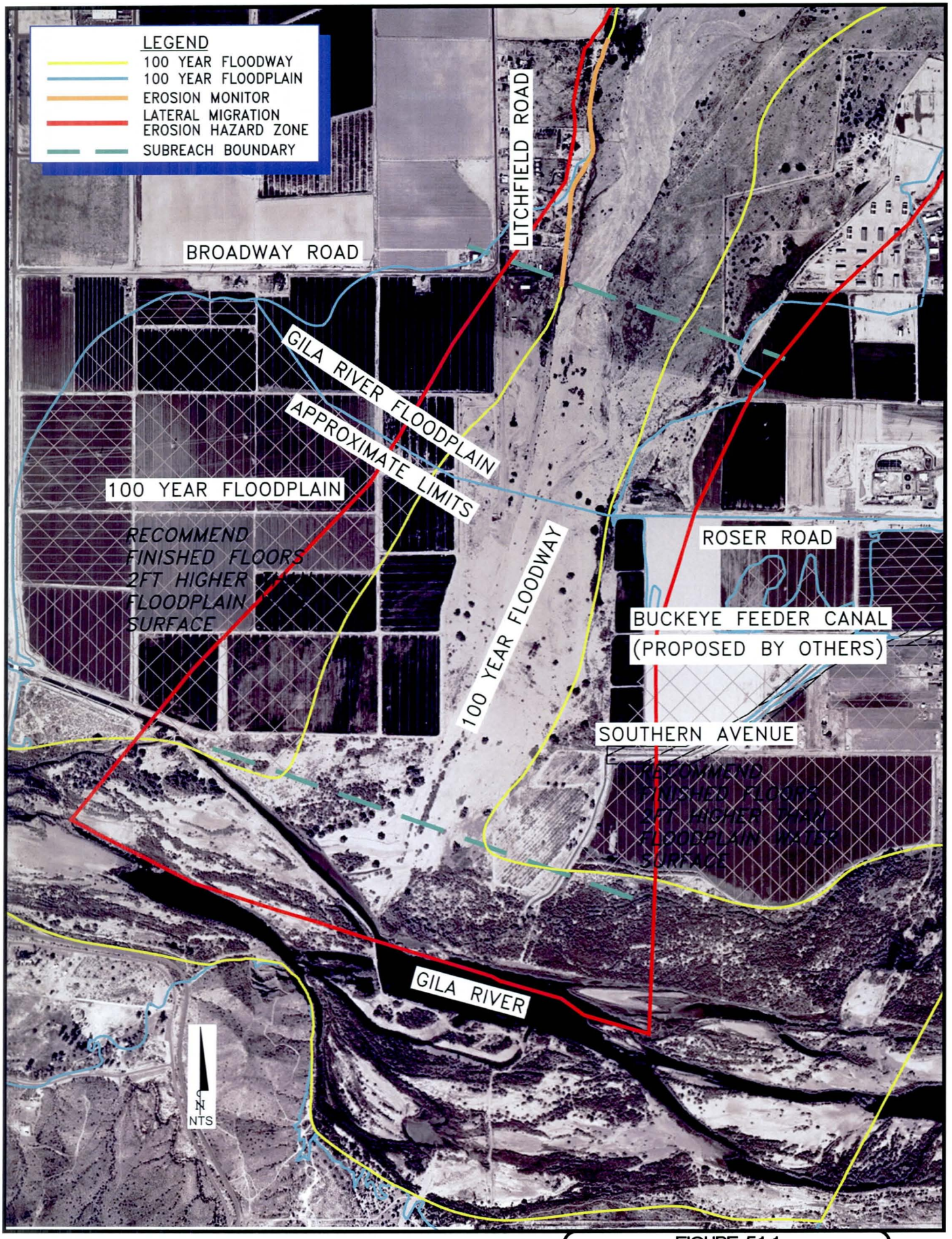

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FIGURE 5.1-1
RECOMMENDED PLAN
CONFLUENCE OF GILA TO BROADWAY ROAD

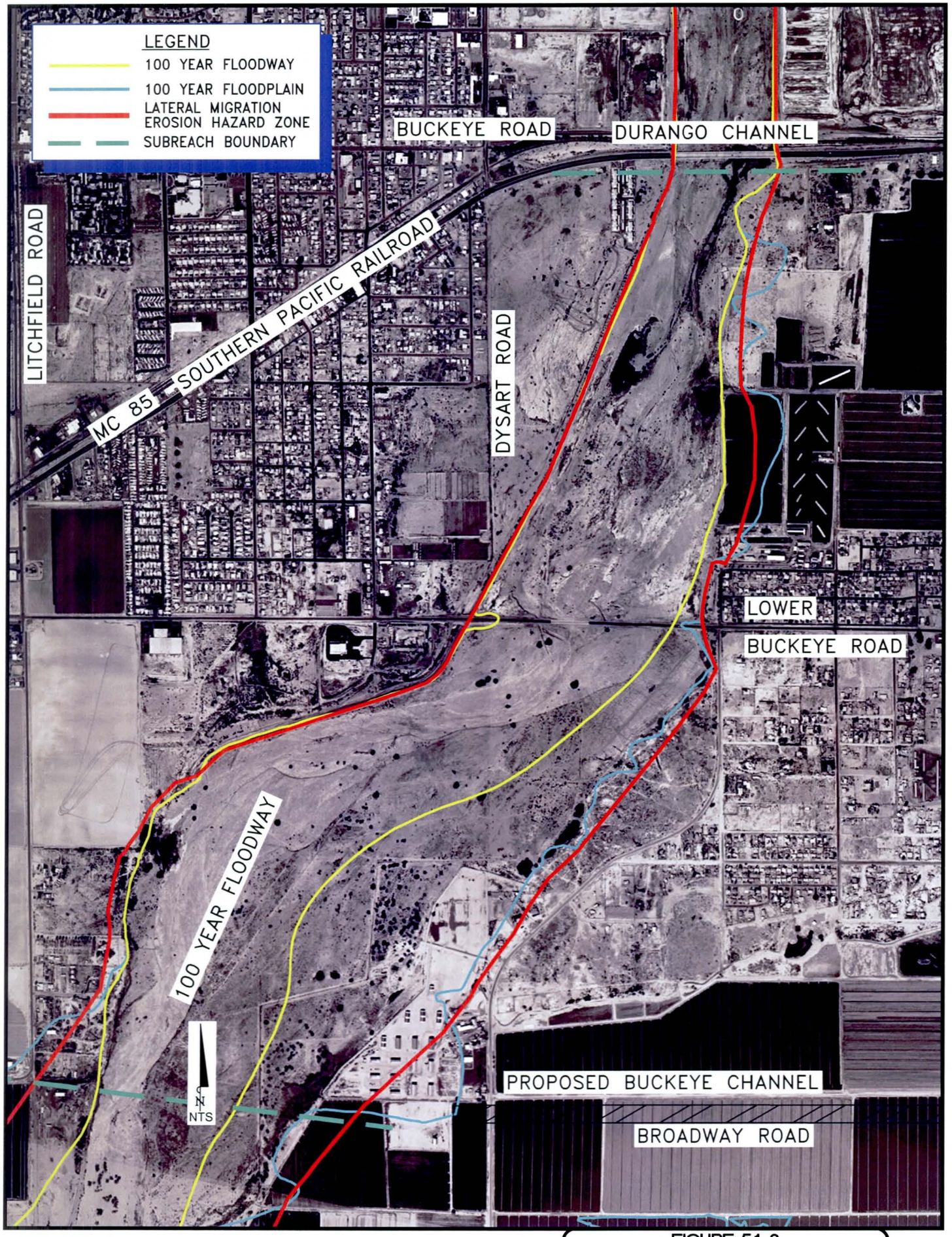

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FIGURE 5.1-2
RECOMMENDED PLAN
BROADWAY ROAD TO MC 85

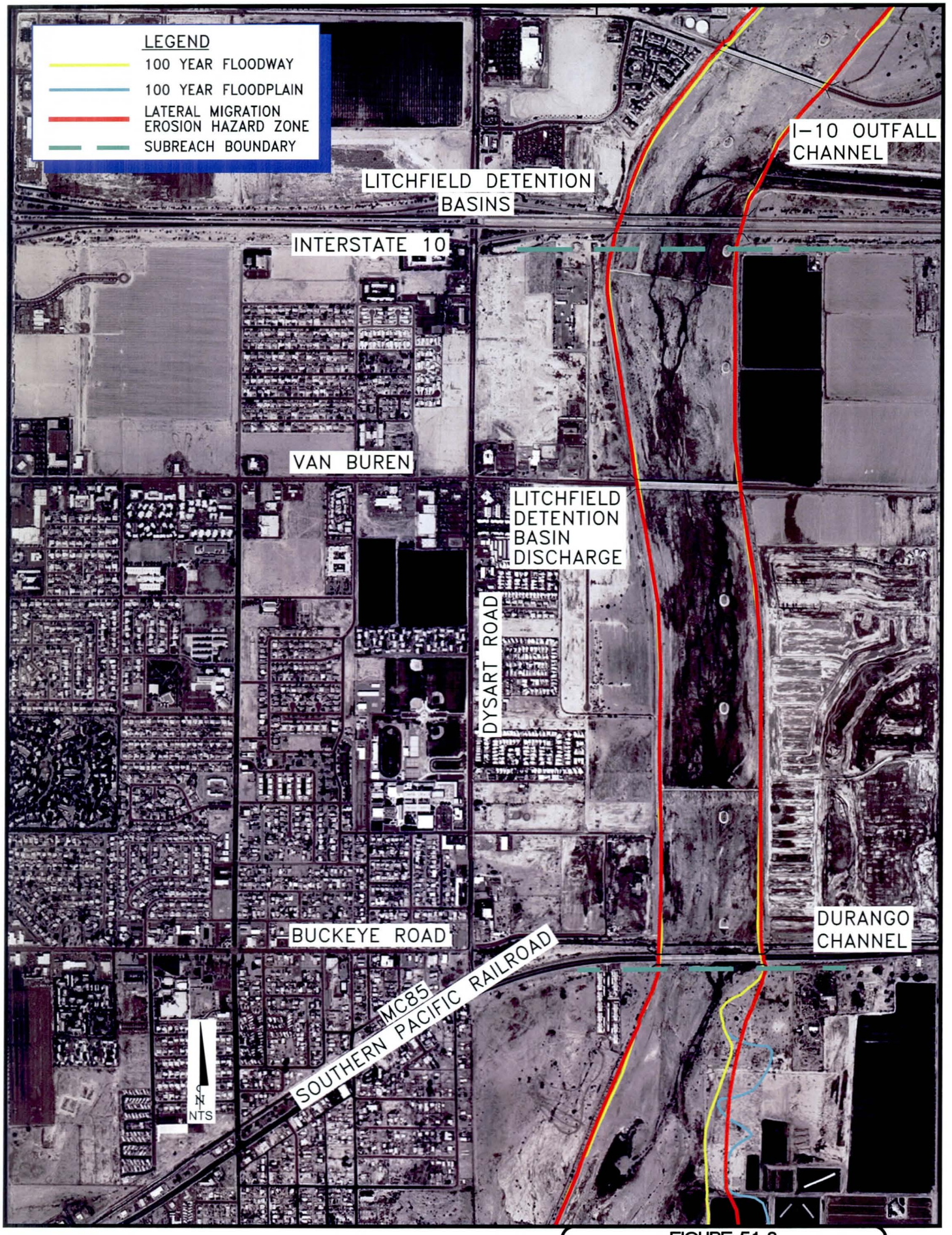

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FIGURE 5.1-3
RECOMMENDED PLAN
MC 85 TO INTERSTATE 10

5.1.4 *I-10 to Indian School Road*

The entire subreach is protected by existing levees. Additional flood control structures or monitoring do not appear to be warranted within this subreach.

5.1.5 *Indian School Road to Confluence of New River*

The east bank is protected by existing levees. The levees extend north to protect the Glendale airport and wastewater treatment plant. The west bank is occupied by several sand and gravel mining operations. Implementation of non-structural management policies within the remainder of the subreach appears to provide adequate flood protection. Additional flood control structures or monitoring do not appear to be warranted within this subreach.

5.1.6 *Confluence of New River to Glendale Avenue*

Sand and gravel mines are in operation on both sides of the river. Implementing non-structural management policies within the remainder of the subreach is proposed. Additional flood control structures or monitoring do not appear to be warranted within this subreach.

5.1.7 *Glendale Avenue to Olive Avenue*

The east bank is protected by existing levees. The levees protect the Glendale landfill and municipal recycling facility. A large sand and gravel mining operation occupies the floodway and portions of the east bank within this subreach.

A grade control structure is recommended downstream of the Olive Avenue Bridge. It would be located between the bridge and a major sand and gravel operation. The purpose of the grade control is to help stabilize the invert of the channel upstream of the grade control, and to arrest potential headcuts from the sand and gravel mine that may develop over time or during a major flood event. The encroachment model indicates a significant degradation at this location.

5.1.8 *Olive Avenue to Cactus Road*

The east bank of the river is a high, nearly vertical bluff from the vicinity of Olive Avenue to Grand Avenue. The bluff is subject to the effects of hillside erosion from the top and to the effects of stream erosion from the bottom. Figure 5.1-8 shows the LMEHZ is located east of the bluff. Numerous buildings are located within the LMEHZ. It is proposed to monitor the rate of slope erosion of the east bank between Olive Avenue

