PRELIMINARY ALTERNATIVE ANALYSIS STUDY FOR THE RIALTO CHANNEL

CITY OF RIALTO, CALIFORNIA

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APPENDIX B: **COST ESTIMATES**

APPENDIX B.1: PRELIMINARY COST ESTIMATES FOR ALTERNATIVE 1

APPENDIX B.2: PRELIMINARY COST ESTIMATES FOR ALTERNATIVE 2

APPENDIX B.3: PRELIMINARY COST ESTIMATES FOR ALTERNATIVE 3

APPENDIX B.4: PRELIMINARY COST ESTIMATES FOR ALTERNATIVE 4

EXHIBITS

EXHIBIT "A": ALTERNATIVE 1 CROSS SECTIONS AND LAYOUT EXHIBIT

EXHIBIT "B": ALTERNATIVE 2 CROSS SECTIONS AND LAYOUT EXHIBIT

EXHIBIT "C": ALTERNATIVE 3 CROSS SECTIONS AND LAYOUT EXHIBIT

EXHIBIT "D": ALTERNATIVE 4 CROSS SECTIONS AND LAYOUT EXHIBIT

EXHIBIT "E": ALTERNATIVE 5 CROSS SECTIONS AND LAYOUT EXHIBIT

TABLE OF CONTENTS

PAGE

I. INTRODUCTION 1

II. PROJECT PURPOSE AND SCOPE 1-3

III. PROJECT SITE OVERVIEW 3-4

IV. HYDROLOGY 4

V. HYDRAULICS 4-5

VI. CHANNEL AND RCB ALTERNATIVE ANALYSIS 5-10

VII. PRELIMINARY ANALYSIS OF ALTERNATIVES 10

VIII. REFERENCES 10

FIGURES

FIGURE 1: GENERAL PROJECT LOCATION MAP

FIGURE 2: PROJECT VICINITY MAP

PROJECT PHOTOGRAPHS

APPENDICES

APPENDIX A: HYDRAULIC CALCULATIONS

APPENDIX A.1: WSPGN HYDRAULIC ANALYSIS FOR ALTERNATIVE 1

APPENDIX A.2: WSPGN HYDRAULIC ANALYSIS FOR ALTERNATIVE 2

APPENDIX A.3: WSPGN HYDRAULIC ANALYSIS FOR ALTERNATIVE 3

APPENDIX A.4: WSPGN HYDRAULIC ANALYSIS FOR ALTERNATIVE 4

APPENDIX A.5: COMPOSITE MANNING'S "N-VALUE" CALCULATIONS

This report has been prepared by or under the direction of the following registered civil engineer who attests to the technical information contained herein. The registered civil engineer has also judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions, and decisions are based.

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SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT PRELIMINARY ALTERNATIVE ANALYSIS STUDY FOR THE RIALTO CHANNEL IN THE CITY OF RIALTO, CA

I. INTRODUCTION

The Rialto Channel is considered by the San Bernardino County Flood Control District (SBCFCD) as a regional facility that extends from the Santa Ana River upstream to Cactus Avenue Basin No. 1 (located on the northwest corner of the Etiwanda Avenue and Cactus Avenue intersection), in the City of Rialto (see Figure 1). SBCFCD owns and maintains the existing channel.

The alternative analysis study includes the reach of the Rialto Channel that stretches from Willow Avenue to Etiwanda Avenue, just downstream of the Cactus Avenue Basin No. 1 (see Figure 2). The topography of the study area flows generally in a north to south direction. The Rialto Channel runs parallel with Cactus Avenue from Etiwanda Avenue to approximately 850 feet downstream of the existing Bloomington Avenue reinforced concrete box (RCB) crossing. The channel bends and then proceeds downstream in a south easterly direction towards the existing Willow Avenue RCB crossing. Throughout the study reach, the channel maintains an average slope of approximately 1.5 percent.

For this study, the Rialto channel was separated into three channel segments. Study Segment 1 consist of the portion of the channel from Willow Avenue upstream to the SCRRA (Metrolink) railroad while Study Segment 2 covers the reach of the channel from the SCRRA (Metrolink) railroad to approximately 400 feet upstream of Rialto Avenue. Study Segment 3 runs from the upstream terminus of Study Segment 2 to Etiwanda Avenue.

This report comprises the preliminary Alternative Analysis for this reach of the Rialto Channel. Five channel design alternatives were prepared for this study. Alternative 1 or the "Preferred" Alternative consists of the trapezoidal concrete-lined channel and multi-cell reinforced concrete box (RCB) at the roadway and railroad crossings. Alternative 2 consists of a combination of rectangular concrete-lined channel with a "soft-bottom" section and articulated block or "Armorflex" channel including multi-cell reinforced concrete box (RCB) at the roadway and railroad crossings. Alternative 3 consists of a combination of rectangular concrete-lined channel with a "low-flow" channel and "Armorflex" channel including multi-cell reinforced concrete box (RCB) at the roadway and railroad crossings. Alternative 4 consists of a combination of a rectangular concrete-lined and "Armorflex" channel and multi-cell reinforced concrete box (RCB) at the roadway and railroad crossings. Alternative 5 is the "No Action" alternative.

II. PROJECT PURPOSE AND SCOPE

AEI•CASC Engineering (AEI•CASC) is under contract with SBCFCD to prepare a preliminary alternative analysis study for the reach of the Rialto Channel extending from Willow Avenue upstream to Etiwanda Avenue. This alternative analysis study was prepared in an effort to preliminarily assess potential project impacts of the proposed channel improvements to the Santa Ana "Sucker" fish. The Santa Ana "Sucker" fish is

federally listed by the U.S. Fish and Wildlife Service as an endangered species and is known to inhabit and spawn near the outfall of the Rialto Channel as it confluences with the Santa Ana River. Since the construction of the Rialto channel upstream of Interstate 10 in the early 1980's, the earthen channel has undergone a natural process of channel degradation and aggradation, resulting in the discharge of sediment load at its confluence point with the Santa Ana River. The Regulatory Agencies have expressed their desire to maintain this natural process in order to minimize any adverse environmental impacts to the existing plant and aquatic life, specifically the Santa Ana "Sucker" fish, located near the discharge point. The Regulatory Agencies' preference is to maintain the soft-bottom characteristics of the channel, thus avoiding any disruption of sediment load supply at the discharge point.

Project Purpose is consistently evaluated by Region 9 of the Environmental Protection Agency (EPA) as the "generic function" of the proposed activity. For example, the basic purpose of a flood control or drainage channel is to provide flood protection to existing development from the 100-year flood event, regardless of the type of channel that might be proposed. Section 230.10(a) requires that if the overall purpose of a project is met through all of the alternatives, then the Least Damaging Practicable Alternative must be selected. For this study, the basic project purpose is to:

- Provide 100-year flood protection to the existing residential and commercial development adjacent to and downstream of the existing unimproved channel with the least interruption to public services.

The overall project purpose is as follow:

1. To provide a flood control channel that safely conveys the 100-year flood flows.
2. To provide a flood control channel that is structurally sound with a minimal chance of catastrophic failure during the design flood event.
3. To provide a flood control channel that is easy to maintain and operate by providing adequate maintenance egress and ingress points, access roads and ramps.
4. To provide a flood control channel that will not pose as a safety hazard to the general public.

The scope of the study includes the following:

1. Development of the various channel design alternatives for the existing Rialto Channel.
2. Development of hydraulic models in support of the various channel and culvert crossing alternatives.

3. Development of preliminary construction cost estimates for the various channel and culvert crossing alternatives.
4. Preparation of the preliminary alternative analysis report and the appropriate exhibits.

III. PROJECT SITE OVERVIEW

As mentioned previously, the preliminary alternative analysis study was separated into three channel segments (see Figure 2). Study Segment 1 is the reach of the channel that extends from Willow Avenue upstream to the SCRRA (Metrolink) railroad while Study Segment 2 covers the reach of the channel from the SCRRA (Metrolink) railroad to approximately 400 feet upstream of Rialto Avenue. Study Segment 3 runs from the upstream terminus of Study Segment 2 to Etiwanda Avenue.