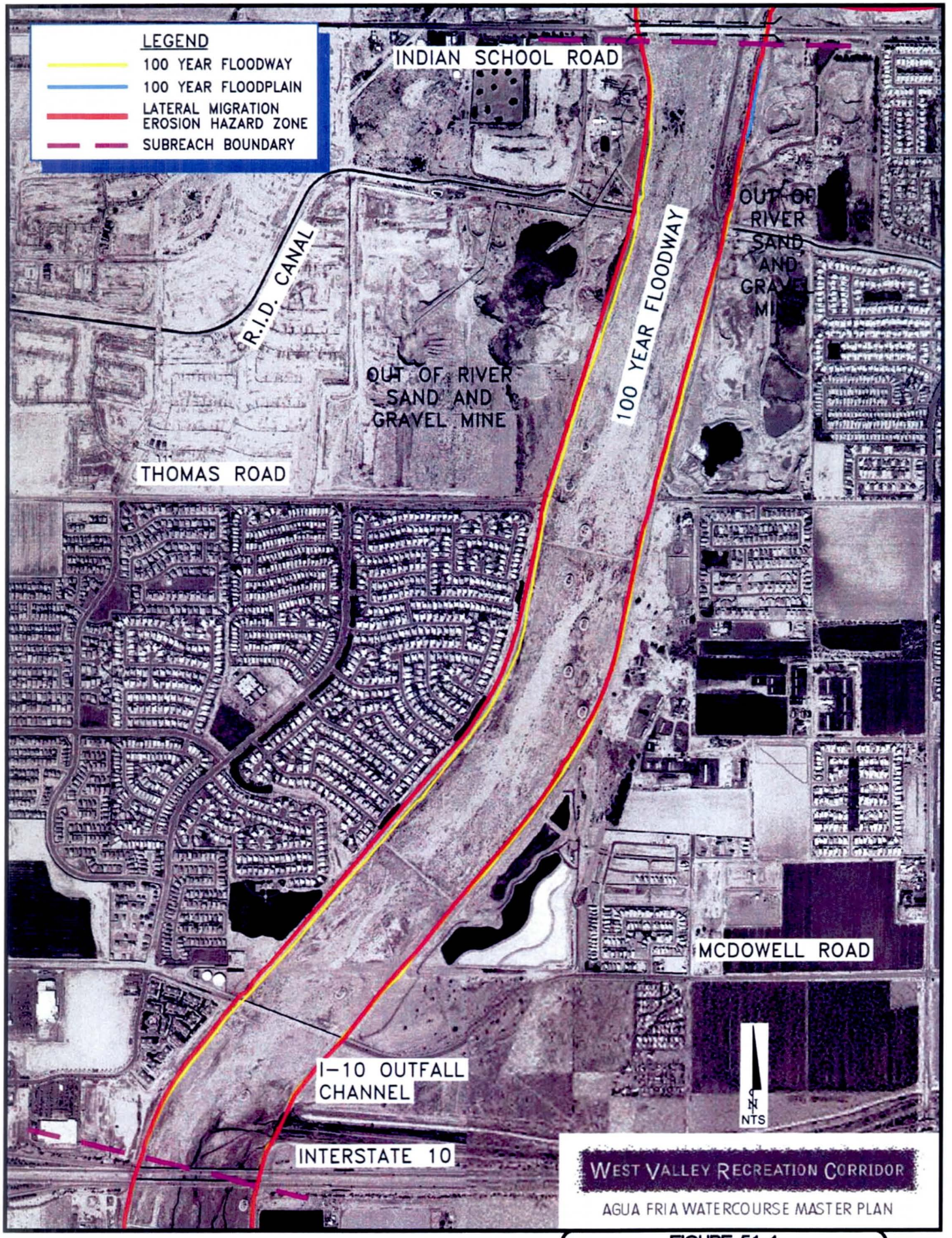

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FIGURE 5.1-4
RECOMMENDED PLAN
INTERSTATE 10 TO INDIAN SCHOOL ROAD

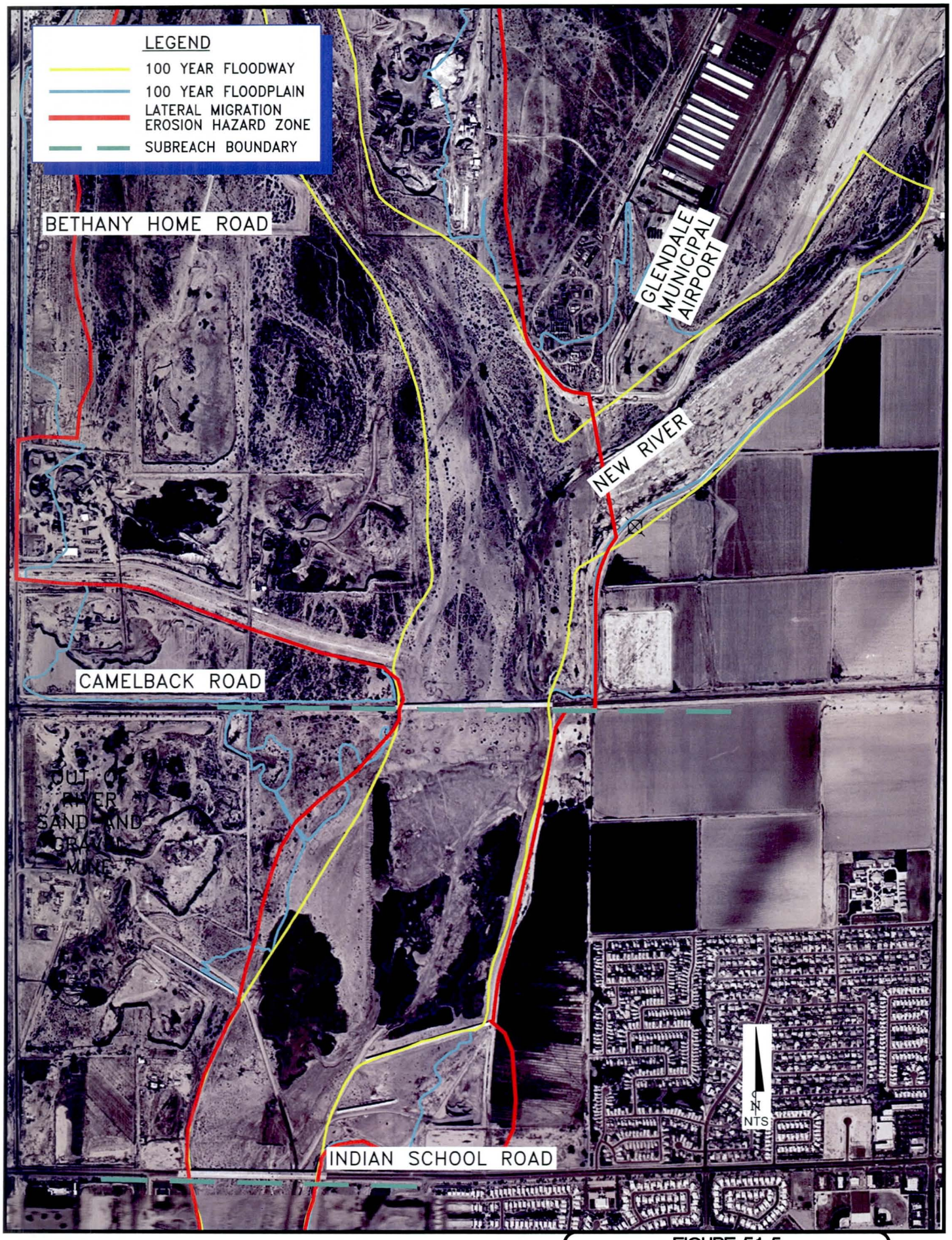

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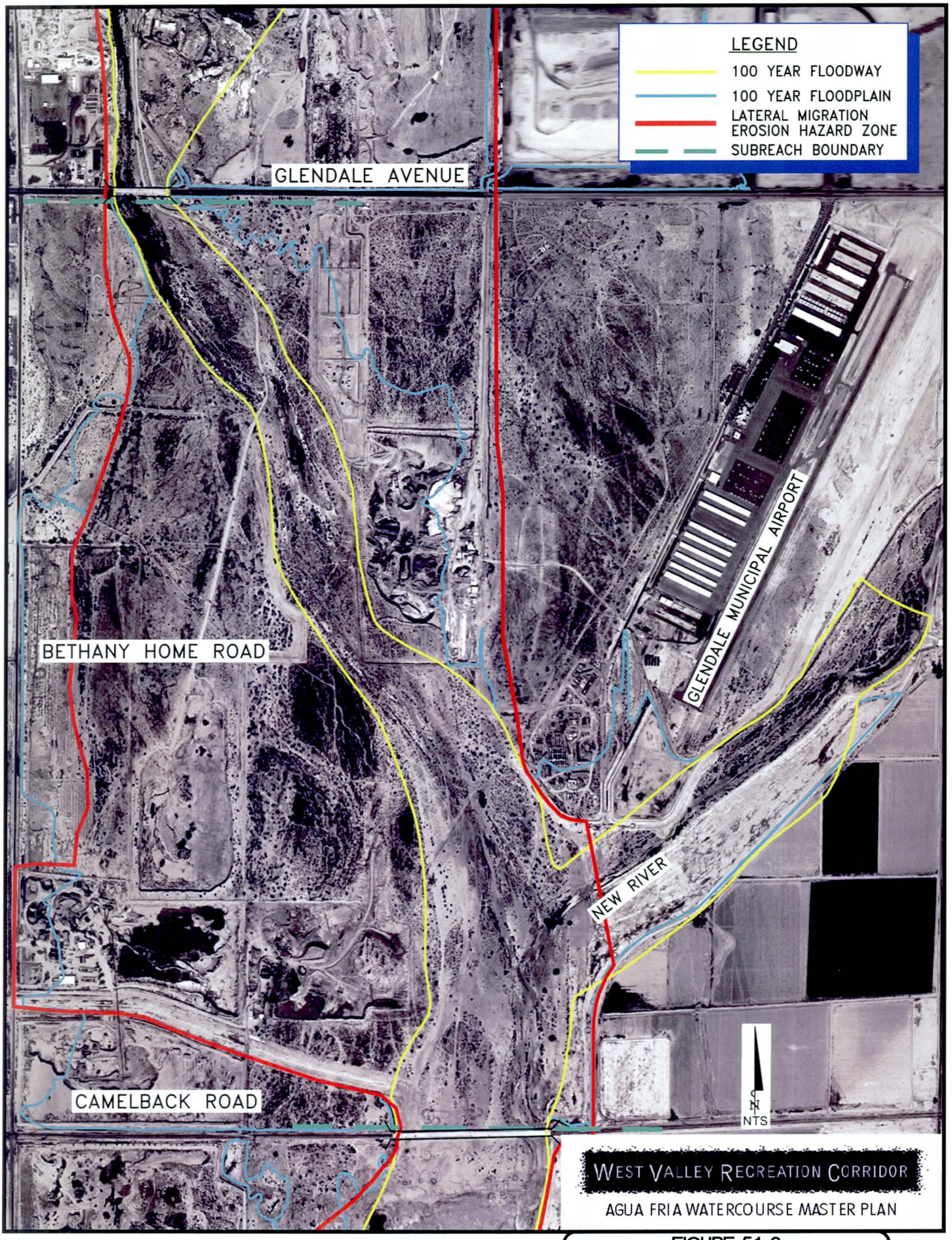
FIGURE 5.1-5
RECOMMENDED PLAN
INDIAN SCHOOL ROAD TO CONF OF NEW RIVER



WEST VALLEY RECREATION CORRIDOR

AGUA FRIA WATERCOURSE MASTER PLAN

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FIGURE 5.1-6
RECOMMENDED PLAN
CONFLUENCE OF NEW RIVER TO GLENDALE AVE

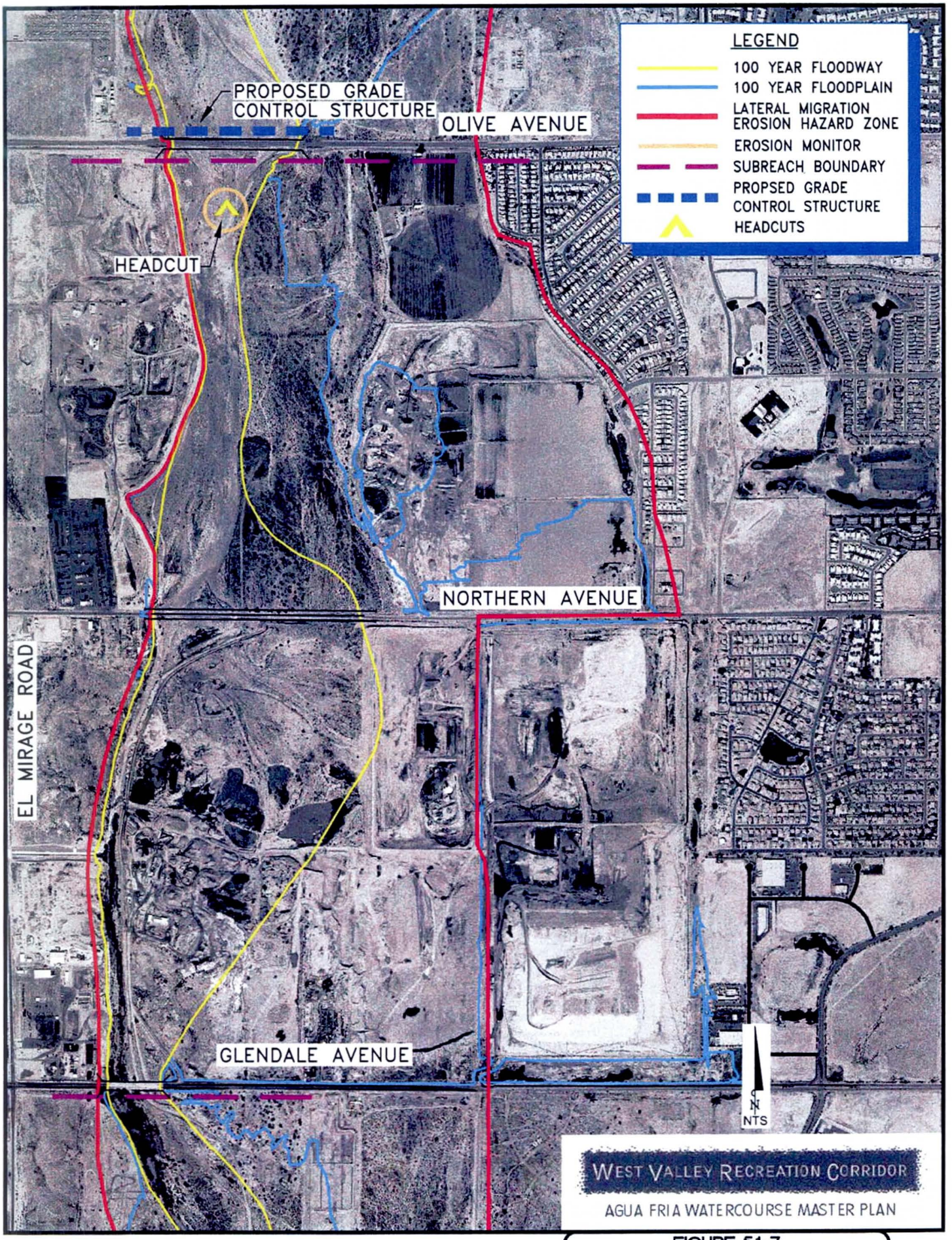

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FIGURE 5.1-7
RECOMMENDED PLAN
GLENDALE AVENUE TO OLIVE AVENUE

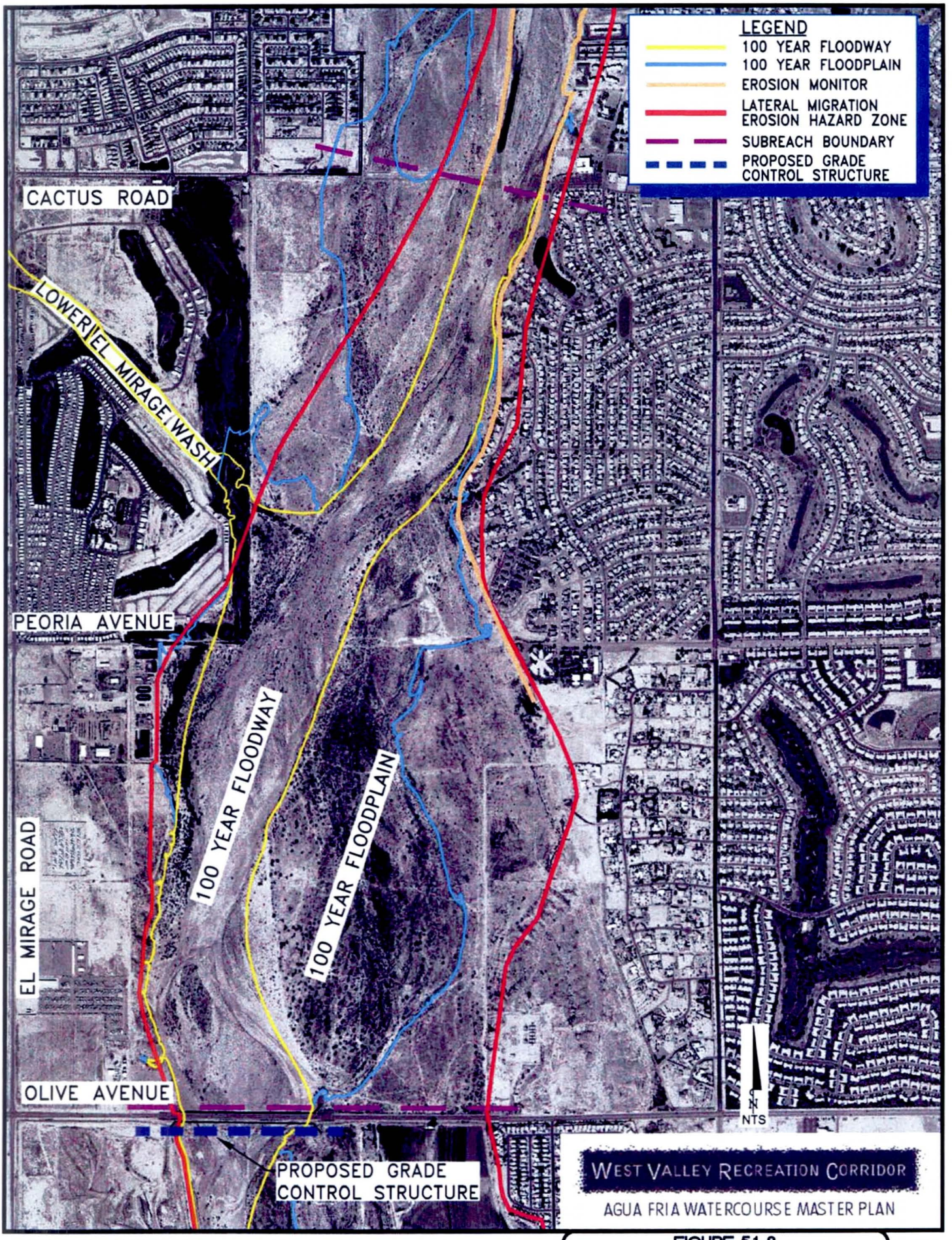

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FIGURE 5.1-8
RECOMMENDED PLAN
OLIVE AVENUE TO CACTUS ROAD

and Cactus Road. Future action may be required if erosion threatens the existing buildings, but a structural solution does not appear to be necessary at this time.

Non-structural flood management without additional monitoring or flood control structures appears to provide adequate protection along the west bank.

5.1.9 *Cactus Road to Grand Avenue*

The El Mirage Landfill occupies the west bank of this subreach. A review of the records associated with the landfill was conducted as part of the master planning process. The results of the record search are documented in *El Mirage Landfill Site, Summary of Status, Kimley-Horn and Associates, 2001*. Unfortunately, there are gaps in the available records and many questions pertaining to the landfill remain unanswered. Further investigation is required before the issues associated with the landfill are resolved. The reader is referred to the above report for a detailed discussion of the situation.

The landfill embankment is protected by riprap made of dumped concrete rubble. The level of protection provided by the riprap is not known. Further investigation of the landfill is required to determine the level of protection offered by the riprap. The size of the riprap and the depth to which the riprap is buried determine the erosive forces the riprap is able to withstand. The riprap visible above the riverbed is simply broken pieces of concrete of varying sizes. Careful investigation by a qualified engineer is required to estimate the adequacy of the riprap to withstand a 100-year storm. The depth to which the riprap is buried (toe down) determines the amount of scour that may occur before the protection is undermined. A potential scour depth of the riverbed may be estimated, but the toe down depth is unknown.

It is difficult to determine the scope and cost of augmenting the bank protection. The extent of the landfill is not clearly defined in the records available for review. Further investigation is necessary to determine the eastern boundary of the landfill. At some point, the investigation will involve excavation or drilling in the vicinity of the landfill. There is a high potential cost and high liability associated with a physical investigation of the landfill, but installation of additional riprap will require excavation to install the toe down for the new riprap. The extent of the landfill must be known before a contractor can begin excavating to construct bank protection or channelization. It is conservatively estimated that the river will require soil

cement bank protection along both banks and across the bottom of the channel throughout the subreach.

The east bank of the river is a high, nearly vertical bluff in this subreach. Protecting the landfill embankment makes this bank more susceptible to erosion. Flow velocities in this area are high enough to cause erosion. The landfill embankment is stabilized (to some extent) and unable to erode, so the opposite bank and the channel bottom must supply the sediment load to the flow. This reflective erosion has been ongoing since the placement of the existing riprap. It will continue unless the east bank is also protected.

As shown in Figure 5.1-9, monitoring of the area is recommended until more is known about the landfill. Non-structural flood control measures may not provide adequate protection in the long term, but additional information is required before a reasonable and feasible solution can be considered.

5.1.10 Grand Avenue to Bell Road

There are no existing buildings within the regulatory boundary from Grand Avenue to Greenway Road. Non-structural policies appear to offer the most suitable means of flood protection through this section of the subreach.

Existing homes abut the floodplain on the west bank, south of Bell Road at the top of a nearly vertical 25-foot bluff. The homes are pre-manufactured units on small lots. Many of the homes have been placed quite close to the edge of the bluff. It forms the boundary of the floodway, floodplain, and LMEHZ. Although the homes are outside the regulatory boundaries, sudden failure of a small portion of the bank would cause homes to fall into the floodway. Bank protection is proposed to prevent loss of life. Figure 5.1-10 shows the location of the proposed bank protection.

Extensive sand and gravel mining operations occupy this subreach. In order to comply with the No Adverse Impact mining policy, it is anticipated that nearly continuous levees will be required on both sides of the river to isolate the mine from the floodway. The owners of the mine would construct the levees.

Existing headcuts have been identified downstream from the Bell Road Bridge. It is recommended that the existing size and location of the headcuts be accurately documented. Monitoring of the area monitored is recommended after flow events to track progression of head cuts or

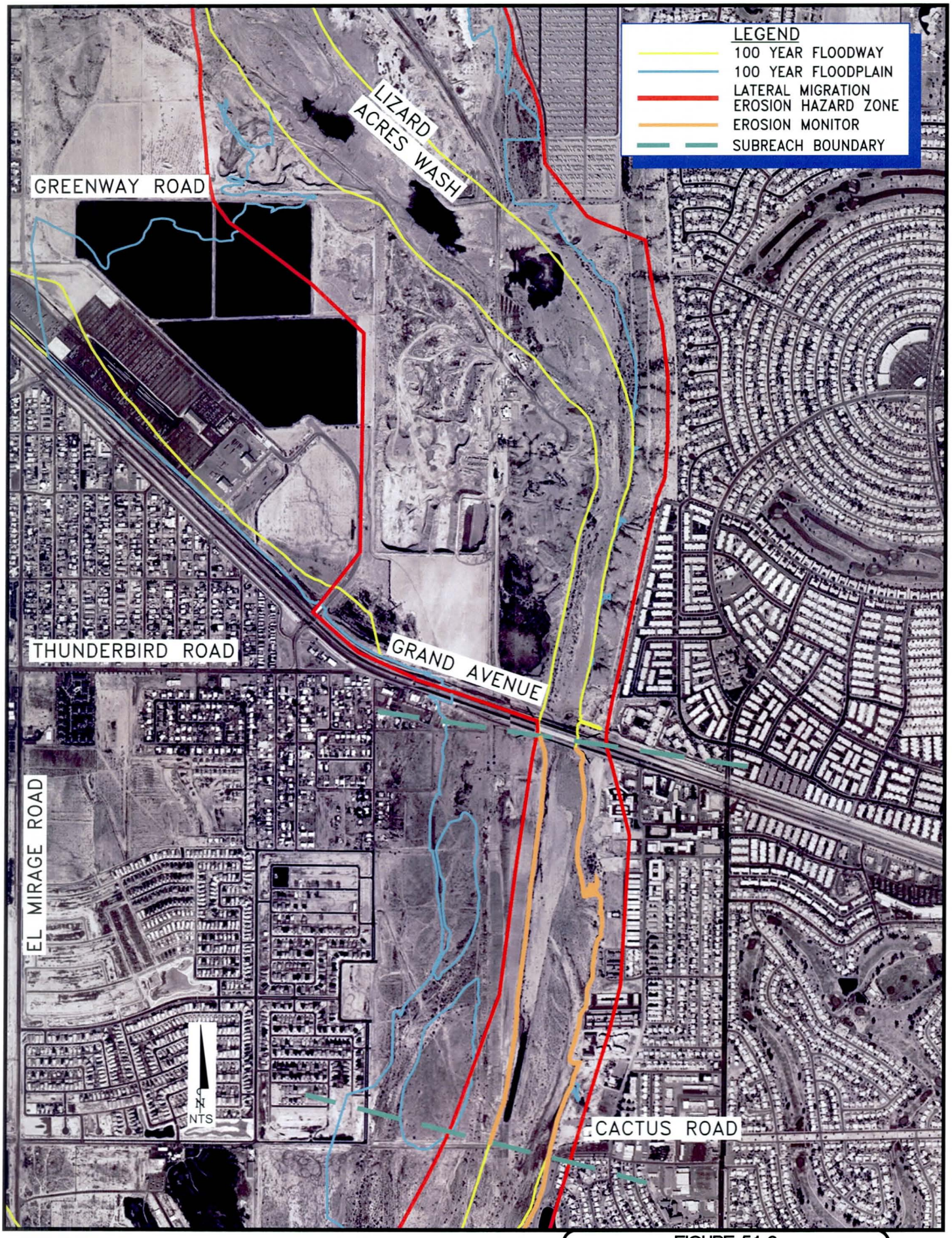

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FIGURE 5.1-9
RECOMMENDED PLAN
CACTUS ROAD TO GRAND AVENUE

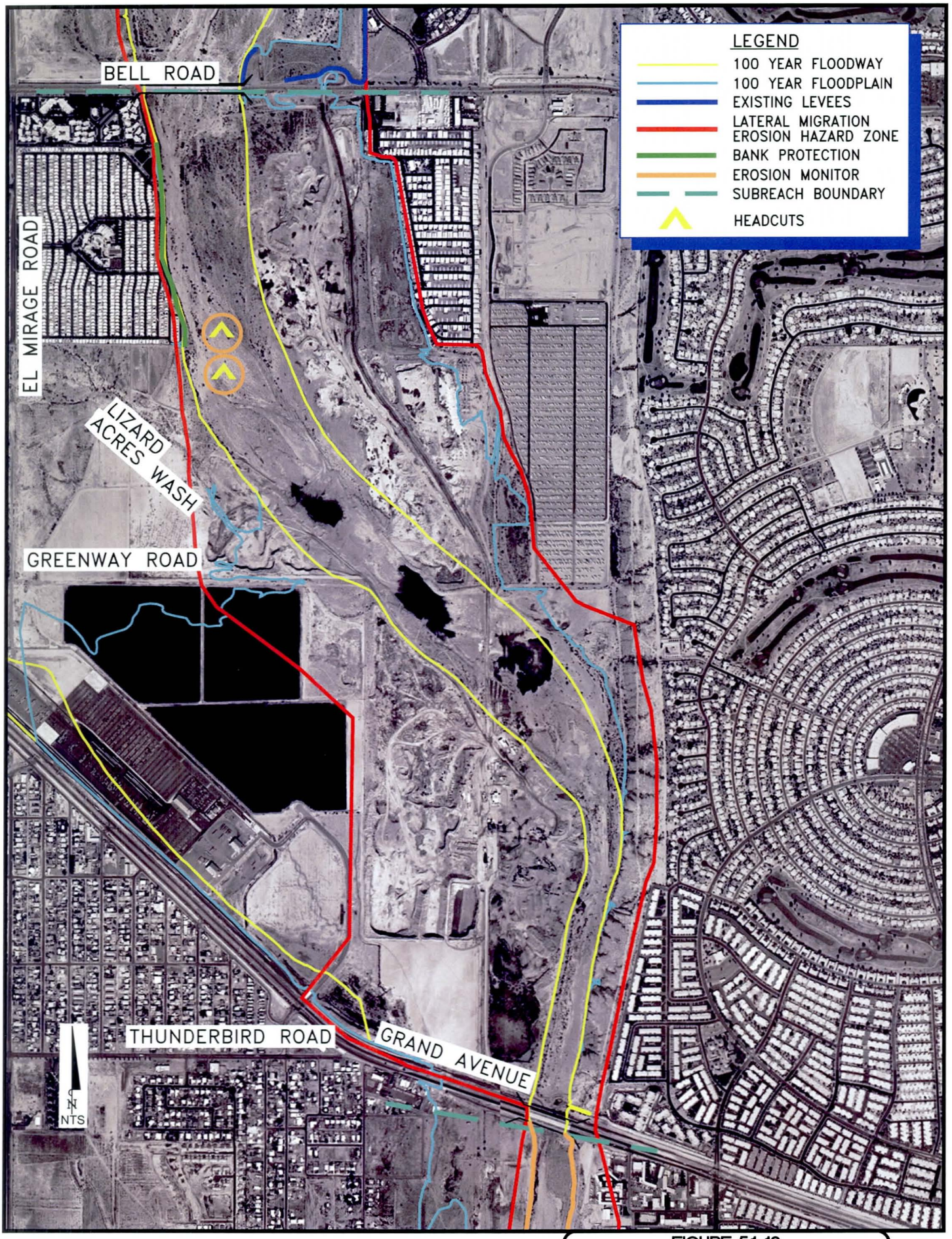

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FIGURE 5.1-10
RECOMMENDED PLAN
GRAND AVENUE TO BELL ROAD

development of new ones. A future grade control structure may be required at this location.

5.1.11 *Bell Road to Beardsley Road*

This subreach is ideally suited to non-structural regulation. There are no buildings within the proposed regulatory boundary. The west bank is quite high and steep. The area west of the river is an undeveloped strip one-quarter mile wide throughout the subreach. The only exception is a building on El Mirage Road, north of Bell Road.

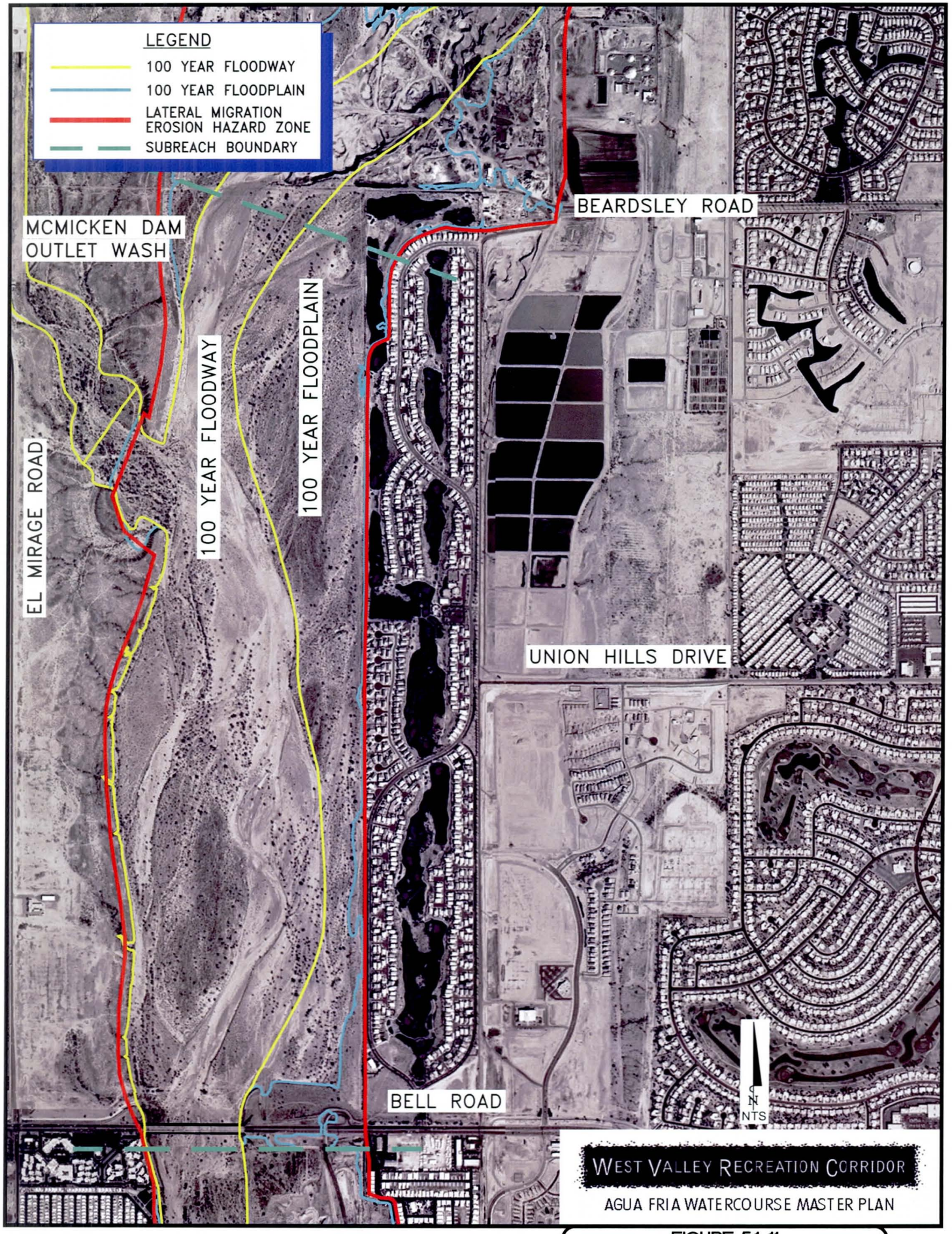
The east bank is defined by the levee protecting the Coyote Lakes subdivision. The levee is an engineered levee. The levee forms the boundary for the LMEHZ and the floodplain. Preventing encroachment beyond the regulatory line would prevent construction in a sizeable tract of undeveloped land along the east bank. The tract is a narrow strip west of the Coyote Lakes subdivision.

This strip is currently in the floodplain, between the Coyote Lakes levee and the floodway. Under current regulations, it is permissible to construct in this area by raising the building on an embankment or by building a levee to protect the building. However, development in this area would be in immediate danger if a storm event exceeds the level of protection provided by a levee or embankment. Damage to buildings could be significant due to depth of flow and velocity of flow. Preventing development of this strip helps reduce losses due to large storms.

5.1.12 *Beardsley Road to Pinnacle Peak Road*

A large sand and gravel mine occupies the lower half mile of the subreach. The mine spans the floodway and also occupies large portions of the flood fringe along both banks. It is not possible to construct a levee or other flood/erosion control structure in this area due to the presence of the mine.

Existing headcuts have been identified upstream from the mine in the vicinity of the Deer Valley Road Alignment. It is recommended that the existing size and location of the headcuts be accurately documented. Monitoring of the area is recommended after flow events to track progression of head cuts or development of new ones. A future grade control structure may be required near Rose Garden Lane.



WEST VALLEY RECREATION CORRIDOR

AGUA FRIA WATERCOURSE MASTER PLAN

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FIGURE 5.1-11
RECOMMENDED PLAN
BELL ROAD TO BEARDSLEY ROAD

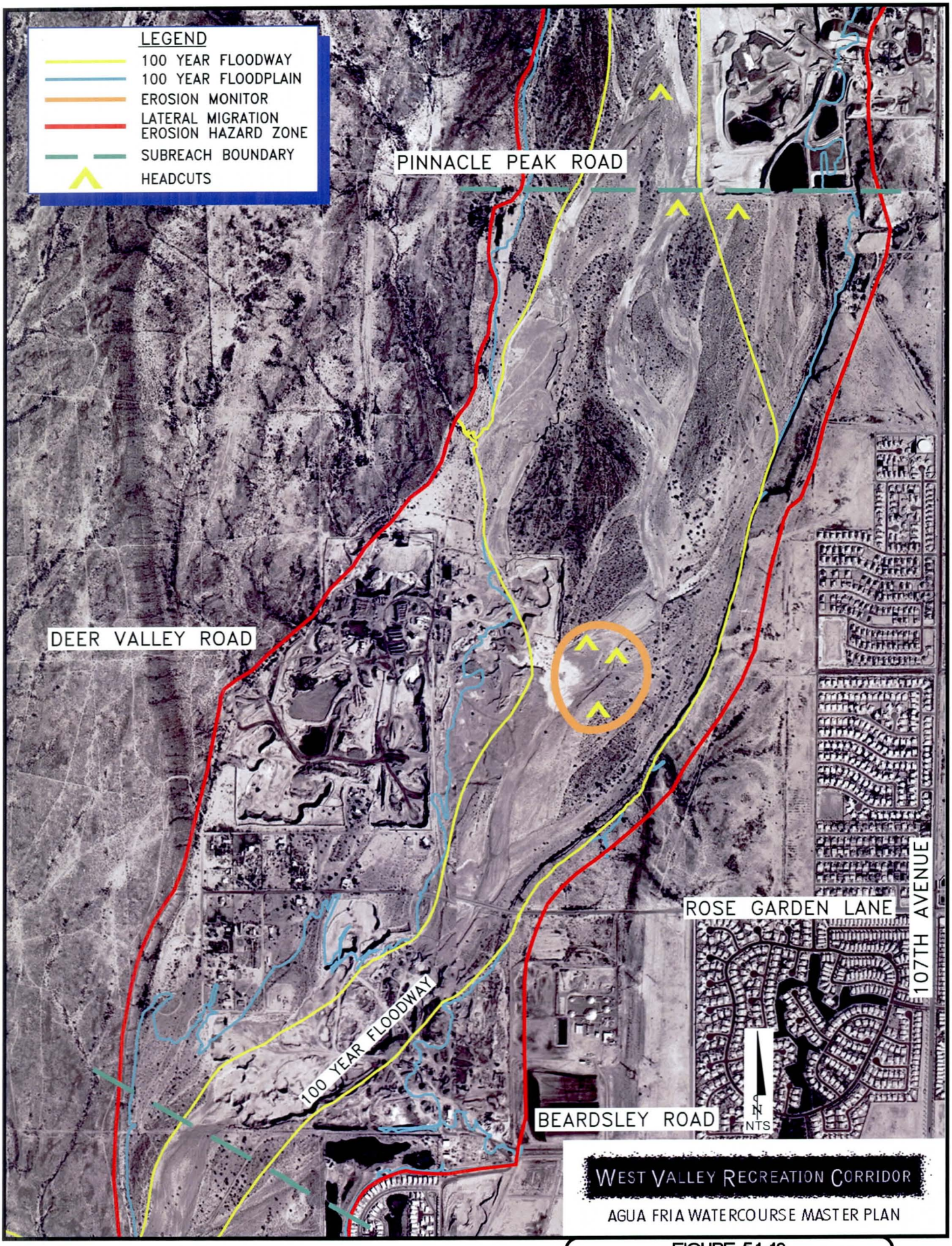

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FIGURE 5.1-12
RECOMMENDED PLAN
BEARDSLEY ROAD TO PINNACLE PEAK ROAD

The remainder of the subreach is undeveloped with smaller sand and gravel operations west of the floodplain. The owners of the mines may be required to construct levees to meet the requirements of the No Adverse Impact policy toward mining within the floodplain. Bank protection might be required along the east bank to arrest reflective erosion if the west bank is armored.

Non-structural regulation of the floodplain is a practical method of protecting the public in this subreach.

Infrastructure required to meet the requirements of the No Adverse Impact policy would be constructed by gravel miners.

5.1.13 *Pinnacle Peak Road to Jomax Road*

A large gravel mine is located immediately north of Pinnacle Peak Road along the east bank. The mine occupies the flood fringe and a considerable area east of the floodplain. The owners of the mine may be required to construct levees to meet the requirements of the No Adverse Impact policy toward mining within the floodplain.

CAP is currently constructing groundwater recharge ponds within the floodplain along the west bank, south of Jomax Road. The ponds are to be located outside the floodway.

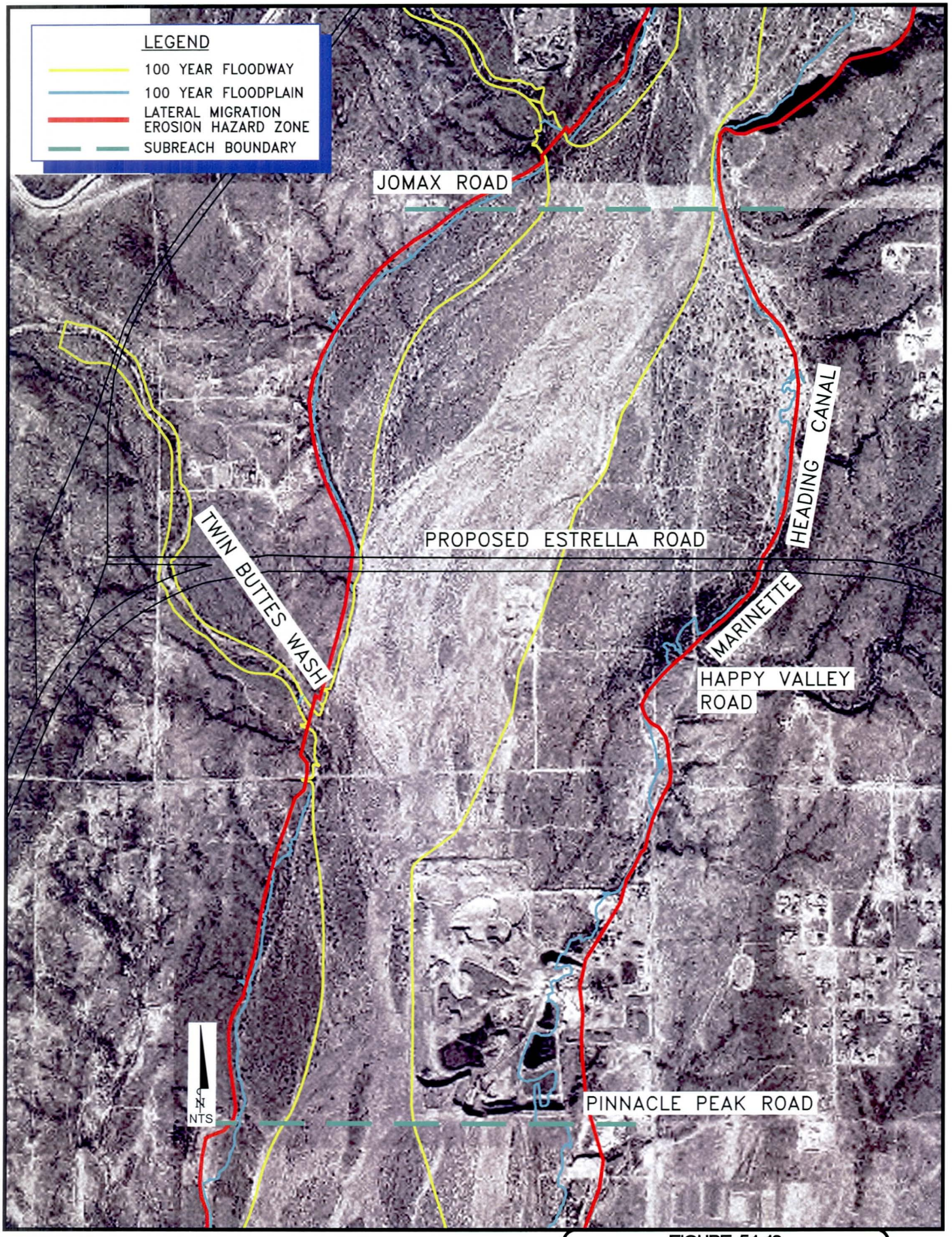
The mine and the recharge ponds are both located within the LMEHZ. These are acceptable land uses within the LMEHZ. Structural protection of these facilities at the taxpayer's expense is not necessary. Non-structural flood control measures provide adequate protection throughout the subreach.

5.1.14 *Jomax Road to Dixileta Drive Alignment*

In the future, water will flow through this subreach from the CAP canal to the recharge ponds south of Jomax. The water will flow along the natural channel bottom. Except for maintenance to remove excessive vegetation, the channel will not be improved.

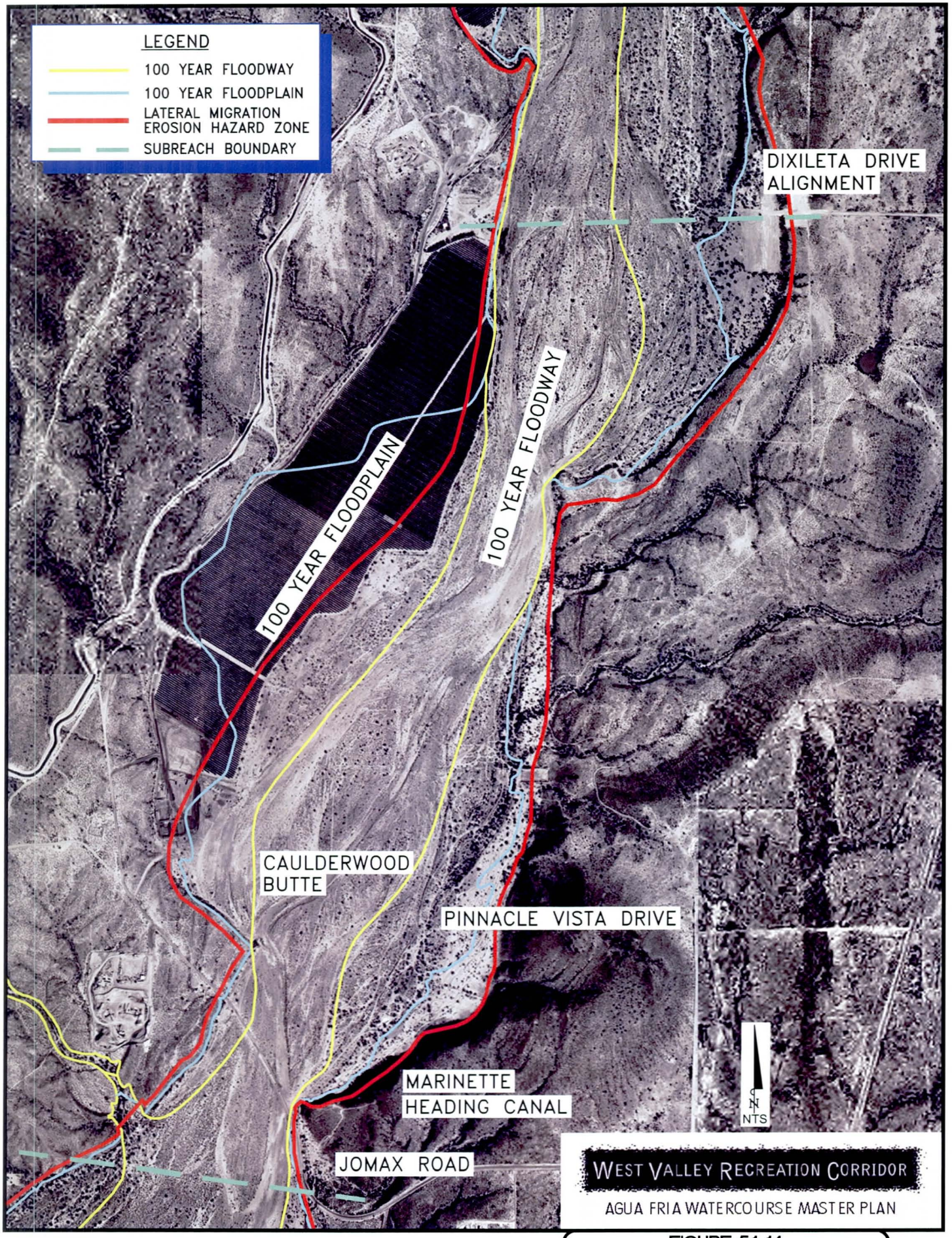
Proposed gravel mines may be located in the floodplain along the west bank. The limits of the mines are undetermined at this time.

There are no existing buildings within the subreach that require structural protection. The subreach is well suited to non-structural flood control.



Kimley-Horn and Associates, Inc.

FIGURE 5.1-13
RECOMMENDED PLAN
PINNACLE PEAK ROAD TO JOMAX ROAD



Kimley-Horn and Associates, Inc.

FIGURE 5.1-14
RECOMMENDED PLAN
JOMAX ROAD TO DIXILETA DRIVE ALIGNMENT

5.1.15 *Dixileta Drive Alignment to the CAP Canal*

In the future, water will flow through this subreach from the CAP canal to the recharge ponds south of Jomax. The water will flow along the natural channel bottom. Except for maintenance to remove excessive vegetation, the channel will not be improved.