Study Segment 1 consists of approximately 9,000 feet of partially improved channel. The existing channel configuration is an earthen trapezoidal channel with 1.5 to 1 side slopes with two 12-foot (average width) earthen access roads within the existing 70-foot wide right-of-way (R/W). The channel bottom width and depth vary throughout this segment from 9 feet to 14 feet and from 2 feet to 8 feet, respectively. The channel is generally protected with small cobbles, rocks, and rock riprap along the channel side slope and base. Existing improvements along this reach consist of double 12' wide x 9' high RCB culverts at Willow Avenue, Lilac Avenue/West San Bernardino Avenue, and Bloomington Avenue. The culvert crossings at Randall Avenue, Merrill Avenue, and SCRRA consist of temporary small CMP culverts. The channel and the RCB/culvert crossings are undersized to convey the ultimate 100-year flow rates.

Study Segment 2 is approximately 1,800 feet in length. The majority of this channel segment is either concrete-lined (from Cactus Avenue to Rialto Avenue) or conveyed by underground RCB (from Rialto Avenue to approximately 400 feet upstream). A relatively short reach of Study Segment 2, approximately 300 feet, located between Cactus Avenue and the SCRRA (Metrolink) railroad, is unlined. The existing culvert crossing at Cactus Avenue and the underground storm drain consist of double CMP culverts and are undersized for the ultimate 100-year flow rates. The existing R/W within Study Segment 2 consists of 70 feet from the SCRRA (Metrolink) railroad to Cactus Avenue, 50 feet from Cactus Avenue to Rialto Avenue, and 40 feet upstream of Rialto Avenue. Although the majority of the existing drainage system is somewhat improved (concrete lining and RCB), the facility was found to be inadequate to convey the ultimate 100-year flows.

Study Segment 3 is approximately 4,800 feet of unlined channel. The channel configuration is an earthen trapezoidal channel with 1.5 to 1 side slopes with two 12-foot (average width) earthen access roads within a 90-foot wide R/W. The channel bottom width and depth vary throughout the segment from 4 feet to 6 feet, and from 6 feet to 8 feet, respectively. The channel is an unprotected earthen channel with small cobble and

rocks. The culvert crossings at Second Street, Foothill Boulevard, and Rosewood Avenue consist of temporary CMP culverts. The existing channel and crossing culverts are undersized to convey the ultimate 100-year flow rates.

IV. HYDROLOGY

The design flows used in this study are based upon the 100-year flood event. SBCFCD provided AEI·CASC with the flow quantities using the equation, [(MPD Q_{100}) X 1.1] - 600 ft^3/sec = Q_{100} design flow rate. The 600 ft^3/sec is the approximate difference in the MPD Q_{100} of 1800 ft^3/sec and the basin outflow of 1,170 ft^3/sec at Baseline Avenue that was recently determined by SBCFCD in conjunction with the Cactus Basin project. The 1.1 factor was used to account for the anticipated difference in the hydrological methods used between the MPD and the current hydrology manual. The MPD is referred to as the District's Comprehensive Storm Drain Plan Project 3-3 Rialto Channel Drainage Area (CSDP 3-3), prepared by James M. Montgomery Consulting Engineers Inc., dated April 1988. The following is a table of the Q_{100} design flow rates for selected reaches of the Rialto Channel:

TABLE III-A

Channel Reach	Q_{100} Design Flow Rate
Willow Ave. to Lilac Ave./West San Bernardino Ave.	6,779 ft^3/sec
Lilac Ave./West San Bernardino Ave. to Bloomington Ave.	5,569 ft^3/sec
Bloomington Ave. to Randall Ave.	4,768 ft^3/sec
Randall Ave. to SCRRA (Metrolink) Railroad	4,109 ft^3/sec
SCRRA (Metrolink) Railroad to Foothill Blvd.	2,764 ft^3/sec
Foothill Blvd. to Etiwanda Ave.	1,170 ft^3/sec