Proposed sand and gravel mines may be located in the floodplain along the west bank. The limits of the mines are undetermined at this time.

There are two existing structures within the subreach: the CAP Canal Siphon and the Beardsley Canal Bridge. A proposed bridge will carry the Loop 303 across the river in the vicinity of Lone Mountain Road. The Loop 303 Alignment is well into the planning phase at this time, but a precise alignment has not been finalized.

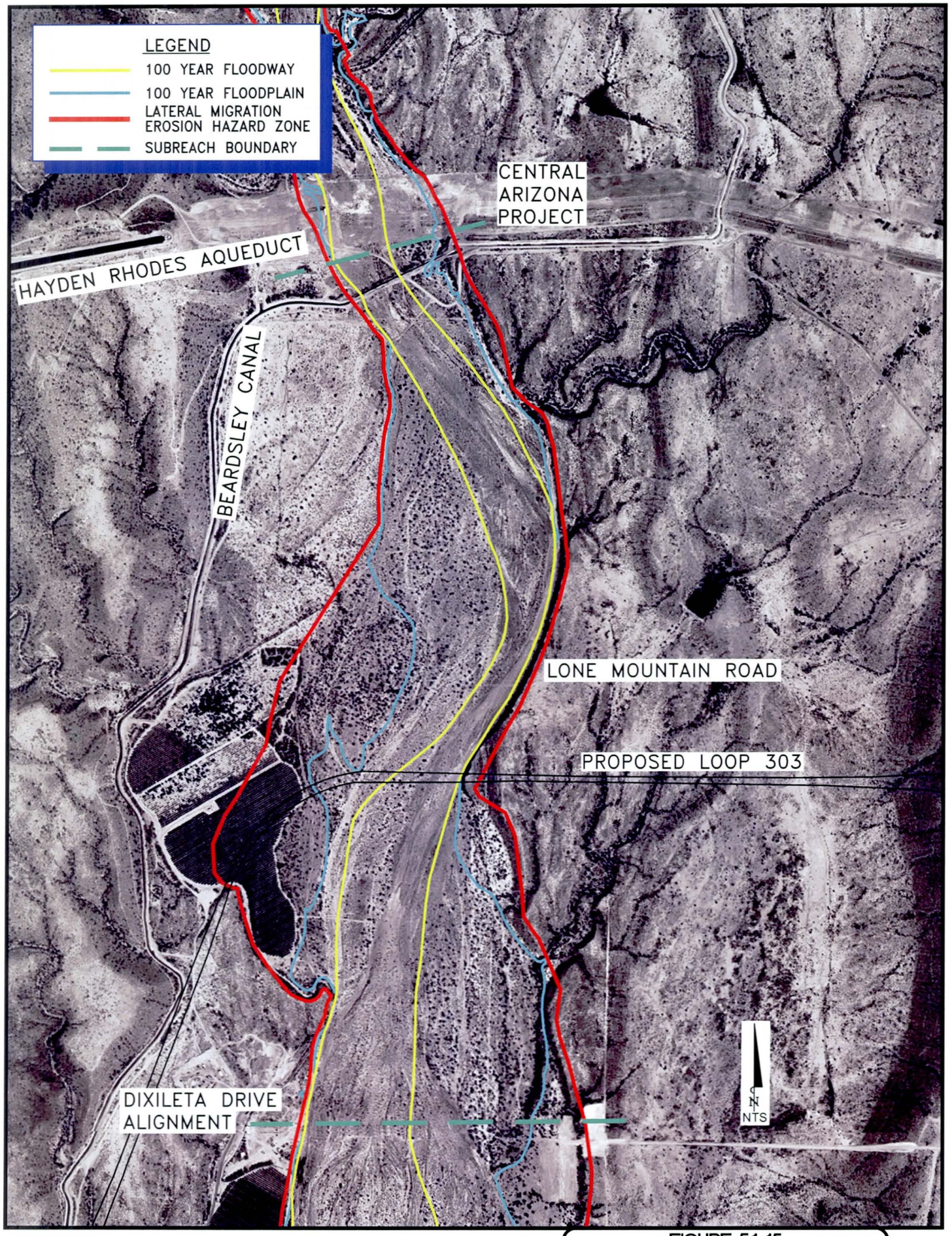
The subreach is well suited to non-structural flood control. There are no existing buildings within the regulatory boundaries.

5.1.16 *CAP Canal to Cloud Road*

The subreach is well suited to non-structural flood control. The area is generally undisturbed desert. There are no existing buildings within the regulatory boundaries. The river is well incised with the floodway line, floodplain line and LMEHZ all being nearly coincidental with one another. The subreach is well suited to non-structural flood control. The area is generally undisturbed desert. There are no existing buildings within the regulatory boundaries. The river is well incised with the floodway line, floodplain line and LMEHZ all being nearly coincidental with one another.

5.1.17 *Cloud Road to New Waddell Dam*

The subreach is well suited to non-structural flood control. The area is generally undisturbed desert. There are no existing buildings within the regulatory boundaries. The river is well incised with the floodway line, floodplain line and LMEHZ all being nearly coincidental with one another.



Kimley-Horn and Associates, Inc.

FIGURE 5.1-15
RECOMMENDED PLAN
DIXILETA DRIVE ALIGNMENT TO CAP CANAL

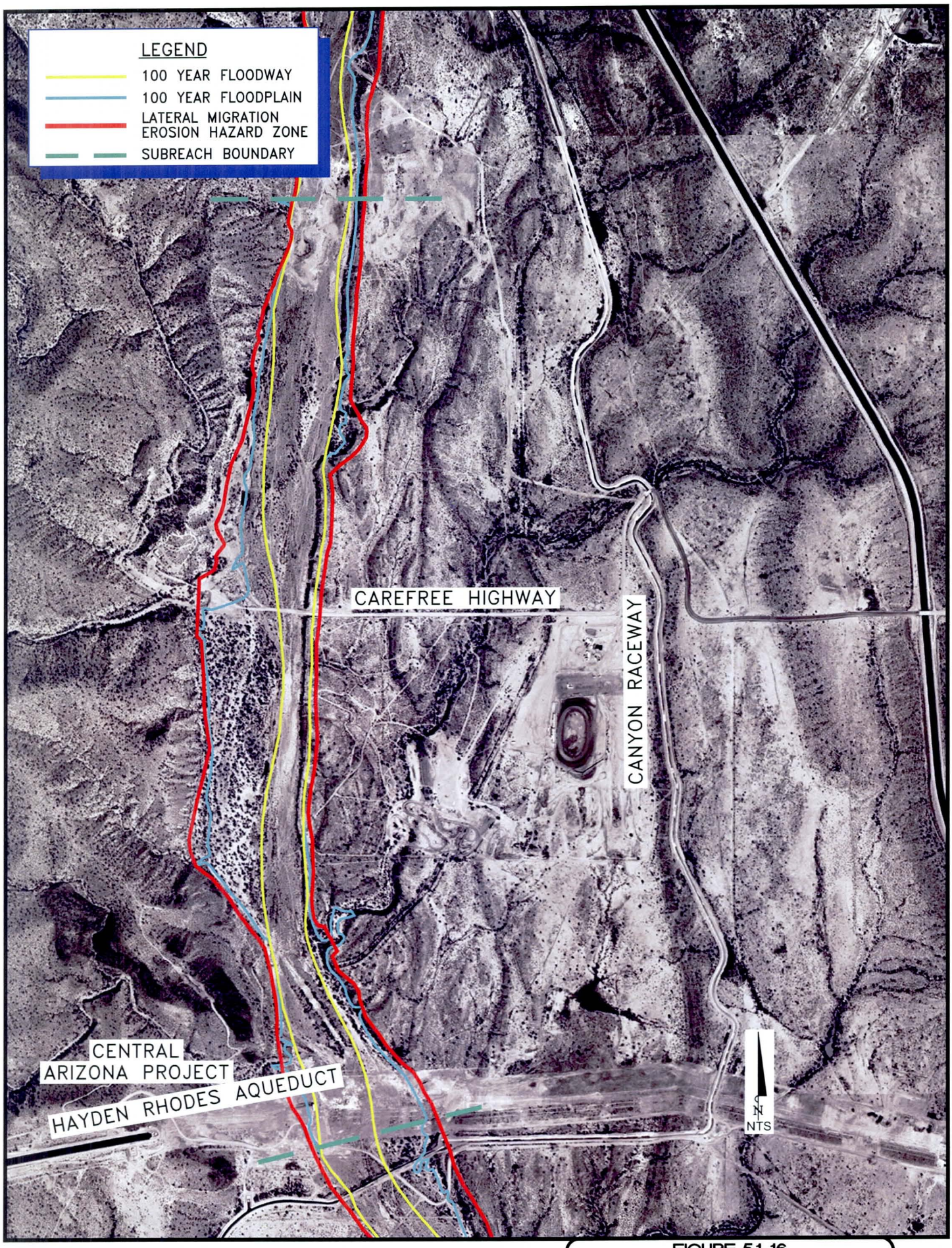


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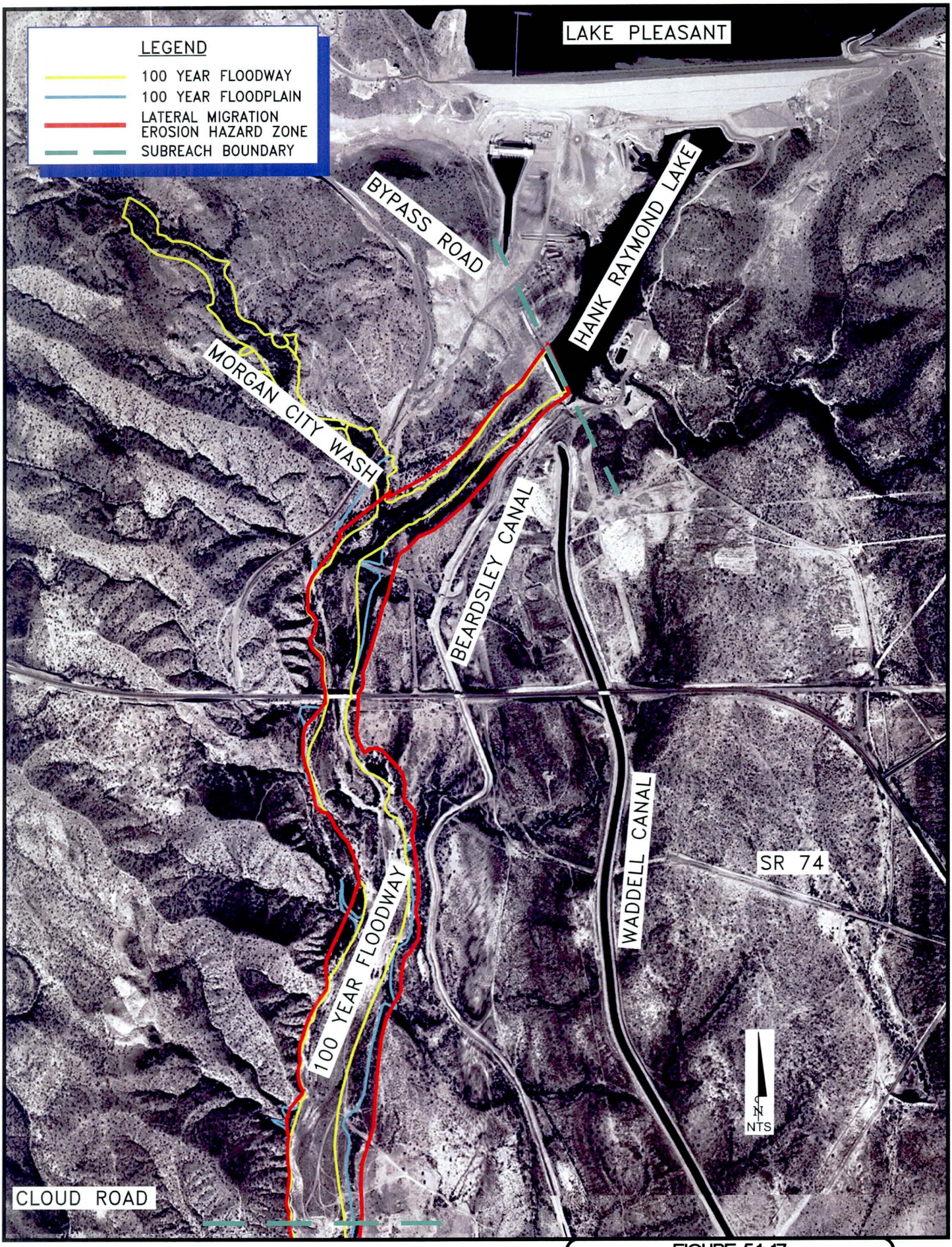
FIGURE 5.1-16
RECOMMENDED PLAN
CAP CANAL TO CLOUD ROAD



Kimley-Horn and Associates, Inc.

FIGURE 5.1-17
RECOMMENDED PLAN
CLOUD ROAD TO NEW WADDELL DAM

6. OPINION OF PROBABLE CONSTRUCTION COST OF FLOOD CONTROL COMPONENTS

A planning level cost estimate in 2001 dollars of the flood control components of the Recommended Plan was prepared (see Table 6-1) to compare and rank the alternatives. Costs were estimated throughout the study area using the following assumptions:

1. Levees and grade control structures are assumed to be constructed of soil cement.
2. Levees and grade control structures are assumed to have a similar configuration as the levees in Avondale.
3. Levees are assumed to have 10 feet of toe down and 3 feet of freeboard in the 100-year storm.
4. Continuous embankments with 6:1 slopes are assumed behind the levees.
5. Embankment height is estimated as high (equal to levee height), medium (equal to half of levee height) or low (equal to one –quarter levee height) based aerial photos.
6. Levee costs include the embankment behind the levee, the land under the footprint of the levee and embankment.
7. Land costs are not included for the channel between the levees.
8. Land costs for the areas under the footprint of grade control structures, levees and embankments are included.
9. Physical parameters such as channel depth and length of levee were calculated from information obtained from the HEC-RAS model.
10. Land cost is estimated at $32,500 per acre.
11. Soil cement cost is estimated at $30.00 per cubic yard.
12. Embankment cost is estimated at $3.00 per cubic yard.
13. Estimated prices were increased 10% for design costs and 30% for contingencies.

Prices of buildings were estimated based on size, use, and type of construction (i.e. mobile home or stationary building). Table 6-1 shows the estimated cost for purchasing the buildings in the event of a buyout. However, the Recommended Plan does not recommend purchasing buildings at this time. It is proposed to protect buildings that are immediately threatened using flood control structures and to monitor bank erosion in areas that do not appear to be immediately threatened. The costs shown are future costs that may be incurred as a result of non-structural flood control management.

Table 6-1– Opinion of Probable Construction Cost of Flood Control Components For the Agua Fria Watercourse Master Plan				
River Reach	**Recommended Alternative**	**Construction Cost ($Million)**	**Addition of 100-ft. Vegetated Trail**	**Comments**
Gila Confluence to Broadway	**Regulatory line/ +2 feet fill**		Probable	
Broadway to MC 85	**Regulatory/monitoring**		Probable	4 buildings in erosion zone
MC85-I 10	Levee in Place		Probable	
I-10 to Indian School	Levee in Place		Probable	
Indian School To New River	**Regulatory**		Probable	
New River to Glendale	**Regulatory**		No	
Glendale to Olive	**Regulatory**		Uncertain	
Glendale to Olive	**Olive Road Grade Control Structure**	**$2.0**	Uncertain	
Olive to Cactus	**Regulatory/monitoring**		Probable	6 homes in erosion zone
(1)Cactus to Grand	*9,800 ft of levee/monitoring*	*$4.2*	*Probable*	*Assumes typical levees, both banks. Monitor east bank.*
(1)Cactus to Grand	*Channel/monitoring*	*$24.0*	*Probable*	*Assumes full channel lining- both banks and bottom*
Grand to Bell	**2,650 Bank Protection**	**$0.8**		West bank, south of Bell Road
Grand to Bell	**Regulatory**		Uncertain	Vegetation OK in upper half

Table 6-1– Opinion of Probable Construction Cost of Flood Control Components For the Agua Fria Watercourse Master Plan

River Reach	Recommended Alternative	Construction Cost ($Million)	Addition of 100-ft. Vegetated Trail	Comments
Bell to Beardsley	**Regulatory**		Probable	
Beardsley to Pinnacle Peak	**Regulatory**		Uncertain	
Pinnacle Peak to Jomax	**Regulatory**		Probable	
Jomax to Dixileta	**Regulatory**		No	
Dixileta to CAP	**Regulatory**		No	
CAP to Cloud	**Regulatory**		No	
Cloud to New Waddell	**Regulatory**		No	
El Mirage Landfill- Flood Control Improvements from Cactus Road to Grand Avenue		**$4.2 to $24 Million**		Costs of flood/erosion protection at El Mirage Landfill uncertain
Other Flood Control Structures		**$2.8 Million**		Bank protection at Bell Road and grade control structure at Olive Avenue
Maintenance Road		**$17.5 to $20.0 Million**		Gila River to New Waddell Dam
Total Anticipated Cost of Recommended Plan		***$24.5 to $46.8 Million***		Costs of flood/erosion protection at El Mirage Landfill uncertain

6.1 *Opinion of Probable Construction Cost of Recreational Components*

- A planning level cost estimate, in 2001 dollars, of the proposed recreational features of the Recommended Plan was prepared to compare and rank the alternatives (see Table 6-2). The cost for non-flood control features of the Watercourse Master Plan must be funded by entities other than the District. Costs were estimated throughout the study area using the following assumptions:
- Land cost is estimated at $32,500 per acre.
- Estimated prices were increased 10% for design costs and 30% for contingencies.
- Trail costs reflect additional signs and other features required to open the maintenance road as a non-motorized trail. Land and surface treatment of the trail are included in the maintenance road costs.
-

Table 6-2 - Opinion of Probable Construction Cost of Recreational Features For the Agua Fria Watercourse Master Plan

Location	Component	Description	Construction Cost (Millions)	Comments
Gila Confluence to Lake Pleasant	Recreational Components of Maintenance Road	Primary Trail	$1.500	
Gila Confluence to Broadway Road	Park/Major Trailhead	Avondale Mitigation Site	$0.500	
Lower Buckeye Road	Equestrian Facilities	Trail head with parking/loading facilities	$0.750	
Lower Buckeye Road	River Theme Development	Commercial Redevelopment of current City offices	-	Private development-No cost to public sector
Buckeye Road	Interpretive Ramada/ Open Space/Trailhead	Interpretive site with railroad theme and minor trailhead	$0.150	
I-10	Interpretive Ramada/ Open Space/Trails	Interpretive site, habitat area, trails, open space	$0.150	
El Mirage	10-Acre Park Site	Recreational Park in Flood Fringe- No Structures	$1.600	
RID Canal	Interpretive Ramada/ Open Space	Interpretive site, trail connection	$0.150	
McMicken Dam Outlet Channel	10-Acre Park Site	Recreational Park in Flood Fringe- No Structures	$1.600	
Bell Road	Major Trailhead	Equestrian Trailhead	$0.500	
Beardsley Road	Minor Trailhead		$0.250	
Jomax Road	Interpretive Ramada/ Open Space	Interpretive site associated with CAP recharge project	$0.250	
Associated with SROG Recharge Facilities (location to be determined)	Interpretive Ramada/ Open Space (1of 2)	To be determined	$0.250	

Table 6-2 - Opinion of Probable Construction Cost of Recreational Features For the Agua Fria Watercourse Master Plan

Location	Component	Description	Construction Cost (Millions)	Comments
Associated with SROG Recharge Facilities (location to be determined)	Interpretive Ramada/ Open Space (2 of 2)	To be determined	$0.150	
Calderwood Butte	Interpretive Ramada	Interpretive site	$0.150	
Casa de Piedras	Interpretive Ramada/ Open Space	Interpretive site	$0.150	
CAP Canal	Interpretive Ramada	Interpretive site	$0.150	
Beardsley Canal	Interpretive Ramada	Interpretive site	$0.150	
SR 74	Major Trailhead/Interpretive Area	Trailhead, habitat conservation areas and interpretive areas in the vicinity of SR 74 and George's Pond	$0.500	
Lake Pleasant Road south of SR 74	Minor Trailhead	Trailhead in association with City of Peoria Regional Park	$0.250	
		TOTAL	**$9.4 Million**	

Appendix I. Management of Sand and Gravel Operations

INTRODUCTION AND PURPOSE

Sand and gravel mining continues to play a vital role in the Valley's economy. The Agua Fria River is a source of abundant, high quality sand and gravel materials that can not readily be replaced. Properly located pits have also provided significant flood storage that has been shown via modeling to provide flood peak attenuation in the 100-year flood.

However, extraction of sand and gravel from floodplains can lead to river instabilities that tend to accelerate erosion and influence lateral migration; and, if left unchecked, these instabilities can lead to damage to infrastructure and buildings.