V. HYDRAULICS

The Los Angeles County Water Surface Profile Gradient (WSPGN) software program by CIVILDESIGN, version 6.1, was utilized to evaluate the water surface profile gradient for the proposed storm drain facility. The beginning water surface elevation (WSE) for the upstream and downstream within the Rialto Channel was based upon critical depth. Mainline junctions with future laterals were based upon the conceptual location and size as identified in the District's CSDP 3-3 report. The hydraulic analysis was performed for the peak flow rates as identified in Table III-A. Additionally, the analysis was performed based on the preliminary channel design for Rialto Channel (see Ref. 4). Channel freeboard and scour depth requirements were determined from the Los Angeles County Flood Control District (LACFCD) Hydrology Manual.

Composite Manning's "N-values" (channel roughness coefficients) were calculated for channel sections that include two or more channel materials. The Flowmaster Program

developed by Haestad Methods Inc. analyzed the channel section using the Manning's formula to calculate the hydraulic parameters including a composite Manning's "N-value". The composite Manning's "N-value" was then utilized in the WSPGN analysis.

The following is a list of Manning's "N" values utilized for the hydraulic analysis:

N = 0.014 for formed concrete structures consisting of rectangular concrete channels, reinforced concrete boxes (RCB) and vertical reinforced concrete retaining walls.

N = 0.015 for the trapezoidal concrete-lined channels, channel transition structures, and concrete-lined side slope protection structures.

N = 0.027 for the "Armorflex" channel (without vegetation growth).

N = 0.035 for the "Armorflex" channel (with vegetation growth) and rock Rip-Rap.

VI. CHANNEL AND RCB ALTERNATIVE ANALYSIS

A number of factors were considered in determining whether an alternative meets the basic and overall project purpose and is therefore practicable. Under the 404 (b)(1) guidelines, "Practicable" is defined as "available and capable of being done after taking into consideration, costs, existing technology, and logistics in light of overall project purposes". The following factors were used in the preliminary alternative analysis:

- Channel Conveyance Capacity
- Channel Flow Velocity and Scour Potential
- Channel Maintenance
- Channel Right-of-Way
- Construction Cost

Channel Conveyance Capacity

All of the explored channel alternatives, with the exception of the No Action alternative, were designed to convey the 100-year design flow. Adequate channel freeboard was provided based upon the resulting flow velocities. The channel freeboard ranges from 3 to 4 feet.

Channel Flow Velocity and Scour Potential

Due to its inherently steep channel gradient, the flow velocities associated with the design flows were found to be excessively high. Channels that exhibit flow velocities in excess of 5 feet per second (fps) generally require protection from scour. As channel velocity

increases, the requirement for channel protective lining becomes essential. The following is a list of acceptable channel protective lining with the maximum allowable flow velocity:

- Turf Reinforced Mat (TRM): flow velocities up to 15 fps with sufficient vegetation growth.
- Articulated Concrete Blocks or "Armorflex": flow velocities up to 20 fps.
- Rock Rip-Rap: flow velocities up to 20 fps (rock size increases with velocity).
- Portland Cement Concrete (PCC): flow velocities up to 50 fps.

Since the flow velocities in Rialto Channel exceed 15 fps, use of TRM was not considered. Moreover, TRM requires sufficient growth to be able to withstand velocities of 15 fps. Therefore, the channel protective lining utilized in this study consists of articulated concrete blocks or "Armorflex", rock rip-rap, and PCC.

Channel Maintenance

In general, channel maintenance is considered an important factor in the design of a flood control channel. If a channel is not properly maintained, the flow conveyance capability of the channel could be compromised, thus resulting in flows overtopping the channel banks and causing major flooding. In order to maintain the hydraulic and structural integrity of the channel, periodic removal of accumulated debris and vegetation growth and replacement of damage sections are necessary. The SBCFCD design standard requires that two 20-ft wide access roads are provided, one access road on each side of the channel. Where right-of-way is restricted, two 15-foot access roads are considered acceptable. The access roads are used for regular scheduled maintenance of the channel and for emergency purposes during a storm event.

Channel Right of Way

Existing developments directly adjacent to the channel has limited the opportunity to purchase additional channel right-of-way required to construct the channel improvements. For this study, the alternatives were developed to fit within the existing right-of-way width.

Construction Costs

The construction costs associated with the explored alternatives will need to balance the environmental benefit derived from each of the alternatives. Since no detailed environmental benefit analysis was determined at this time, a comparative study was not performed. However, the construction cost for each of the alternatives was prepared and included in Appendix "B".

Channel Design Alternatives

As previously mentioned, five channel design alternatives were explored in this study. Alternative 1 or the "Preferred" alternative consists of the trapezoidal concrete-lined channel and multi-cell reinforced concrete box (RCB) at the roadway and railroad crossings. Alternative 2 consists of a combination of rectangular concrete-lined channel with a "soft-bottom" section and "Armorflex" channel including multi-cell RCB at the roadway and railroad crossings. Alternative 3 consists of a combination of rectangular concrete-lined channel with a "low-flow" channel and "Armorflex" channel including multi-cell RCB at the roadway and railroad crossings. Alternative 4 consists of a combination of a rectangular concrete-lined and Armorflex channel and multi-cell RCB at the roadway and railroad crossings. Alternative 5 is the "No Action" alternative. A detailed description of the unimproved and partially improved portion of the existing Rialto Channel is described under Section III.

Alternative 1: "Preferred" Alternative; Concrete-lined Rectangular and Trapezoidal Channel Sections

Alternative 1 consists of a rectangular concrete-lined channel from Willow Avenue to the SCRRA (Metrolink) railroad (Study Segment 1). The bottom width of the channel varies from 16 feet to 24 feet while the channel height varies from 11 feet to 12 feet. The existing RCBs at Willow Avenue, San Bernardino Avenue and Bloomington Avenue will remain in place. New double-cell RCBs (12' wide X 8' high) are proposed at Randall Avenue and Merrill Avenue. For Segment Study 2, which extends from the SCRRA (Metrolink) railroad to approximately 400 feet upstream of Rialto Avenue, Alterative 1 consists of an underground double cell 10' wide X 8' high RCB. Three-cell RCBs are proposed under the SCRRA (Metrolink) railroad. Segment Study 3 consists of a trapezoidal concrete-lined channel with a bottom width that varies from 8 feet to 10 feet, varying height of 7 feet to 9 feet, and 1.5:1 side slopes. Double-cell RCBs are proposed at Second Street, Foothill Boulevard, Rosewood Street, and Etiwanda Street. Concrete-lined channel transition structures connect the multi-cell RCBs to the trapezoidal channel. High strength concrete is proposed to protect the structure from potential scour. The thickness of the channel walls and inverts are increased by utilizing 2 to 3 inches of "sacrificial" concrete to provide extra protection against scour.

In an effort to mitigate impacts to the ecology of the Santa Ana River "Sucker" fish, 12 inches of native dirt material will be provided in the invert section of the concrete-lined channels and RCB culverts.

Two access roads are provided for maintenance. Fencing is proposed at the right of way to prevent unwanted intrusion into the channel. Additionally, locked gates are proposed where the channel crosses the existing street or roadway.

The preliminary opinion of probable construction costs for this alternative is estimated at **$7,354,000** with a 10 percent contingency. Exhibit "A" shows the typical cross-sections and layout for Alternative 1.

Alternative 2: Rectangular Channel with a "Soft-Bottom" Section and "Armorflex" Channel