These seemingly contrasting statements summarize the challenge facing the sand and gravel industry, government, and the citizens of Maricopa County. The purpose of this Appendix is to provide those implementing the Agua Fria Watercourse Master Plan with an understanding why specific management strategy for sand and gravel resources was proposed as part of the Agua Fria Watercourse Master Plan.

BACKGROUND

The fluvial geomorphologists associated with the Agua Fria Watercourse Master Plan have concluded that the Agua Fria is a degrading river that is still approaching equilibrium slope conditions. Two factors have primarily contributed to this imbalance. These factors are the damming of the Agua Fria River, and the sand and gravel mining that has occurred in the Agua Fria over the past 50 years.

The sediment supply of the lower Agua Fria River was limited with the construction of the Waddell Dam in late 1920's and early 1930's. While this clearly impacted sediment inflow to the river, data does not indicate any significant or widespread response by the river to the dam. This in part could be due to sufficient sediment being available in the river reaches below the dam that allowed for continued transport of sediment downstream.

Sand and gravel activities were first noted in the 1950's with demand being driven by some of the first developments in the west valley. The first significant impacts to the river were associated with these gravel mining activities.

Today sand and gravel mining can be found throughout the river, with significant clusters found between Camelback Road and Olive Avenue and the reach between Grand Avenue and Jomax Road. There are proposed operations within these mined reaches as well as operations proposed north of Jomax Road and south of the CAP.

Sediment trend investigations were performed to project the impact that sand and gravel might have on the river. Sediment transport was modeled assuming a single flood event approximating a 100-year storm. The models evaluated the existing condition (assuming little or no mining) and a proposed condition that incorporated existing and proposed mines. The model included the currently permitted mines as if they were excavated to the fullest extent of the permitted plan. The existing condition model demonstrated that the river was relatively stable, with some isolated points of degradation. The proposed condition model indicates an increase in degradation of the riverbed, with some areas experiencing more than 5 feet of scour. It is anticipated that if this investigation were performed using a multi-event scenario that the model would continue to predict significant degradation.

The sand and gravel industry is truly mining the river. Without a source of sediment replenishment, the river can only respond by shifting upstream sediment into downstream holes. This causes both a general lowering of the river and severe localized scour. These effects may manifest themselves rapidly in a single event, potentially causing the catastrophic loss of a bridge or other infrastructure. A general lowering of the river, if severe enough, may impact infrastructure and lead to bank instabilities that potentially threaten land and developed areas on the banks of the river.

It is estimated that there are nearly 13,000 acres in the current regulatory floodplain of the Agua Fria River, approximately 5,200 of which are within the floodway. From the New River Confluence to the CAP siphon, it is estimated that there are 8,600 acres in the floodplain with 3,100 acres in the floodway. Assuming a value of $35,000 per acre, the current land value of the floodplain in this reach is $301 million. The value in the floodway is $108.5 million.

REGULATORY CONTROLS

Sand and gravel operations are regulated via floodplain use permits and through Section 404 of the Clean Water Act permit process. Current regulation of sand and gravel activities by the District is limited to the area within the 100-year floodplain. Historically, regulation of sand and gravel has been accomplished using standards of care that approximate no offsite impact. Restrictions include limitations on pit depths, incorporating "safe" side slopes, using property setbacks, or using techniques to fill the

pit with water to mitigate potential headcuts. In most cases, compliance with these guidelines has led to permits being approved based on the assumption that impacts are kept on site.

However, the Agua Fria River has such an overwhelming sediment imbalance; these rule of thumb approaches have not limited impacts to the mining sites, as demonstrated by the results of the sediment trend analysis. Clearly, a change in management policy is required to protect the river environment, existing infrastructure and public safety.

In the mid-1990's, it was determined that activities such as sand and gravel mining would fall under Section 404 of the Clean Water Act. In Maricopa County and in other parts of the state, there were significant barriers associated with obtaining 404 Permits from the US Army Corps of Engineers. Due to the vagaries of the law, and challenges with applying 404 to this environment, the permit process was arduous. In many cases, continued operations were allowed only via time extensions or other tactics that significantly curtailed operations but did not necessarily shut down the mining activity.

Rock products trade organizations filed a lawsuit in Washington District court against the US Army Corps of Engineers. In part, the lawsuit challenged the authority the Corps had to regulate excavation activities, since Section 404 is based on the placement of fill. The Corps had premised their authority on the fact that even an excavation process will cause the disturbance of adjacent material or that spillage in the process constituted a fill (incidental fall back). The Court ruled in favor of the rock products association, determining that the incidental fall back definition was not proper.

Recently the Corps has reissued regulations related to what constitutes "incidental fallback". Based on recent conversation with Arizona Staff of the Corps of Engineers, it is believed that excavation activities are once more regulated under Section 404.

MANAGEMENT APPROACHES

Development of the watercourse master plan has been premised on the District adopting a management strategy associated with in-stream mining activities. It is recommended that the management strategy include provisions requiring that mining activities cause No Adverse Impact. The decision making process was being guided, in part, by sand and gravel policy investigations independent of this master plan. To date, these investigations have not yielded a clear direction. In order to finalize the master plan, it is necessary for the District to adopt a management strategy.

A principal concern relates to the potential public cost of installing structures or other works to correct conditions either created by past mining activities or allow future

extraction. To date, a key component of this watercourse master plan is that capital expenditures without broad public benefits should not be considered if it results in a windfall to private interests, or lead to significant long term operational costs for public entities.

In order to implement the components of the Master Plan, it will be necessary for the District to adopt a management strategy. Three alternative management strategies toward in-stream sand and gravel mining were considered as part of the master planning process. The alternative strategies are outlined below.

NO CHANGE STRATEGY

The No Change Strategy proposes to allow sand and gravel operators to extract sand and gravel based on the design assumptions currently employed. However, erosion and lateral migration analyses completed in conjunction with the Master Plan indicate it is not likely that mine operators will be able to limit the cumulative impact of their activities to their property. Significant degradation of the riverbed is anticipated. Due to the sporadic spacing and random depth of pits, it is not practical to assume that grade control structures can be implemented in any meaningful fashion since it is not feasible to control mining activities between pits. This plan assumes that the existing bridges north of Camelback Road and south of the CAP Canal ultimately will be replaced, and that bank stabilization for the entire reach of the floodplain would need to be constructed. These actions are anticipated more on a demand basis rather than on a programmed basis.

Estimated Cost: $140,000,000

NO ADVERSE IMPACT STRATEGY

The No Adverse Impact Strategy is premised on truly limiting the impact of mining operations to the boundary of the property being mined. The strategy would be implemented when mine owners attempt to renew their Floodplain Use Permits. In order to renew the permit, a mine owner would have to show that the engineering design of the pit limits the impact of the 100-year storm to his property boundary.

It is anticipated that this strategy will lead to movement of the mining activities away from the floodway; mitigation of reflective erosion; construction of protective works to separate mines from the river; and incorporation of features that would allow mine pits to drown out during major floods to replace channel storage.

Mining within the floodway is expected to be extremely limited. The LA District of the U.S. Army Corps of Engineers published *Sand and Gravel Mining Guidelines, 1987*, to provide recommendations related to in-stream mining near Corps structures. These include:

- Incorporation of set back from bridges and utilities of 500 feet, and maximum pit depths no deeper than that allowed by a 1% slope (a pit initiated 500 feet downstream from the structure would be no deeper than 10 feet deep at a point 1,000 feet downstream from the bridge or utility).
- Pit depths would not be lower than the existing thalweg elevation.
- Pits would be set back from channel banks 500 feet, and pit depths would be limited to being no deeper than a 10:1 slope as measured from the setback.
- Mining operations should be continuous and not be set up to promote skipping over land areas.

It is anticipated that similar guidelines will be adopted to minimize riverbed degradation due to mining, providing the floodway boundary line is equivalent to the bank line.

Mine owners would be expected to provide the infrastructure necessary to limit mining impacts to their property line. However, the current state of the river indicates that grade stabilization will be required to arrest further degradation of the riverbed. A grade control structure is recommended downstream from the Olive Road Bridge to protect the existing bridge and utility crossings. The structure could be programmed into the District's construction budget based on project priority.

Miners are not currently required to isolate mine pits from the floodway with engineered levees. Adding this requirement would increase the capital improvements required to operate a mine. In order to offset this cost increase, it is proposed that the District pursue a river-wide 404 Permit from the Corps. The permit would encompass the entire reach from New Waddell Dam to the confluence of the Gila River. The District would then assist individual miners to obtain site-specific 404 Permits for their mines.

Estimated Cost $2,000,000

RIVER CHANNELIZATION STRATEGY

The River Channelization Strategy is premised on restricting the Agua Fria floodplain to a constructed channel. The channel would be approximately 800 feet wide, stabilized with rip-rap, and include a 150-foot wide bench that could be used for linear recreation features and buffering. Excavated materials from the channel either could be moved onto the immediate overbank, minimizing haul costs, or could be dumped into existing

sand and gravel pits for future processing and sale. While the sale of the material may lead to some potential financial return, the reality is that an extended haul distance would quickly exceed the return on the raw material. Sand and gravel mining would then be excluded from the channel. Sand and gravel mining activities outside of the channel would be set back a distance of 200 feet with a pit depth not exceeding a depth of 5:1 as measured from the set back in accordance with the Corps *Guidelines*. The *Guidelines* suggest that pit depth would be limited to the depth of the thalweg although this is not totally clear. Limiting excavation depth to the thalweg appears to be very conservative in this channel configuration.

Estimated Cost: $186,000,000 to $248,000,000

IMPACTS ON RIVER BASED FUNCTIONS AND WATERCOURSE MASTER PLAN

Flood Control

The No Change Strategy significantly alters the philosophy of the watercourse master plan by causing the District to be reactive to damages. The No Change Strategy bears a huge hidden cost related to litigation and legal actions associated with damage. Extensive erosion or lateral migration may occur during a single storm event. This may result in localized damages if mitigation measures have not been put in place before the storm.

The River Channelization Strategy provides the most consistent means of flood control. It also allows continued sand and gravel mining in the areas "reclaimed" from the floodplain. The principal drawback to this strategy is that it will encourage development of the "reclaimed" land. This could significantly increase disaster costs for a flood event that just exceeds the design capacity of the channel. Additional disadvantages of this strategy are the significant construction cost and the highest annual maintenance cost of the strategies considered.

The No Adverse Impact Strategy provides the least cost solution but also brings with it a degree of uncertainty as to the timing and phasing of sand and gravel extraction within the floodplain.

Environmental and Cultural

The vegetation and habitat in the reach between CAP Canal and Camelback Road is highly impacted due to existing mines and lack of water. Cultural sites are primarily located in overbank areas outside the floodplain.

The No Change Strategy would most likely lead to individual permits for most sand and gravel sites. There are some areas with limited riparian value in and around the El Mirage wastewater treatment plant that may be impacted with the No Change Strategy.

The River Channelization Strategy would most likely require miners to obtain a 404 permit. In other parts of the Valley, the Corps has been reluctant to provide 404 clearance for projects that appear to open land for development.

The No Adverse Impact Strategy would most likely have environmental impacts similar to the No Change Strategy.

Recreation

The primary recreational feature promoted in the watercourse master plan is a multi-purpose trail that can be used for maintenance, hiking, and other uses. Parks considered in the plan were those that are proposed by local jurisdictions, In most cases, these parks are located in the outer portions of the flood fringe and least prone to impact.

As part of the master plan, a preliminary alignment was identified for the multi-purpose trail. Alignment of the trail in and around sand and gravel mines raises significant concerns. Locating a recreational trail near haul roads and mine pits may create an unacceptable liability. The No Change Strategy does not solve the issues of alignment, and leaves trail improvements prone to damage with a degrading river. The No Change Strategy would further suggest that the District must move quickly to secure land rights for an alignment, or the potential for finding an adequate alignment will be severely diminished.

The River Channelization Strategy provides the best opportunity for a secured right-of-way and a linear connector for this reach. However, it also presents challenges for establishing staging areas and connector trails to the main channel. The proposed channel configuration includes a 150-foot wide bench that may be too narrow to accommodate both hiking/biking and horse trails. One option would be to have horse trails be in the bottom of the channel, providing both horizontal and vertical separation between users. This configuration brings

with it the highest need for incorporating flood safety components in the plan such as warning systems and flash flood egress points.

The No Adverse Impact Strategy allows for acquisition of a trail alignment, but it shares the same concerns associated with the No Change Strategy. However, unlike the No Change Strategy a relatively undisturbed floodway will ultimately be in place, perhaps providing an opportunity for unimproved trails for hiking and horseback riding. However, this reach is not an area where recreational hiking for the scenic beauty is anticipated. Hence, an unimproved trail will not serve the needs of those using the trail as a mode of transportation to other locations.

Visual Character

The lower and middle sections of this reach are dominated by industrial activity such as sand and gravel mining. Residential development is beginning to encroach the edges of the floodplain. Most of the development has treated the river as a "back door" amenity and have not considered treatments that would enhance the view of these developments from the river. Near Jomax Road, the river transitions into a somewhat less disturbed area with interesting land forms, lush vegetation, and panoramic views.

The No Change Strategy would ultimately lead to a significantly altered landscape in this reach. It is unclear to what extent the District will be able to protect the visual character of the river through enforcement of meaningful reclamation plans.

The River Channelization Strategy provides the best opportunity for enhancing the visual character of the river with landscaping. The use of setbacks and landscaping buffers may provide a sense of separation from the urban and industrial environment around the channel. However, this option also has the potential to isolate recreational users from the panoramic views that currently are possible.

Preserving the visual character in the No Adverse Impact Strategy would be dependent on securing the right-of-way for the multi-purpose trail.

Groundwater Recharge

There is significant discussion related to the creation of ground water recharge facilities in the Agua Fria River. Water sources include effluent as well as CAP and SRP canal water. In the northern reach, a recharge facility is currently under construction by CAP.

The No Change Strategy implies operational challenges to the operators of recharge facilities. Conveyance channels as well as recharge basins may be prone to significant degradation as the channel lowers.

The River Channelization Strategy may or may not provide opportunities to locate recharge facilities in the river. The low flow channel may be used to convey water to a recharge basin, but the channel bottom may be too low drain directly into the basin. It may be possible to design upstream diversion structures that would allow for a gravity drain or use pumps to lift the water into the recharge basins. In either case, an in channel headwork of some type would be required to stop, pond and divert the water. This type of standing water feature may be desirable in that it provides amenities for other users. However, if these features are in or around the areas of existing sand and gravel operations it may lead to ground water seepage into the pits.

The No Adverse Impact Strategy provides a level of protection to recharge facilities, although special considerations are necessary to convey flows past the proposed grade control features. The presence of recharge water within the river will most likely lead to more vegetation growing upstream of the grade control structures. This should be considered in the overall design and maintenance of the recharge facility.

Erosion Setbacks and Fluvial Geomorphology

The No Change Strategy will have the most dramatic impact on the geomorphology, leading to significant degradation with the potential for wider ultimate erosion setbacks.

The River Channelization Strategy provides the opportunity to contain the river for the design event, leading to less chance for avulsions and leading to a decrease or perhaps elimination of the severe erosion set back line. However, it should be recognized that in events larger than the design storm, the potential exists for the river to recapture historic floodplain areas.

The No Adverse Impact Strategy presents the most significant implementation challenges. Pits that occur within the fringe will need to be evaluated for reflective erosion and designed so that drown out features do not create a secondary erosive current in the pit that can lead to damage. Additionally, the No Adverse Impact Strategy will also require the most in-depth investigations related to appropriate flood way activities.

Public Concerns

Many of the pubic concerns have been related to non-flood impacts of sand and gravel (noise, dust, and proximity to haul roads). None of the options presented effectively address these issues since they fall so far outside the Districts authority. There has been strong support from the public to take steps to minimize public expenditures for capital improvements and maintenance activities. Hence, in the event that an option such as a channel were pursued, it will be necessary to form a strong public/private partnership that balances costs with benefits derived. The No Change Strategy would not address non-authority issues, would not address additional degrading of the river, and over time, would result in additional expenditures of public dollars to replace or reinforce damaged and threatened infrastructure.

The River Channelization Strategy represents a significant public expense but also brings with it non-flood benefits associated with recreational opportunities, and perhaps enhanced aesthetics as compared to the No Change Strategy. The solution does not directly address sand and gravel mining, but this strategy may attract alternative development.

The No Adverse Impact Strategy is the least costly alternative, but would not provide for multi-use opportunities near mines. Perhaps when sand and gravel mining ceases or the pits are reclaimed, there may be future opportunities for multi-use.

Aggregate Mining

The citizens and visitors to Maricopa County, as well as the sand and gravel industry, have all benefited from having quality, affordable rock products available for all facets of construction. At the same time, aggregate mining within floodplains has the potential to cause adverse impacts to public infrastructure and to private property.

Short-term economics would suggest that a No Change Strategy might be in the best interest of the industry and the Valley. However, a longer-term vision would suggest that continued operation in the floodplain may become dependent on modifications of standard practices that ensure that flood related impacts associated with sand and gravel mining are contained "on-site."

The economics surrounding sand and gravel mining are not necessarily complex, but they are important to understand. Informal telephone surveys for five southwest markets were conducted to obtain information regarding the pricing of rock product materials. The markets surveyed were Phoenix, El Paso, Las Vegas, Albuquerque, and Santa Fe. It was confirmed that mining occurs outside of the watercourse in both Las Vegas and El Paso. In Albuquerque and Santa Fe, it was not possible to confirm that mining predominantly occurs outside the watercourse, but inspection of aerial photographs near the operations would suggest that mining is not occurring in the watercourse. Due to differences in cost of living and associated factors, it was not thought reasonable to directly compare prices, so the prices were adjusted utilizing construction adjustment factors published by (Building News General Construction 2000 Cost Book). In general, ready-mix concrete prices were quite comparable between communities, however Phoenix prices for aggregate and rip-rap were significantly lower than other southwest markets.

The No Change Strategy may be in the best short-term interest of individual operators, but it is anticipated some will face additional scrutiny for 404 permits. Based on past flood events, it is possible that damages will be sought via legal actions against miners for future impacts to bridges, infrastructure, and private property. In the long-term, the No Change Strategy introduces significant uncertainty into the business side of mining operations.

The River Channelization Strategy would be the best method for allowing continued sand and gravel mining, while meeting flood control objectives for controlling adverse impacts; providing that a public/private partnership can be formed for implementation. Approached as a project, it also would have the lowest degree of uncertainty since it would not necessarily rely on regulatory implementation. The advantage to the rock product industry is that is would virtually eliminate concerns related to 404 permits or floodplain use permits. Set backs proposed by the Corps and limits to mining depth outside the project may be difficult if not impossible, to enforce unless some type of easement were perfected.

The No Adverse Impact Strategy may strike the best balance of cost, and continued ability to mine within the floodplain. There will be additional up-front costs associated with mining operations, but these costs should not be overly burdensome. Due to the nature of the industry, miners have the personnel, equipment and the materials readily available to allow them to construct protective works at an overall lower cost. On the positive side, this proposal would greatly enhance the feasibility for deep mines, while reducing pit exposure to flood damages.

RECOMMENDATIONS

Based on the work of the Agua Fria Watercourse Master Plan, it is recommended that the District pursue implementation of the No Adverse Impact Strategy. The NAI strategy allows continued mining of the floodplain, benefiting both the public and the mining industry. During the development of the Watercourse Master Plan, two fundamental philosophies have guided many important decisions. These philosophies are:

- Do not use public funds to subsidize private enterprise or private development.
- Do not encourage uses of the floodplain that tend to create future flood/erosion problems.

Implementation of the NAI strategy requires mines to be protected by levees constructed by the owners/operators. The levees would be engineered to isolate pits from flood flows below the 50-year storm and allow the pits to drown-out during storms that exceed the 50-year storm. The pits are allowed to drown-out in larger storms to replace the channel storage found in the existing floodplain. Without the drown-out feature, the encroachment of the floodplain would lead to higher peak flows within the river system.

The following figures and tables are needed to set weir and levee elevations, calculate storage volume in the existing floodplain and calculate weir lengths. An electronic version of the HEC-RAS model used to calculate these water surface elevations may be found on the compact disk included with this report.