Alternative No. 2 consists of a combination of rectangular channel with a "soft-bottom" section and "Armorflex" channel. The rectangular channel with a "soft-bottom" section is proposed for the entire reach of Study Segment 1 (from Willow Avenue to the SCRRA [Metrolink] railroad). The channel bottom width varies from 25 feet to 31 feet. The height of the channel varies from 16 feet to 18 feet. A 12-inch thick layer of dirt spans across the invert of the channel. Below the dirt invert, 2-ton rock riprap is provided due to high flow velocities. Unlike Alternative 1, the existing RCBs at Willow Avenue, San Bernardino Avenue and Bloomington Avenue will need to be replaced. New double-cell RCBs (15' wide X 10' high) are proposed at those streets including Randall Avenue and Merrill Avenue. The proposed improvements for Study Segment 2 with this alternative are similar to Alternative 1. For Study Segment 3, a trapezoidal "Armorflex" channel is proposed with a channel height of 8 feet, varying bottom width from 10 feet to 20 feet, and channel side slopes of 2:1. The "Armorflex" lining will be buried under a 12-inch layer of dirt. Similar to Alternative 1, double-cell RCBs are proposed at Second Street, Foothill Boulevard, Rosewood Street, and Etiwanda Street. Concrete-lined channel transition structures connect the multi-cell RCBs to the "Armorflex" trapezoidal channel.

Two access roads are provided for maintenance. Fencing is proposed at the right of way to prevent unwanted intrusion into the channel. Additionally, locked gates are proposed where the channel crosses the existing street or roadway.

The preliminary opinion of probable construction costs for this alternative is estimated at **$17,625,000** with a 10 percent contingency. See Exhibit "B" for the typical cross-sections and layout for Alternative 2.

Alternative 3: Rectangular Concrete-Lined Channel with Earthen "Low-Flow" Channel and "Armorflex" Channel

Alternative 3 consists of a rectangular concrete-lined channel with an adjacent natural "low-flow" channel for the entire Study Segment 1 (from Willow Avenue to the SCRRA [Metrolink] railroad). The bottom width of the channel varies from 16 feet to 24 feet. The height of the channel varies from 10 feet to 12 feet. The earthen "low-flow" channel has a bottom width of 5 feet, varying depth from 3 feet to 5.5 feet, and 2:1 side slopes. Due to the restricted right-of-way, only one 20-foot access road is provided alongside the rectangular concrete-lined channel. The connection of future master plan of drainage facilities will be problematic with this alternative due to the location of the low-flow channel. Like Alternative 1, the existing RCBs at Willow Avenue, San Bernardino

Avenue and Bloomington Avenue will remain in place. New double-cell RCBs (12' wide X 8' high) are proposed at Randall Avenue and Merrill Avenue. The proposed improvements for Study Segments 2 and 3 for this alternative are similar to Alternative 2.

The preliminary opinion of probable construction costs for this alternative is estimated at **$11,606,000** with a 10 percent contingency. Refer to Exhibit "C" for the typical cross-sections and layout for this alternative.

Alternative 4: Rectangular Concrete-Lined Channel and "Armorflex" Channel

Alternative 4 consists of a combination of rectangular concrete-lined channel and "Armorflex" channel. The rectangular concrete-lined channel is proposed for the entire Study Segment 1, from Willow Avenue to the SCRRA (Metrolink) railroad. The bottom width of the channel varies from 16 feet to 24 feet. The height of the channel varies from 11 feet to 12 feet. Like Alternative 1, the existing RCBs at Willow Avenue, San Bernardino Avenue and Bloomington Avenue will remain in place. New double-cell RCBs (12' wide X 8' high) are proposed at Randall Avenue and Merrill Avenue. The proposed improvements for Study Segments 2 and 3 with this alternative are similar to Alternative 3.

Like Alternative 1, which includes provisions for mitigating impacts to the ecology of the Santa Ana River "Sucker" fish, 12 inches of native dirt material will be provided in the invert section of the concrete-lined channels and RCB culverts.

The preliminary opinion of probable construction costs for this alternative is estimated at **$10,143,000** with a 10 percent contingency. Exhibit "D" shows the typical cross sections and layout for Alternative 4.

Alternative 5: "No Action" Alternative

Alternative 5, the "No Action" alternative, assumes that no major channel improvements will be implemented for this study reach of the Rialto Channel (see Exhibit "E"). Unlike the preceding alternatives, this alternative exposes the existing residential and commercial developments located adjacent to Rialto Channel to major flooding risk. The results of the preliminary hydraulic analysis indicate that the capacity of the existing channel within Study Segments 1, 2 and 3 is approximately 47 percent, 31 percent, and 42 percent of the 100-year flows, respectively. The flow capacities of the existing culverts located at those study segments are significantly lower. For Study Segment 1, the culverts at Randall Avenue, Merrill Avenue, and the SCRRA (Metrolink) railroad were found to only convey approximately 11 percent of the 100-year flows. Moreover, it is expected that the recent completion of the Highland Channel improvements in conjunction with the I-210 freeway will exacerbate the current flooding problems in this area. Although no detailed flood damage assessment was performed for this study, SBCFCD firmly believes that this alternative is not practicable due to the high potential

for significant flooding to adjacent properties and public infrastructures including loss of life.

VII. PRELIMINARY ANALYSIS OF ALTERNATIVES

The "No Action" Alternative appears to have no adverse impacts to the Santa Ana River "Sucker" fish or at the very least, this alternative seems to maintain the current impact to the ecology of the "Sucker" fish. On the other hand, Alternatives 1, 2, 3 and 4 appear to have reduced impacts.

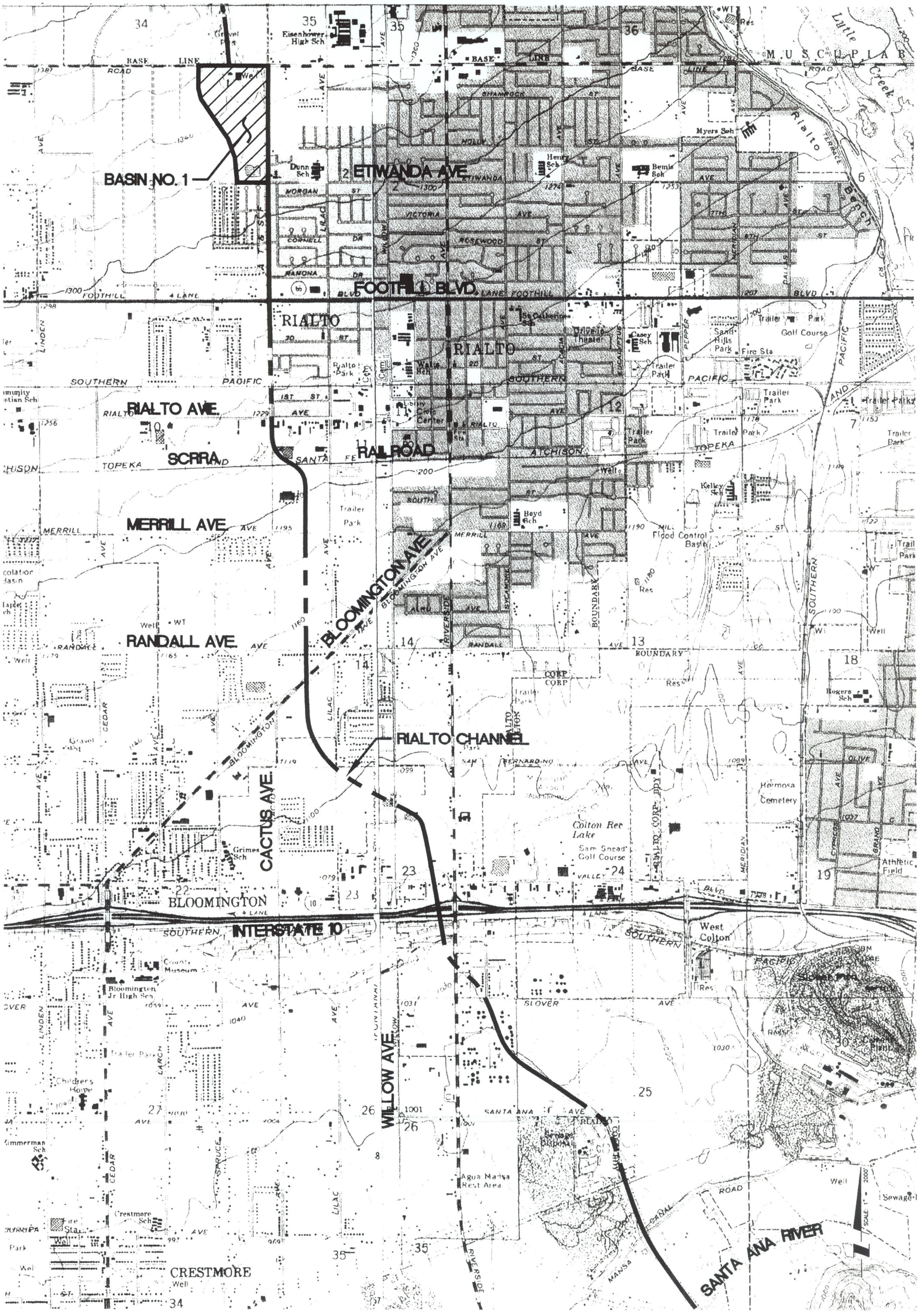
Alternatives 1 through 4 are superior to Alternative 5 or the "No Action" alternative with regards to flooding and surface drainage.