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Gila River Confluence to Broadway Road Alignment

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
37,000	0.16	909.6	915.86	917.43	1.57
37,000	0.25	910.9	917.4	918.95	1.55
37,000	0.35	911.4	918.97	920.42	1.45
37,000	0.44	912.8	920.38	921.78	1.40
37,000	0.54	913.7	921.34	922.91	1.57
37,000	0.63	915.7	922.76	924.15	1.39
37,000	0.73	916.9	924.1	925.54	1.44
37,000	0.83	917.3	925.27	926.60	1.33
37,000	0.92	919.3	926.32	927.63	1.31
37,000	1.01	921.2	927.24	928.70	1.46
37,000	1.1	922.5	928.12	929.60	1.48
37,000	1.17	923.6	929.05	930.64	1.59
37,000	1.25	924.4	930.33	931.91	1.58
37,000	1.33	925.5	932.42	933.79	1.37

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Broadway Road Alignment to MC 85

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
37,000	1.4	927.1	933.54	935.10	1.56
37,000	1.48	926.7	935.37	936.68	1.31
37,000	1.56	926.1	935.86	937.34	1.48
37,000	1.64	927.9	936.09	937.70	1.61
37,000	1.71	928.2	936.38	938.00	1.62
37,000	1.79	929.2	936.79	938.42	1.63
37,000	1.87	931.1	937.43	938.91	1.48
37,000	1.94	932.3	938.44	939.77	1.33
37,000	2.02	932.7	939.32	940.57	1.25
37,000	2.1	934.3	940.16	941.60	1.44
37,000	2.18	934.4	941.07	942.54	1.47
37,000	2.25	935	941.99	943.43	1.44
37,000	2.33	936.2	943.26	944.82	1.56
37,000	2.41	937.4	944.19	945.89	1.70
37,000	2.51	938.7	945.29	946.90	1.61
37,000	2.6	939.6	946.26	947.83	1.57
37,000	2.7	940.4	947.33	948.64	1.31
37,000	2.8	942	948.05	949.27	1.22
37,000	2.89	942.9	948.66	949.83	1.17
37,000	2.99	942.3	949.27	950.44	1.17
37,000	3.08	942.5	949.78	950.94	1.16
37,000	3.18	943.4	950.23	951.37	1.14
37,000	3.27	944.5	950.97	952.07	1.10
37,000	3.37	943.4	951.86	952.94	1.08
37,000	3.4	945.1	951.92	952.76	0.84
37,000	3.43	946	953.85	954.80	0.95
37,000	3.47	946.1	954.39	955.39	1.00
37,000	3.55	948	955.37	956.42	1.05
37,000	3.64	948.8	956.88	957.90	1.02
37,000	3.69	951	957.85	958.99	1.14
37,000	3.729	952.2	959.26	960.53	1.27
37,000	3.734	952.3	959.28	960.55	1.27
Bridge	3.7405	952.3	959.35	960.62	1.27
37,000	3.747	952.3	959.43	960.74	1.31
37,000	3.757	952.1	959.46	960.76	1.30

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

MC 85 to I-10					
50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
37,000	3.767	952.9	959.45	960.75	1.30
Bridge	3.7685	952.9	959.5	960.74	1.24
37,000	3.77	952.9	959.63	960.98	1.35
38,000	3.78	952.9	959.69	961.05	1.36
38,000	3.8	953.1	959.8	961.16	1.36
38,000	3.81	953.3	959.8	961.14	1.34
38,000	3.83	952.8	960.07	961.45	1.38
38,000	3.93	953.5	960.5	961.87	1.37
38,000	4.02	953.9	961.01	962.39	1.38
38,000	4.04	954.5	961	962.35	1.35
38,000	4.06	954.9	961.25	962.63	1.38
38,000	4.092	955.2	961.43	962.80	1.37
38,000	4.094	958.5	961.83	962.61	0.78
38,000	4.16	957.2	964	965.04	1.04
38,000	4.26	957	964.67	965.75	1.08
38,000	4.27	957.1	964.79	965.87	1.08
38,000	4.3	957.6	965.05	966.19	1.14
38,000	4.39	957.6	965.59	966.77	1.18
38,000	4.48	957.8	966.1	967.33	1.23
38,000	4.5	957.8	966.16	967.38	1.22
38,000	4.52	958	966.3	967.57	1.27
38,000	4.6	958.1	966.66	967.95	1.29
38,000	4.7	959.1	967.06	968.36	1.30
38,000	4.754	960.3	967.33	968.66	1.33
Bridge	4.7565	960.3	967.4	968.68	1.28
38,000	4.759	960.3	967.46	968.81	1.35
38,000	4.79	961.1	967.36	968.71	1.35
38,000	4.89	961.8	968.72	969.88	1.16
38,000	4.98	962.8	969.72	970.87	1.15
38,000	5	963.4	969.83	970.97	1.14
38,000	5.02	964.1	969.94	971.10	1.16
38,000	5.1	965.2	970.71	971.78	1.07
38,000	5.15	967.4	971.61	972.48	0.87
38,000	5.201	969.1	973.14	973.91	0.77
38,000	5.203	970	972.85	973.52	0.67
38,000	5.25	970.2	974.9	975.63	0.73
38,000	5.27	970.7	975.32	976.04	0.72
38,000	5.29	971.5	976.1	976.99	0.89
Bridge	5.2975	971.5	976.2	977.14	0.94
38,000	5.305	971.5	976.36	977.29	0.93

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

I-10 to Thomas Road					
50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
39,000	5.317	971.7	976.43	977.34	0.91
Bridge	5.3225	971.7	976.5	977.49	0.99
39,000	5.328	971.7	976.67	977.64	0.97
39,000	5.38	971.4	977.07	978.03	0.96
39,000	5.48	972.7	978.49	979.52	1.03
39,000	5.51	972.7	978.76	979.64	0.88
39,000	5.54	972.6	979.11	980.20	1.09
39,000	5.65	972.9	979.68	981.63	1.95
39,000	5.689	973.85	980.29	982.10	1.81
Bridge	5.6945	973.85	980.3	982.13	1.83
39,000	5.7	973.85	980.41	982.21	1.80
39,000	5.75	973.7	980.65	982.39	1.74
39,000	5.77	973.5	980.82	982.48	1.66
39,000	5.79	974.6	981.1	982.68	1.58
39,000	5.81	974.6	981.8	983.32	1.52
39,000	5.9	975.4	982.55	983.98	1.43
39,000	5.99	975.5	983.39	984.75	1.36
39,000	6.07	976.7	984.06	985.39	1.33
39,000	6.16	979.1	984.81	986.12	1.31
39,000	6.26	980.2	985.7	986.94	1.24
39,000	6.35	980.5	986.93	988.10	1.17
39,000	6.43	981	987.88	989.00	1.12
39,000	6.52	981.5	989.16	990.38	1.22
39,000	6.54	982.4	989.09	990.28	1.19
39,000	6.56	982.1	989.52	990.79	1.27
39,000	6.59	981.8	989.82	991.11	1.29
39,000	6.61	981.8	989.77	991.05	1.28
39,000	6.64	982.4	990.18	991.51	1.33
39,000	6.66	982.2	990.29	991.61	1.32
39,000	6.69	982.2	990.66	991.98	1.32
39,000	6.71	981.5	990.8	992.12	1.32
39,000	6.73	982.4	990.95	992.30	1.35
39,000	6.77	985.1	990.73	991.89	1.16
39,000	6.79	984.3	992.07	992.94	0.87
39,000	6.82	984.8	992.66	993.73	1.07
39,000	6.89	989.4	993.13	994.18	1.05
39,000	6.91	989.5	994.09	994.81	0.72
39,000	6.93	989.9	995.03	996.11	1.08
39,000	6.97	990.4	995.54	996.63	1.09

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Thomas Road to Camelback Road

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
39,000	6.99	990.2	995.57	996.59	1.02
39,000	7.02	989.1	996.46	997.62	1.16
39,000	7.06	989.6	996.8	997.96	1.16
39,000	7.08	990.5	996.95	998.08	1.13
39,000	7.1	990.9	997.2	998.35	1.15
39,000	7.2	990.7	998.6	999.80	1.20
39,000	7.29	993.2	999.28	1000.48	1.20
39,000	7.39	993.8	1000.47	1001.69	1.22
39,000	7.49	995.2	1001.34	1002.60	1.26
39,000	7.58	995.4	1002.25	1003.56	1.31
39,000	7.67	994.3	1002.96	1004.39	1.43
39,000	7.77	996.1	1003.23	1004.69	1.46
39,000	7.87	997.4	1003.83	1005.28	1.45
39,000	7.96	998.6	1004.51	1005.97	1.46
39,000	7.99	999.1	1004.73	1006.18	1.45
39,000	8	999.2	1004.86	1006.32	1.46
Bridge	8.005	999.2	1005	1006.37	1.37
39,000	8.01	999.2	1005.13	1006.61	1.48
39,000	8.03	999.2	1004.78	1006.34	1.56
39,000	8.105	1000.5	1006.36	1007.43	1.07
39,000	8.198	1001.5	1007.3	1008.37	1.07
39,000	8.325	1002.1	1009.06	1010.02	0.96
39,000	8.433	1005	1011.12	1012.10	0.98
39,000	8.534	1010	1013.75	1015.13	1.38
39,000	8.646	1010.6	1015.48	1016.69	1.21
39,000	8.768	1008.4	1016.81	1018.14	1.33
39,000	8.875	1009.1	1019.01	1020.06	1.05
39,000	8.992	1008.1	1020.79	1021.82	1.03
39,000	9.098	1009.9	1021.5	1022.62	1.12
39,000	9.177	1010.4	1022	1023.12	1.12

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Camelback Road to Bethany Home Road

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
39,000	9.191	1010.7	1022.03	1023.17	1.14
39,000	9.198	1011.1	1022.06	1023.19	1.13
39,000	9.266	1013.7	1022.73	1023.82	1.09
39,000	9.343	1014.4	1023.47	1024.53	1.06
39,000	9.435	1015.2	1024.45	1025.47	1.02
39,000	9.519	1016.3	1025.38	1026.40	1.02
39,000	9.605	1018.7	1026.5	1027.50	1.00
39,000	9.696	1018.7	1027.71	1028.76	1.05
23,000	9.79	1019.5	1028.59	1030.49	1.90
23,000	9.885	1021.1	1029.66	1031.02	1.36
23,000	9.981	1022.8	1031.25	1032.14	0.89
23,000	10.071	1024.9	1032.31	1033.25	0.94
23,000	10.167	1023.3	1033.28	1034.23	0.95
23,000	10.265	1026.4	1033.95	1034.82	0.87
23,000	10.343	1026.7	1035.74	1036.67	0.93

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Bethany Home Road to Northern Avenue

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
23,000	10.442	1029.4	1037.82	1039.14	1.32
23,000	10.538	1031.2	1038.94	1040.40	1.46
23,000	10.632	1031.7	1039.74	1041.10	1.36
23,000	10.752	1031.3	1040.93	1042.13	1.20
23,000	10.846	1031.6	1042.23	1043.34	1.11
23,000	10.942	1034.2	1043.39	1044.53	1.14
23,000	11.029	1034.7	1044.12	1045.30	1.18
23,000	11.128	1036.1	1044.82	1046.11	1.29
23,000	11.224	1038.1	1045.26	1047.06	1.80
23,000	11.325	1039.4	1046.76	1048.31	1.55
23,000	11.41	1041.8	1050.82	1051.84	1.02
Bridge	11.419	1041.8		1053.30	
23,000	11.428	1041.8	1052.26	1053.38	1.12
26,500	11.46	1041.3	1052.45	1053.53	1.08
26,500	11.557	1041.7	1054.09	1054.85	0.76
26,500	11.653	1043.1	1054.63	1057.41	2.78
26,500	11.75	1043.2	1057.09	1058.84	1.75
26,500	11.847	1044.6	1059.69	1061.16	1.47
26,500	11.9	1045.2	1059.89	1061.40	1.51
26,500	11.943	1046.7	1061.16	1063.22	2.06
26,500	12.042	1048.5	1062.88	1064.60	1.72
26,500	12.141	1049.3	1063.78	1065.39	1.61
26,500	12.247	1050.7	1064.64	1066.10	1.46
26,500	12.359	1051.7	1065.1	1066.51	1.41
26,500	12.42	1054	1065.34	1066.75	1.41

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Northern Avenue to Peoria Avenue Alignment

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
26,500	12.47	1054.9	1065.42	1066.82	1.40
26,500	12.529	1056.1	1065.54	1066.94	1.40
26,500	12.63	1056.2	1065.84	1067.17	1.33
26,500	12.725	1056.6	1066.15	1067.66	1.51
26,500	12.816	1057.4	1066.93	1068.28	1.35
26,500	12.913	1058.6	1068.16	1069.30	1.14
26,500	13.007	1062	1069.53	1070.55	1.02
26,500	13.103	1062.5	1071.45	1072.72	1.27
26,500	13.2	1063	1072.35	1073.72	1.37
26,500	13.296	1063.5	1072.9	1074.33	1.43
26,500	13.395	1064	1073.37	1074.84	1.47
26,500	13.45	1063.8	1074.32	1075.61	1.29
Bridge	13.4585	1064		1075.61	
26,500	13.467	1064.1	1074.35	1075.64	1.29
26,500	13.518	1064.2	1074.76	1075.94	1.18
26,500	13.565	1065.8	1076.3	1077.28	0.98
26,500	13.663	1065.7	1078.44	1079.39	0.95
26,500	13.76	1067.9	1080.24	1081.24	1.00
26,500	13.856	1071.2	1081.56	1082.58	1.02
26,500	13.952	1073.3	1082.84	1083.75	0.91
26,500	14.049	1074.5	1085.1	1085.84	0.74
26,500	14.145	1076.9	1086.76	1087.55	0.79
26,500	14.24	1080.3	1087.94	1088.74	0.80
26,500	14.335	1079.8	1089.4	1090.25	0.85
26,500	14.43	1083.2	1090.93	1091.83	0.90
26,500	14.525	1083.2	1092.18	1093.19	1.01

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Peoria Avenue Alignment to Grand Avenue

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
26,500	14.619	1086.3	1093.25	1094.20	0.95
26,500	14.708	1088.4	1095.11	1095.85	0.74
26,500	14.809	1087.1	1096.54	1097.43	0.89
26,500	14.905	1088.6	1097.8	1098.81	1.01
26,500	15	1088.8	1098.58	1099.75	1.17
26,500	15.094	1089.9	1099.72	1101.20	1.48
26,500	15.188	1089	1101.01	1102.10	1.09
26,500	15.281	1092.6	1102.44	1103.40	0.96
26,500	15.374	1093.8	1104.11	1105.02	0.91
26,500	15.469	1095.2	1106.48	1107.73	1.25
26,500	15.564	1096.2	1107.45	1108.76	1.31
26,500	15.658	1097.1	1108.51	1109.77	1.26
26,500	15.719	1093.7	1109.11	1110.39	1.28
26,500	15.814	1094.4	1109.93	1111.20	1.27
26,500	15.909	1097.8	1111.33	1112.57	1.24
26,500	16.004	1099.7	1112.03	1113.32	1.29
26,500	16.099	1100.8	1112.43	1113.62	1.19
26,500	16.195	1100.8	1112.83	1114.21	1.38
26,500	16.289	1100.8	1113.67	1115.12	1.45
26,500	16.385	1103.7	1114.64	1115.57	0.93
29,000	16.471	1105.4	1117.88	1119.31	1.43
29,000	16.482	1105.6	1118.43	1119.83	1.40
Bridge	16.494	1105.5		1119.83	

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Grand Avenue to Bell Road

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
29,000	16.506	1105.4	1118.62	1120.02	1.40
29,000	16.514	1105.7	1118.52	1119.87	1.35
Bridge	16.516	1105.7		1119.61	
29,000	16.518	1105.7	1120.23	1121.55	1.32
29,000	16.612	1108.3	1121.13	1122.46	1.33
29,000	16.707	1109.7	1122.08	1123.45	1.37
29,000	16.801	1108.9	1123.03	1124.39	1.36
29,000	16.895	1109.8	1123.75	1125.22	1.47
29,000	16.99	1110.9	1124.57	1126.03	1.46
29,000	17.085	1111.5	1125.64	1127.15	1.51
29,000	17.18	1112.2	1126.7	1128.18	1.48
29,000	17.277	1113.7	1128.08	1129.6	1.52
29,000	17.37	1115.2	1128.42	1130.07	1.65
29,000	17.458	1116.5	1128.79	1130.51	1.72
29,000	17.548	1122	1129.39	1131.05	1.66
29,000	17.638	1130	1133.39	1134.12	0.73
29,000	17.73	1130	1137.52	1138.53	1.01
29,000	17.821	1130	1138.91	1140.02	1.11
29,000	17.91	1130	1139.7	1141.12	1.42
29,000	18	1130	1140.08	1141.60	1.52
29,000	18.093	1130.1	1140.62	1142.14	1.52
29,000	18.182	1129.8	1141.44	1142.83	1.39
29,000	18.275	1130.1	1142.66	1143.87	1.21
29,000	18.369	1134.4	1144.42	1145.31	0.89
29,000	18.464	1138.5	1146.91	1148.18	1.27
29,000	18.558	1142.1	1148.47	1150.01	1.54
29,000	18.653	1143	1150.11	1151.51	1.40
29,000	18.748	1143.5	1151.69	1152.77	1.08
29,000	18.839	1144.6	1153.15	1154.19	1.04
29,000	18.937	1146.8	1154.22	1155.31	1.09
29,000	18.962	1147.3	1154.4	1155.48	1.08
Bridge	18.97	1147.5	1154.4	1155.48	1.08

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Bell Road to Beardsley Road Alignment

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
27,000	18.978	1147.6	1154.44	1155.54	1.10
27,000	19.066	1149.4	1155.71	1156.76	1.05
27,000	19.162	1150.9	1157.65	1158.55	0.90
27,000	19.256	1153.6	1159.72	1160.57	0.85
27,000	19.352	1154.6	1162.31	1163.44	1.13
27,000	19.446	1155.9	1163.45	1164.66	1.21
27,000	19.542	1157	1164.61	1165.77	1.16
27,000	19.635	1159.1	1165.96	1167.17	1.21
27,000	19.732	1160.9	1167.36	1168.61	1.25
27,000	19.827	1163.2	1169.09	1170.33	1.24
27,000	19.92	1164	1170.55	1171.75	1.20
27,000	20.015	1166.1	1171.87	1172.98	1.11
27,000	20.111	1166.8	1173.42	1174.50	1.08
27,000	20.207	1167.2	1174.73	1175.89	1.16
27,000	20.294	1166.7	1175.97	1177.37	1.40
27,000	20.343	1168.7	1176.63	1177.93	1.30
27,000	20.388	1168.9	1177.26	1178.46	1.20
27,000	20.435	1168.8	1178.12	1179.31	1.19
27,000	20.483	1169.8	1179.17	1180.38	1.21
27,000	20.579	1171.9	1180.54	1182.04	1.50
27,000	20.675	1171.3	1182.02	1183.66	1.64
25,410	20.769	1173.1	1183.48	1185.40	1.92
25,410	20.864	1176	1184.26	1186.13	1.87
25,410	20.958	1176.6	1185.28	1187.06	1.78
25,410	21.061	1176.5	1186.34	1188.15	1.81

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Beardsley Road Alignment to Pinnacle Peak Road Alignment

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
25,410	21.157	1176.6	1188.04	1189.87	1.83
25,410	21.245	1184	1189.07	1190.70	1.63
25,410	21.337	1180	1189.97	1191.59	1.62
25,410	21.431	1181	1189.96	1191.75	1.79
25,410	21.524	1182	1192.33	1193.63	1.30
25,410	21.621	1182.5	1192.91	1194.29	1.38
25,410	21.716	1183.1	1193.21	1194.59	1.38
25,410	21.798	1188	1194.87	1196.35	1.48
25,410	21.893	1187.4	1197.51	1198.55	1.04
25,410	21.986	1191.8	1199.75	1200.79	1.04
25,410	22.082	1194.9	1200.96	1202.19	1.23
25,410	22.177	1196	1201.41	1203.12	1.71
25,410	22.273	1197.6	1203.65	1204.73	1.08
23,960	22.368	1198.5	1205.6	1206.64	1.04
23,960	22.462	1200.3	1206.73	1207.70	0.97
23,960	22.558	1203.4	1208.34	1208.95	0.61
23,960	22.651	1204.9	1210.99	1211.65	0.66
23,960	22.745	1206.3	1212.32	1213.01	0.69
23,960	22.839	1208.7	1213.93	1214.64	0.71
23,960	22.935	1209.5	1215.18	1215.86	0.68
23,960	23.029	1211.8	1216.64	1217.26	0.62
23,960	23.124	1213.9	1218.82	1219.36	0.54
23,960	23.219	1214.7	1220.55	1221.16	0.61
23,960	23.314	1216.1	1222.56	1223.11	0.55
23,960	23.409	1218.8	1224.85	1225.65	0.80

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Pinnacle Peak Road Alignment to Jomax Road

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
23,960	23.504	1220.8	1226.6	1227.88	1.28
23,960	23.598	1221.4	1228.02	1229.30	1.28
23,960	23.692	1223.8	1229.73	1230.73	1.00
22,510	23.79	1224.2	1232.04	1233.48	1.44
22,510	23.881	1225.1	1233.26	1234.94	1.68
22,510	23.974	1227.5	1235.24	1236.86	1.62
22,510	24.067	1229.3	1236.89	1238.34	1.45
22,510	24.165	1231.4	1237.75	1239.10	1.35
22,510	24.212	1231.3	1238.17	1239.45	1.28
22,510	24.26	1231.7	1238.65	1239.86	1.21
22,510	24.353	1233.6	1239.48	1240.59	1.11
22,510	24.449	1235	1240.87	1241.69	0.82
22,510	24.543	1237.6	1242.93	1243.76	0.83
22,510	24.631	1239.8	1244.72	1245.57	0.85
22,510	24.721	1241.1	1246.67	1247.61	0.94
22,510	24.816	1241.8	1248.38	1249.47	1.09
22,510	24.91	1244.7	1250.06	1251.25	1.19
22,510	24.996	1246.3	1251.69	1252.87	1.18
22,510	25.098	1249.7	1254.07	1255.16	1.09
21,060	25.192	1250	1255.78	1256.79	1.01
21,060	25.288	1251.3	1257.25	1258.05	0.80
21,060	25.382	1253.7	1259.1	1259.82	0.72
21,060	25.478	1253.9	1260.6	1261.33	0.73
21,060	25.526	1253.7	1261.66	1262.51	0.85
21,060	25.572	1254.7	1262.15	1262.84	0.69
21,060	25.666	1255.4	1263.26	1264.48	1.22

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Jomax Road to Dixileta Drive Alignment

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
21,060	25.691	1258	1264.59	1265.96	1.37
21,060	25.72	1257.8	1266.01	1266.77	0.76
21,060	25.79	1258.8	1267.63	1268.96	1.33
21,060	25.86	1260	1267.97	1269.69	1.72
21,060	25.94	1264.2	1271.52	1272.20	0.68
21,060	26.03	1266.3	1273.65	1275.08	1.43
21,060	26.12	1267.6	1274.73	1276.26	1.53
21,060	26.2	1269.2	1276.32	1277.69	1.37
21,060	26.29	1271.6	1278.54	1280.03	1.49
21,060	26.37	1271.9	1280.15	1281.51	1.36
19,610	26.47	1275.3	1281.59	1283.09	1.50
19,610	26.55	1276.6	1283.36	1284.77	1.41
19,610	26.63	1279.5	1285.15	1286.65	1.50
19,610	26.73	1279.8	1286.28	1287.77	1.49
19,610	26.83	1282.3	1287.74	1288.83	1.09
19,610	26.94	1282.1	1289.69	1290.89	1.20
19,610	27.03	1283.4	1290.73	1292.01	1.28
19,610	27.11	1288	1291.91	1293.23	1.32
19,610	27.19	1287.8	1293.11	1294.61	1.50
19,610	27.3	1289.2	1294.78	1296.31	1.53
19,610	27.39	1290.3	1296.47	1297.98	1.51
19,610	27.48	1291.5	1298.22	1299.86	1.64
19,610	27.58	1294.2	1300.13	1301.64	1.51
19,610	27.68	1294.7	1301.82	1303.30	1.48

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Dixileta Drive Alignment to the CAP Canal

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
19,610	27.77	1297.4	1303.98	1305.43	1.45
18,150	27.86	1297.5	1305.41	1307.08	1.67
18,150	27.94	1299.1	1306.83	1308.23	1.40
18,150	28.04	1303.6	1308.92	1310.27	1.35
18,150	28.12	1304.6	1310.12	1311.66	1.54
18,150	28.21	1304.4	1311.71	1313.37	1.66
18,150	28.31	1305.9	1312.87	1314.75	1.88
18,150	28.39	1306.7	1314.32	1315.79	1.47
18,150	28.45	1306.7	1315.22	1316.83	1.61
18,150	28.52	1307.1	1316.55	1318.46	1.91
18,150	28.58	1309	1317.64	1319.33	1.69
18,150	28.67	1311.5	1318.59	1320.19	1.60
18,150	28.76	1312.5	1320.15	1322.06	1.91
18,150	28.86	1313.1	1322.06	1323.94	1.88
18,150	28.95	1312.3	1324.54	1325.93	1.39
18,150	29.04	1317.2	1326.03	1327.54	1.51
16,700	29.14	1319.4	1327.06	1328.45	1.39
16,700	29.23	1321.4	1328.28	1329.76	1.48
16,700	29.3	1322.3	1329.55	1331.24	1.69
16,700	29.39	1324.6	1331.78	1333.04	1.26
16,700	29.47	1324.1	1332.63	1333.97	1.34
16,700	29.54	1326.7	1333.38	1334.88	1.50
16,700	29.611	1328.9	1335.15	1336.06	0.91

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

CAP Canal to the Cloud Road Alignment

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
Bridge	29.6175			1338.31	***
16,700	29.624	1328.5	1337.54	1339.22	1.68
16,700	29.72	1330.5	1338.33	1340.28	1.95
16,700	29.8	1331.2	1339.23	1341.04	1.81
16,700	29.89	1331.6	1339.8	1341.62	1.82
16,700	29.99	1332.9	1340.57	1342.56	1.99
16,700	30.07	1334.4	1343.31	1345.27	1.96
16,700	30.17	1335.6	1344.97	1346.65	1.68
16,700	30.26	1338.9	1345.91	1347.88	1.97
16,700	30.36	1341.2	1347.08	1348.85	1.77
16,700	30.46	1341.2	1348.86	1350.48	1.62
15,250	30.55	1343.4	1350.45	1352.08	1.63
15,250	30.65	1343.7	1351.88	1353.33	1.45
15,250	30.73	1345.2	1353.55	1355.01	1.46
15,250	30.82	1345.2	1355.34	1356.97	1.63
15,250	30.92	1346	1356.26	1358.21	1.95
15,250	31.01	1349.5	1357.06	1359.21	2.15
15,250	31.11	1349.4	1358.51	1360.52	2.01
15,250	31.2	1349.9	1360.28	1362.25	1.97
15,250	31.29	1355.5	1361.61	1363.37	1.76
15,250	31.39	1356.8	1363.99	1365.63	1.64
15,250	31.49	1359.5	1365.55	1366.97	1.42
15,250	31.59	1360.1	1366.9	1368.38	1.48
15,250	31.67	1361.1	1367.8	1369.57	1.77
15,250	31.77	1363	1368.84	1370.7	1.86

50-Year and Encroached 100-Year Water Surface Elevations
Agua Fria River Watercourse Master Plan

Cloud Road Alignment to New Waddell Dam

50-Year Peak Flow	River Station	Thalweg	50-Yr WSEL	Encroached 100-Yr WSEL (Encroached)	Delta WSEL
15,250	31.86	1365.3	1370.3	1372.16	1.86
13,800	31.96	1364.3	1371.49	1373.30	1.81
13,800	32.05	1362.2	1372.51	1374.19	1.68
13,800	32.15	1366.2	1373.95	1375.37	1.42
13,800	32.24	1366.9	1375.89	1377.37	1.48
13,800	32.34	1368.2	1377.63	1379.18	1.55
13,800	32.43	1370.7	1378.74	1380.57	1.83
13,800	32.52	1372.4	1379.32	1381.34	2.02
13,800	32.58	1370.5	1380.05	1382.00	1.95
13,800	32.64	1366.2	1380.78	1382.67	1.89
13,800	32.72	1363.8	1381.3	1383.11	1.81
13,800	32.79	1367.2	1382.22	1384.14	1.92
13,800	32.86	1374.9	1383.85	1385.70	1.85
13,800	32.92	1381	1387.75	1388.39	0.64
13,800	32.979	1379.7	1389.93	1391.15	1.22
13,800	32.984	1378.4	1390.54	1392.20	1.66
Bridge	32.9885	1378.4		1392.92	***
13,800	32.993	1378.4	1391.76	1393.34	1.58
13,800	32.998	1381.4	1391.68	1393.23	1.55
13,800	33.06	1384	1393.9	1395.56	1.66
13,800	33.12	1384.4	1394.48	1396.22	1.74
13,800	33.19	1385.8	1394.68	1396.47	1.79
13,800	33.25	1385.2	1394.89	1396.80	1.91
13,800	33.29	1380.3	1396.52	1397.86	1.34
13,800	33.3	1380.4	1397.26	1398.68	1.42
13,800	33.36	1381.9	1397.62	1399.17	1.55
13,800	33.41	1386.9	1398.19	1399.81	1.62
9,000	33.46	1381.9	1399.02	1400.82	1.80
9,000	33.54	1384.4	1399.3	1400.98	1.68
9,000	33.63	1384	1399.9	1401.32	1.42
9,000	33.73	1390.5	1401.09	1402.05	0.96
9,000	33.82	1387.4	1402.69	1403.22	0.53

Appendix II. Example Calculation

Determine Cross Sectional Topography

Using the CAD drawings included with this report, determine which HEC-RAS cross sections are located on the property in question. If there are less than 3 cross sections on the property, draw interpolated cross sections between the existing cross sections. The interpolated cross sections should be perpendicular to the unimpeded river flow. Locate the interpolated cross sections so that the volume calculations give a fair estimate of the existing channel storage volume behind the levee.

Develop a profile of the existing ground using stations and elevations, as would be done to develop HEC-2 GR cards. Ground point stations and elevations may be determined using the data in the HEC-RAS cross sections, or graphically, using the CAD drawing.

In this example, the information is obtained graphically from the CAD drawing. The figure shows the cross sections, the limits of the ground profiles (between hash marks on the cross section line) and the average distances between the cross sections. Distances between cross sections should be measured within the limits of the pit.

The cross sectional information is shown on the spreadsheet.

Determine Area of Storage Prism Behind Levee

Using the ground profile, calculate the area between the existing ground and the 100-year water surface elevation. Assume a vertical wall at the levee.

Determine Storage Volume Behind Levee

Calculate the average area between adjoining cross sections. Multiply by the distance between the cross sections to obtain the storage volume between the cross sections. Add the volumes across the pit.

The resulting total volume is the amount of storage to be provided within the pit during storms that exceed the 50-year event. Total volume available for flow storage must equal or exceed the calculated volume.

Calculate Flow Height Over Weir

The flow height over the weir is **Delta H**, the difference between the 100-year water surface elevation and the 50-year water surface elevation. As shown in the

spreadsheet, the difference between the water surfaces may vary from cross section to cross section.

The spreadsheet shows calculations for minimum and maximum flow heights over the weir. This is done to illustrate the variation in weir lengths based on weir location. If the height of flow varies greatly along the length of the weir, use an average height of flow as **Delta H**.

The actual flow over the weir at any given time during the storm will vary with the height of the flow over the weir. To simplify the calculation of the weir length, calculate the height of flow over the weir that produces the *average* flow. This occurs at:

$$\text{Design H} = \frac{\textbf{Delta H}}{2}$$

Calculate Average Required Inflow

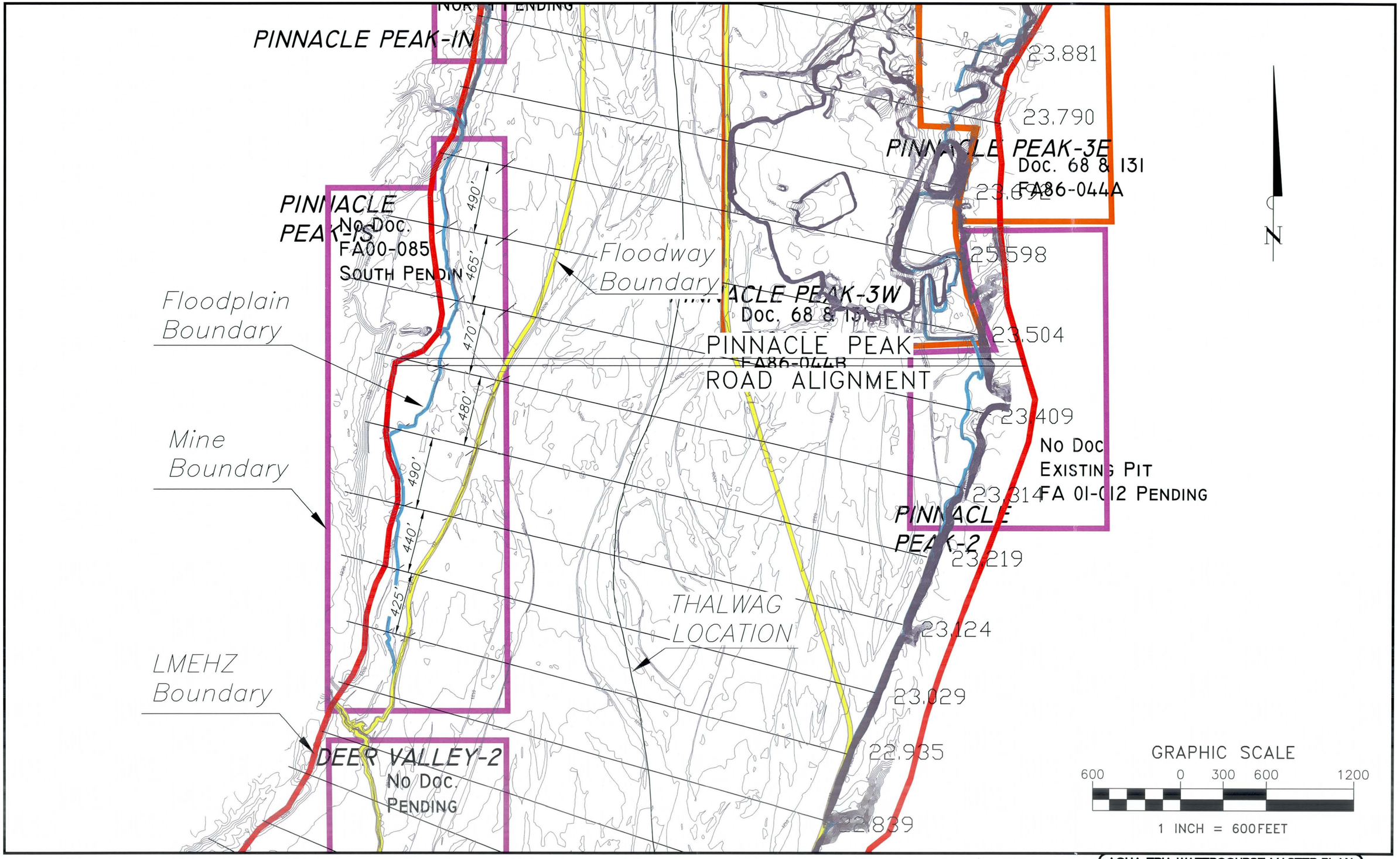
Based on examination of river hydrographs, the water surface associated with the 100-year storm is expected to exceed the 50-year water surface for approximately 2 hours. Assume a 2-hour inflow period for all locations. During this 2-hour period, the pit must be able to accept a flow volume equal to the calculated volume of channel storage behind the levee. Divide the total volume required (in cubic feet) by 7,200 seconds to obtain the average required inflow in cubic feet per second.

Calculate Length of Weir

Use the equation:

$$L = \frac{Q}{C(\text{Design H})^{3/2}}$$

Where L = Length of weir required (ft)
Q = Average required inflow (cfs)
C = 2.5
Design H at actual weir location, (ft)



AGUA FRIA WATERCOURSE MASTER PLAN
IMPLEMENTATION AND MAINTENANCE PLAN EXAMPLE
WEST BANK AT PINNACLE PEAK ROAD

Agua Fria Watercourse Master Plan
Implementation and Maintenance Plan
Example Calculation

Kimley-Horn and Associates, Inc.

Location: West bank, at Pinnacle Peak Road

River Station		Cross Sections							WSE_{50} (ft)	WSE_{100} (ft)	Delta H (ft)	$AREA_{100}$ (sf)	Distance to Upstream Cross Section (ft)	VOL_{100} (cf)
22.935														
	X	0	100	160					1215.18	1215.86	0.68	242		
	Y	1214	1214	1216										
23.029													425	70,125
	X	0	140	180					1216.64	1217.26	0.62	88		
	Y	1216	1217.56	1218										
23.124													440	55,009
	X	0	238	350					1218.82	1219.36	0.54	162		
	Y	1218	1219.36	1220										
23.219													490	85,805
	X	0	325	560					1220.55	1221.16	0.61	188		
	Y	1220	1221.16	1222										
23.314													480	157,100
	X	0	420	640					1222.56	1223.11	0.55	466		
	Y	1222	1222	1224										
23.409													470	426,278
	X	0	240	280	320	330	335		1224.85	1225.65	0.8	1348		
	Y	1222	1222	1220	1220	1222	1224							
23.504													465	675,215
	X	0	220	320	330	380	390	410	1226.6	1227.88	1.28	1556		
	Y	1225	1224	1224	1222	1222	1224	1226						
23.598													490	640,896
	X	0	230	270	330	340	360		1228.02	1229.3	1.28	1059		
	Y	1227.5	1226	1224	1224	1226	1228							
													Total	**2,110,427**

Inflow Rate Calculations

Required Inflow Volume	2110427.5 cf
Inflow Time Period	2 hrs
Calculated Inflow Rate	**293 cfs**

Weir Length Calculations

Weir Length Calculations For Minimum Weir Length:

C	2.5
Q_{AVE}	293 cfs
Maximum Delta H	1.28 ft
Maximum Design H	0.64 ft
L_{MIN}	**229 ft**

Design H_{MAX} =Delta H_{MAX}/2

Weir Length Calculations For Maximum Weir Length.

C	2.5
Q_{AVE}	293 cfs
Minimum Delta H	0.54 ft
Minimum Design H	0.27 ft
L_{MAX}	**836 ft**

Design H_{MIN} =Delta H_{MIN}/2

Notes:

1. Delta H is difference between 50-yr and 100-yr water surface elevations, see tables in Appendix I.
2. Area calculated based on cross sectional area shown. Use 100-yr water surface elevation as top of cross sectional area.
3. Volume calculated using average end area method
4. Inflow time period set at 2 hours for all locations. Established based on design storm hydrographs
5. Weir coefficient established by District for broad crested weir.

Appendix III. Sources of Funding

INTRODUCTION AND PURPOSE

The Agua Fria Watercourse Master Plan recommends many recreational and flood control improvements. Research has identified funding sources at the local, state and federal level that may be approached for construction monies. The following tables and notes describe the funding sources, the types of projects that are available for which funds and contact information.

West Valley Recreation Corridor - Agua Fria Watercourse Master Plan				
Potential Funding Sources Index				
Non-Flood Improvement Category				
	Trailheads	Parks (Active/Flatlands)	Parks (Specialty)	Trails
Funding Resource				
Congestion Mitigation Air Quality Funds	N	Y	N	Y
BLM Grants	Y	Y	Y	Y
Capital Improvement Program	Y	Y	Y	Y
Corp of Engineers Grants			N	
Heritage Funds – Parks	Y	Y	N	Y
Heritage Funds – Historic Preservation	Y	Y	N	Y
Heritage Funds - Game & Fish	Y	N	N	Y
Heritage Funds – Trails	Y	N	N	Y
API	Y	Y	Y	Y
Bonds	Y	Y	Y	Y
LWCF	Y	Y	Y	Y
TEA-21 Grants	Y	N	N	Y

Y – Yes, this is a potential source of funding.
N - No, this is not a potential source of funding.

FUNDING SOURCE:

Congestion Mitigation Air Quality Funds - TCMs in Section 108(f)(1)(A) of the CAAA

Funding Cycle:

Maricopa County Department of Transportation Fiscal Year

Purpose:

In non-attainment areas, to explore options for market-based Transportation. Control Measures including road pricing, congestion pricing, VMT tax, and parking pricing as cost effective ways to reduce VMT and congestion.

MCDOT also has developed its Congestion Management System (CMS) to identify congested roads, and recommends various ways to ease traffic congestion. Recommendations include adding bicycle and pedestrian improvements.

Applicable Types of Projects:

New construction and major reconstruction of paths, tracks or areas solely for the use by pedestrian or other non-motorized means of transportation when economically feasible and in the public interest. Programs for secure bicycle storage facilities and other facilities, including bicycle lanes, for the convenience and protection of bicyclists, in both public and private areas: Bicycle parking facilities, showers and lockers for bicyclists. Bicycling education and marketing programs. Creation of bicycle paths and rights-of-way to enable and encourage cycling. Provision of security for bicycle paths and rights-of-way. Accommodations for bicyclists in transit.

Grant Amounts:

FY 2001 - 2005 TIP projects are jointly funded by MCDOT through inter-governmental agreements and partnerships. MCDOT has an annual process for TIP project selection and approval by County Board of Supervisors. Selection is primarily based on commitment to complete development and construction of projects.

Required Match: City / Small Town Partnership with MCDOT

Contact: Reed Kemton, Bicycle/Multi-Modal Planner
Maricopa County Department of Transportation

Address: 2901 W. Durango Street
Phoenix, AZ 85009
602.506.1630
reedkempton@mail.maricopa.gov

FUNDING SOURCE:

USBLM - Easements for Conservation, Access Roads, Trails, and Improvements

Purpose:

The Bureau acquires land when it is in the public interest and consistent with publicly-approved land use plans. The BLM's land acquisition program is designed to: 1) improve management of natural resources through consolidation of Federal, State and private lands; 2) secure key property necessary to protect endangered species, promote biological diversity, increase recreational opportunities, and preserve archaeological and historical resources; and, 3) implement specific acquisitions authorized by Acts of Congress by acquiring minimal non-Federal lands or interest in lands.

Applicable types of Projects:

Conservation, Access Roads, Trails and Improvements.

Grant Amounts:

Easements for conservation, access roads, trails, and improvements allow BLM to control rights on private property, which usually involve access or development. The lands remain in private ownership with limited rights owned by the BLM. Easements allow landowner to maintain existing land uses but protects the land from incompatible uses through conservation easements; provides access to "landlocked" public lands allowing BLM to construct road improvements for better management and increased public access.

Required Match: None.

Contact: BLM - Phoenix Field Office
Address: 2015 West Deer Valley Road
Phoenix, AZ 85027-2099
623.580.5500

FUNDING SOURCE:

Capital Improvement Program - City of Avondale

Funding Cycle:

The Avondale City Council adopted a tentative budget of approximately $106 million for the 2001/2002 fiscal year. A public hearing on the adoption of a final budget and expenditure limitation for the city is scheduled for July 16. The proposed budget represents a 54% increase over last year's budget, a result of a voter-approved half-cent sales tax increase to fund major capital improvement projects; an increase in state shared revenues because of the latest census numbers; and carry-over of funds for certain projects. Requests for CIP funds are submitted to Council in January of each year as an update to the 5-year CIP plan. CIP Budgets for FY02/02, 03/04, and 04/05 forecasts $600,000 each year for Parks & Recreation.

Applicable Types of Projects:

Capital improvement projects including wetland recharge, trails, trailheads, flatland parks, ATC, and specialty parks.

Grant Amounts:

There is no minimum or maximum required. Funding is based on project budget.

Required Match: None.

Contact: Kevin Artz, Finance/Budget Director
Address: 525 N. Central
Avondale, AZ 85323
623.925.0015

FUNDING SOURCE:

Capital Improvement Program - City of Glendale

Funding Cycle:

Summer through Fall of each year. Requests for CIP funds are submitted to Council in January of each year as an update to the 5-year CIP plan.

Applicable types of Projects:

Capital improvement projects including trails, trailheads, flatland parks, ATC, and specialty parks.

Grant Amounts:

There is no minimum or maximum required. Funding is based on budget.

Required Match: None.

Contact: Cathy Foland
City of Glendale, Budget Office

Address: 6829 North 58th Drive
Glendale, Arizona 85301
623.930.2222

FUNDING SOURCE:

Capital Improvement Program - City of Peoria

Purpose:

The 5 year CIP budgets for major public improvements to build or expand roads, bridges, parks and recreational facilities, water, stormwater, wastewater, and public safety facilities.

Funding Cycle:

The CIP is the City Council's plan for the priority, timing, and financing of projects, and is re-evaluated annually to incorporate any changes to priorities and to incorporate new projects.

Applicable types of Projects:

Capital improvement projects including trails, trailheads, flatland parks, ATC, and specialty parks.

Grant Amounts:

There is no minimum or maximum required. Funding based on budget, but for FY 2001 shows 8% of $105 million operating budget is earmarked for parks.

Required Match: None.

Contact: Terrence Ellis, City Manager and Jeff Tyne, Budget Officer
City of Peoria Municipal Complex

Address: 8401 W. Monroe Street
Peoria, Arizona 85345
623.773.7150
www.peoriaaz.com

FUNDING SOURCE:

U.S. Army Corps of Engineers

Funding Cycle:

See Grants Amount below.

Purpose:

The Corps' role as a funding source for a project should be characterized as the project becoming a federal project meeting federal objectives. The Corps identifies problems & opportunities, define objectives, and formulate solutions that meet those objectives.

Grant Amounts:

Improvements to Environment -Section 1135 of the Water Resources Development Act of 1986, as amended, authorizes a program of modifications to water resources projects constructed by the Corps for the improvement of the environment. Projects that address degradation of the quality of the environment caused by a Corps project may also be undertaken. Non-Federal sponsors are responsible for 25% of the project cost and usually 100% of the operation, maintenance, replacement, and rehabilitation. Up to 80% of the non-Federal share may be provided as work-in-kind. Non-governmental entities may serve as the non-Federal sponsor. The Federal per project limit is $5 million and the annual appropriation limit is $25 million. After initial headquarters approval to initiate a study, projects are usually approved by the division.

Aquatic Ecosystem Restoration- Section 206 of the Water Resources Development Act of 1996 authorizes the Secretary to carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest, and are cost-effective. Individual projects are limited to $5 million in Federal cost. Non-Federal interests must contribute 35% of the cost of construction and 100% the cost of operation, maintenance, replacement, and rehabilitation. The program has an annual program limit of $25 million. This program received initial funding of $6 million in FY 1998.

Required Match: See *Grant Amounts* above.

Contact Name:	John Drake US Army Corps of Engineers
Address:	3636 N. Central Suite 740 Phoenix, Arizona 602.640.2003 http://www.usace.army.mil/inet/functions/cw/cecwa2/cecw_temp/plngrms.htm

FUNDING SOURCE:

LRSP - Local, Regional and State Parks (Heritage Fund)

Funding Cycle:

Application Deadline - No later than 5:00 p.m. on the last official workday of February.

Purpose:

To support land acquisition and development of facilities for outdoor recreation throughout Arizona.

Grant Amounts:

Budget - Up to $3.5 million annually from the Arizona State Parks Board Heritage Fund.

Who can apply?

Incorporated municipalities, counties, state agencies, and Indian Tribes.

Required Match: None

Contact: Arizona State Parks
Address: 1300 W. Washington
Phoenix, Arizona 85007
602.542.4174 or from Area Code 520 or,
call toll free 1-800-285-3703
http://www.pr.state.az.us

FUNDING SOURCE:

Arizona State Parks - Historic Preservation Heritage Fund

Funding Cycle:

Annual grant cycle with applications due to the ASP GARP Section on the last working day of March. Application manuals are available annually in the winter and informational workshops are held before the application due date.

Applicable types of Projects:

Historic preservation activities eligible for funding include but are not limited to: stabilization, rehabilitation, restoration, reconstruction, education and preservation program development, interpretive development and acquisition. To qualify for grant assistance, projects must directly involve resources either listed on the Arizona or National Register of Historic Places or determined eligible by the State Historic Preservation Officer (SHPO) to be listed on the Arizona Register.

Eligible Applicants:

Incorporated municipalities, counties, state agencies, tribal governments, and public educational institutions. Private non-profit organizations must meet certain conditions in order to apply for funding.

Grant Amounts:

ASP receives up to $1.7 million each year from the Arizona Lottery Fund. Grants are awarded on a matching basis, where the applicant must provide at least 40% of the total project cost and the grant provides the remainder. For awarded grants, grantees are reimbursed for costs incurred during the approved project period. Matching funds,can be in the form of cash or in-kind contributions.

Required Match:	See grant amounts above.
Contact:	Arizona State Parks Board Grants and Recreation Programs (GARP) Section
Address:	1300 West Washington Phoenix, Arizona 85007 602.542.7131 www.pr.state.az.us

FUNDING SOURCE:

Arizona State Parks - Game & Fish Heritage Fund

Funding Cycle:

Application Deadline - No later than 5:00 p.m. on the last official workday of November each year.

Applicable types of Projects:

Environmental Education; Schoolyard Grants; Identification, Inventory, Acquisition, Protection, and Management of Sensitive Species and Habitats (IIPAM); Urban Wildlife and Urban Wildlife Habitat; Public Access.

Grant Amounts:

Environmental education ($27,000); Schoolyard grants ($41,300); Identification, Inventory, Acquisition, Protection, and Management of Sensitive Species and Habitats (IIPAM) ($270,000); Urban Wildlife and Urban Wildlife Habitat ($169,000); Public Access ($100,000).

Eligible Applicants:

Federal government or any federal department or agency, Indian tribes, State of Arizona, all departments, agencies, boards, and commissions of State of Arizona, counties, school districts, cities, towns, all municipal corporations and any other political subdivisions of State of Arizona.

Contact:	Robyn Beck, Heritage Grants Coordinator Heritage Grants Coordinator, Funds/Planning Section
Address:	Arizona Game and Fish Department 221 West Greenway Road Phoenix, Arizona 85023-4312 602.789.3530 http://www.rbeck@gf.state.az.us

FUNDING SOURCE:

Arizona State Parks - Heritage Fund, Trails

Funding Cycle:

Application Deadline - No later than 5:00 p.m. on the last official workday of February.

Purpose:

Purpose - To support non-motorized trail acquisition, construction and improvements throughout Arizona.

Grant Amounts:

Budget - Up to $500,000 annually from the Arizona State Parks Board Heritage Fund.

Eligible Applicants:

Incorporated municipalities, counties, state agencies, federal agencies, and Indian Tribes.

Required Match: None

Contact: Arizona State Parks
Address: 1300 West Washington
Phoenix, AZ. 85007
602.542-4174
http://www.pr.state.az.us

FUNDING SOURCE:

Arizona Preserve Initiative (API)

Funding Cycle:

The grant program for 11 years beginning in July 2000 was created in November 1998 after passage of Proposition 303 by voters for acquisition or lease of Trust Lands for conservation.

Purpose:

To encourage the preservation of select parcels of State Trust Lands in and around urban areas for open space to benefit future generations. State Trust Lands can be leased for up to 50 years, or sold for the long-term benefit of the land, the beneficiaries, lessees, the public, unique resources such as open space, scenic beauty, protected plants, wildlife, archaeology, and multiple use values.

Applicable types of Projects:

A state or local government, business, state land lessee or a group of citizens may petition the State Land Commissioner to have certain Trust land nominated and reclassified for conservation purposes. After all appropriate notifications, public hearings, consideration of physical and economic impacts to lessees and the Trust, the Commissioner may reclassify the subject land as suitable for conservation purposes. The Commissioner must consider recommendations from five-member Conservation Advisory Board that was established by law, as well as consult with local and regional planning authorities.

Grant Amounts:

$20 million per year for 11 years to award grants for the acquisition of State Trust Lands, leasing of up 50 years, purchases of a parcel's development rights, or fee simple purchase of a parcel. Grants may be made by ASP Board for up to 50% of the appraised value of a land parcel.

Required Match: Public-private matching required by Land Commissioner

Contact:	State Land Commissioner Land Department
Address:	1616 West Adams Phoenix, Arizona 85007 602.542-4621 www.land.state.az.us/asld/htmls/apinfo/htm

FUNDING SOURCE:

Revenue Bonds - City of Peoria

Funding Cycle:

Annual budget cycle.

Purpose:

Revenue bonds are issued by the county or municipality and backed by a dedicated revenue stream. The advantage to using revenue bonds is that people using the facilities pay for the facilities via park entrance fees or other charges.

Applicable types of Projects:

Recreational facilities including swimming pools, parks, playgrounds, municipal golf course, ball parks, and open space.

Contact:	City of Peoria
Address:	8401 West Monroe Street Peoria, Arizona 85345 623.773-7114

FUNDING SOURCE:

Land and Water Conservation Fund (LWCF)

LWCF has two components: A federal (BLM) program and a State matching grants program. Each state prepares & updates its statewide comprehensive outdoor recreation plan (SCORP), which identify needs and new opportunities for recreation. States initiate statewide competition for allocation for award via matching grants through National Park Service.

Funding Cycle:

LWCF is a visionary and bipartisan program, established by Congress in 1964 to create parks and open spaces, protect wilderness, wetlands, and refuges, preserve wildlife habitat, and enhance recreational opportunities.

Purpose:

From parks, playgrounds, wilderness to wetlands, bicycle paths to hiking trails, LWCF has helped communities acquire nearly seven million acres of parkland, water resources, and open space.

Grant Amounts:

$900 million per year.

Contact Name:	Denise Meridith, BLM Director Arizona State Office
Address:	PO Box 45155 222 North Central Avenue Phoenix, Arizona 85004 602.417.9197

FUNDING SOURCE:

Federal Transportation Efficiency Act for the 21st Century (TEA-21)

Funding Cycle:

Set annually by ADOT

Purpose:

TEA-21 funds are federal funds available through the Transportation Enhancement Act for the 21st Century signed into law by President Clinton. The funds are made available to each state to disperse at their discretion for non-motorized transportation projects. The Arizona Department of Transportation works with Associations and Councils of Governments throughout the state to disperse these funds. It has formed a citizen committee to identify and award funds to projects throughout the state on an annual basis.

Applicable types of Projects:

Multi-modal transportation including bicycle, pedestrian, and transit needs.

Grant Amounts:

FY 2001 - 2005 TIP projects are jointly funded by MCDOT through inter-governmental agreements and partnerships. MCDOT has an annual process for TIP project selection and approval by County Board of Supervisors. Selection is primarily based on commitment.

Required Match:	In kind or cash varies up to 5%
Contact:	Dawn Coomer Maricopa Association of Governments
Address:	302 North 1st Avenue Phoenix, Arizona 85003 602.254.6300 dcoomer@mag.maricopa.gov

SELECTED FEMA PROGRAMS FOR FLOODS

	MITIGATION		NFIP	RESPONSE AND RECOVERY	
	Flood Mitigation Assistance	**Hazard Mitigation Grant Program**	**Flood Insurance**	**Federal Individual Assistance**	**Public Assistance**
Fund Source	NFIP policyholders' premiums	Appropriations	NFIP policyholders' premiums	Appropriations	Appropriations
Type of program	Grant	Grant	Insurance	Disaster Assistance	Disaster Assistance
Conditions	Pre- flood disaster	Post-disaster, covering all hazards, in an amount up to 20% of Individual and Public Assistant obligations	Covered flood losses, 30-day waiting period	Presidentially declared disaster, for all hazards	Presidentially declared disasters, for all hazards
Purpose	Reduce or eliminate the frequency and severity of NFIP claims	Reduce risk of future damage and loss in areas affected by major disasters, and reduce disaster costs	Provide financial protection for homeowners, renters, businesses	Assist renters and home and business owners who sustained property damage or loss	Repair infrastructure and public facilities and take emergency measures to save lives and protect health, safety or property
Types of Assistance	Flood mitigation planning and project grants for NFIP insurable structures, such as elevation, acquisition, relocation, demolition, dry floodproofing	Elevation of flood-prone buildings, acquisition or relocation, and seismic strengthening, and other mitigation projects.	Maximum insurance coverage is $250,000 for single-family home and $100,000 for contents; $500,000 for business buildings and $500,000 for contents; $20,000 for Increased Cost of Compliance.	Disaster housing, low-interest loans (SBA, USDA), and disaster grants averaging $2,500 for those unable to repay loans	Debris removal, emergency protective measures, and repair of roads systems and bridges, water control facilities, public buildings, utilities, and parks and recreational facilities
Eligibility	States and participating NFIP communities	Local governments in States which have experienced Presidentially-declared disasters	Individuals and businesses in participating NFIP communities	Renters, homeowners and business owners who have sustained damage or losses	State and local governments, political subdivisions, private non-profit organizations, and Native American Indian Tribes

SELECTED FEMA PROGRAMS FOR FLOODS

	MITIGATION		NFIP	RESPONSE AND RECOVERY	
	Flood Mitigation Assistance	**Hazard Mitigation Grant Program**	**Flood Insurance**	**Federal Individual Assistance**	**Public Assistance**
Non-Federal cost share	25%	25%	Average premium is about $364	25% for Individual and Family Grants	Not more than 25%
Administered by	State	State	By FEMA, largely through 86 private insurance companies	Administered by FEMA, SBA and other Federal agencies and voluntary agencies, under overall FEMA coordination	State

SELECTED FEMA PROGRAMS FOR FLOODS

	MITIGATION		NFIP	RESPONSE AND RECOVERY	
	Flood Mitigation Assistance	Hazard Mitigation Grant Program	Flood Insurance	Federal Individual Assistance	Public Assistance
Insurance Requirement				Mandatory purchase requirements apply to recipients of all Federal disaster assistance in Special Flood Hazard Areas. After one flood loss, applicants must purchase and maintain flood insurance on the building in order to qualify for future Federal disaster assistance. A portion of the Individual and Family Grant is used by the State to purchase a 3-year group policy, covering the maximum grant award ($13,900). Flood insurance must be maintained for IFG recipients to be eligible for future disaster assistance.	Grant amounts are reduced by the amount of actual or anticipated insurance proceeds received. In the case of buildings in Special Flood Hazard Areas, the grants are reduced by the maximum amount that NFIP coverage would have provided. Insurance must be obtained and maintained to cover at least the amount of eligible damage to be funded by the public assistance grant.

SELECTED FEMA PROGRAMS FOR FLOODS

	MITIGATION		NFIP	RESPONSE AND RECOVERY	
	Flood Mitigation Assistance	**Hazard Mitigation Grant Program**	**Flood Insurance**	**Federal Individual Assistance**	**Public Assistance**
Assistance Process		FEMA provides the State with an estimate of funding, which amounts to 15% of anticipated IA and PA obligations. The State develops or updates mitigation plan within 180 days after disaster, and provides technical assistance to applicants. Local governments submit applications, which are prioritized by the State against the plan. State selects projects based on priorities and available funds, and forwards project proposals to FEMA for review of eligibility, cost-benefit and environmental requirements. FEMA approves projects and transfers funds to the State, which oversees project completion. Funds must be obligated within 2 years of the disaster.	Policyholder reports loss to insurance company or agent. A claims adjuster is assigned the loss. Within 60 days of loss, policyholder must file "proof of loss". Claims payments are made directly to policyholder by insurance company or agent.	FEMA takes applications by phone at 1-800-462-9029. A single application is used for all forms of assistance. FEMA inspectors inspect property to verify loss. If approved for temporary housing assistance, FEMA issues checks in 7-10 business days. FEMA submits applications to SBA to determine if applicants qualify for loans. If they do, and applicant agrees, SBA processes loan application, prepares agreement and issues check. If not qualified for a loan, FEMA sends application to State to determine if applicants qualify for Individual and Family Grants of up to $13,900. IFG checks are sent out by State, based on FEMA grant.	FEMA redesigned program in 1998. State, as grantee, provides technical assistance and processes sub-grants to applicants. State briefs applicants on available assistance and eligibility requirements. Within 30 days after declaration or area designation, applicants submit a Request for PA to State. A FEMA PA Coordinator is assigned to manage case. Applicants prepare Project Worksheets that describe damage and estimate costs. Large projects (>$47,100) are formulated by joint FEMA/State/local team and actual costs are reimbursed. Small projects are formulated by applicant and reimbursed on basis of estimated costs. Projects are validated by FEMA and/or State officials to verify damage and costs. FEMA approves projects and FEMA Region allocates funds to State. State sub-grants and transfers funds to applicant and oversees completion.

Appendix IV. Erosion Monitoring Procedure – Grand Avenue to Peoria

The recommended plan calls for interim monitoring of bank erosion in the reach from Grand Avenue to Peoria Avenue. The primary purpose of the monitoring is to determine if bank instabilities are occurring that might threaten buildings constructed along the east bank, or the banks of the El Mirage Landfill. Figures 5.1-8 and 5.1-9 show the extent of the area to be monitored, in addition to showing the limits of the Lateral Migration Erosion Hazard Zone.

Monitoring will consist of activities that occur on an annual basis, and activities that will occur at minimum following flow events in the river.

Annual Monitoring

Visual observations of the toe of bank for both the east and west bank should be conducted on an annual basis. The purpose of this evaluation is to look for evidence of recent bank sloughing, evidence of recently formed gullies, and to identify reference points such as fence lines or other similar features that might serve as a gage from which to measure bank erosion. These locations should either be marked on an aerial photograph in the field, or recorded with a GPS unit. Each area identified should be photographed. The data obtained from the field should be incorporated into a digital data layer in order to facilitate the use and retrieval of this data.

Following Flow Events

Surveyed cross sections of the channel and bank should be obtained following flow events. It is recommended that they be obtained at minimum once every five years. The first survey should occur following the first annual monitoring of the bank line. The purpose of this step is to allow for pre-plotting of approximate survey cross section locations in order to capture a representative sample of eroding and stable bank lines.

During the first survey, a control line from Grand Avenue to Peoria is to be established that can be recreated in subsequent surveys. It is suggested that this control line be set approximately 50 feet west of the east bank toe in order to facilitate cross sectioning of the east bank. At approximately 1000 foot intervals, a full cross section of the Agua Fria is to be obtained that extends to the top of bank but it need not be wider than the limits of the lateral migration erosion hazard zone depicted on figures 5.1-8 and 5.1-9. The cross section should be of sufficient detail to pick up break points of one foot or more, with a maximum spacing between shots of 50 feet. The cross sections are to be

properly documented such that subsequent surveyors could duplicate the cross section locations from the surveyed control line.

Along the east channel bank, at approximately 200 foot intervals, a cross section of the bank is to be established that originates from the control line and captures the toe and top of bank. The toe and top of bank should clearly be identified in the survey notes.

In the office, the cross sections should be plotted with subsequent years plotted in a fashion so as to overlay the previous data. Likewise, in plan view, the toe of slope line and top of slope line should be plotted with overlays from subsequent years. These data should be examined for changes in section, or general trends in plan view that would suggest a change in bank position.