In terms of water quality and groundwater recharge, Alternatives 2, 3 and 5 are better than Alternatives 1 and 4. However, the maintenance costs for Alternatives 2, 3 and 5 are anticipated to be significantly higher than Alternatives 1 and 4.

Based solely on construction costs, Alternative 1 or the "Preferred" Alternative is the Least Damaging Environmentally Practicable Alternative.

VIII. REFERENCES

1. San Bernardino County Flood Control District Hydrology Manual, August 1986.
2. "Rialto Channel Drainage Area Comprehensive Storm Drain Plan" Report, April 1988, prepared by JMM Consulting Engineers, Inc.
3. Los Angeles County Flood Control Design Manual, March 1982.
4. Preliminary Design for Rialto Channel, AEI-CASC Engineering, August 2003.



GENERAL PROJECT LOCATION MAP

FIGURE 1

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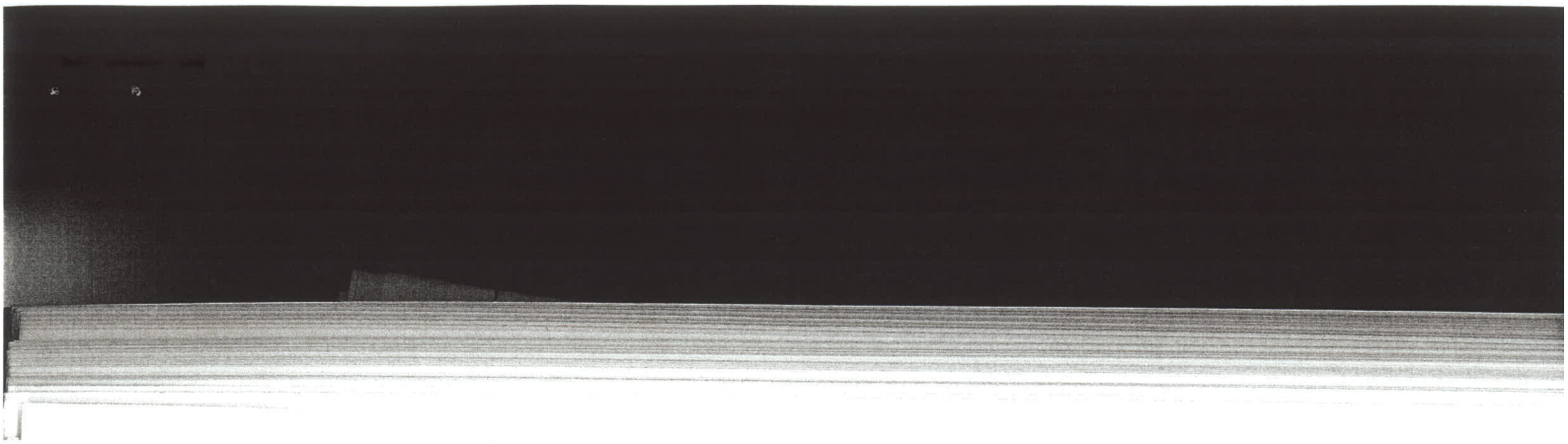
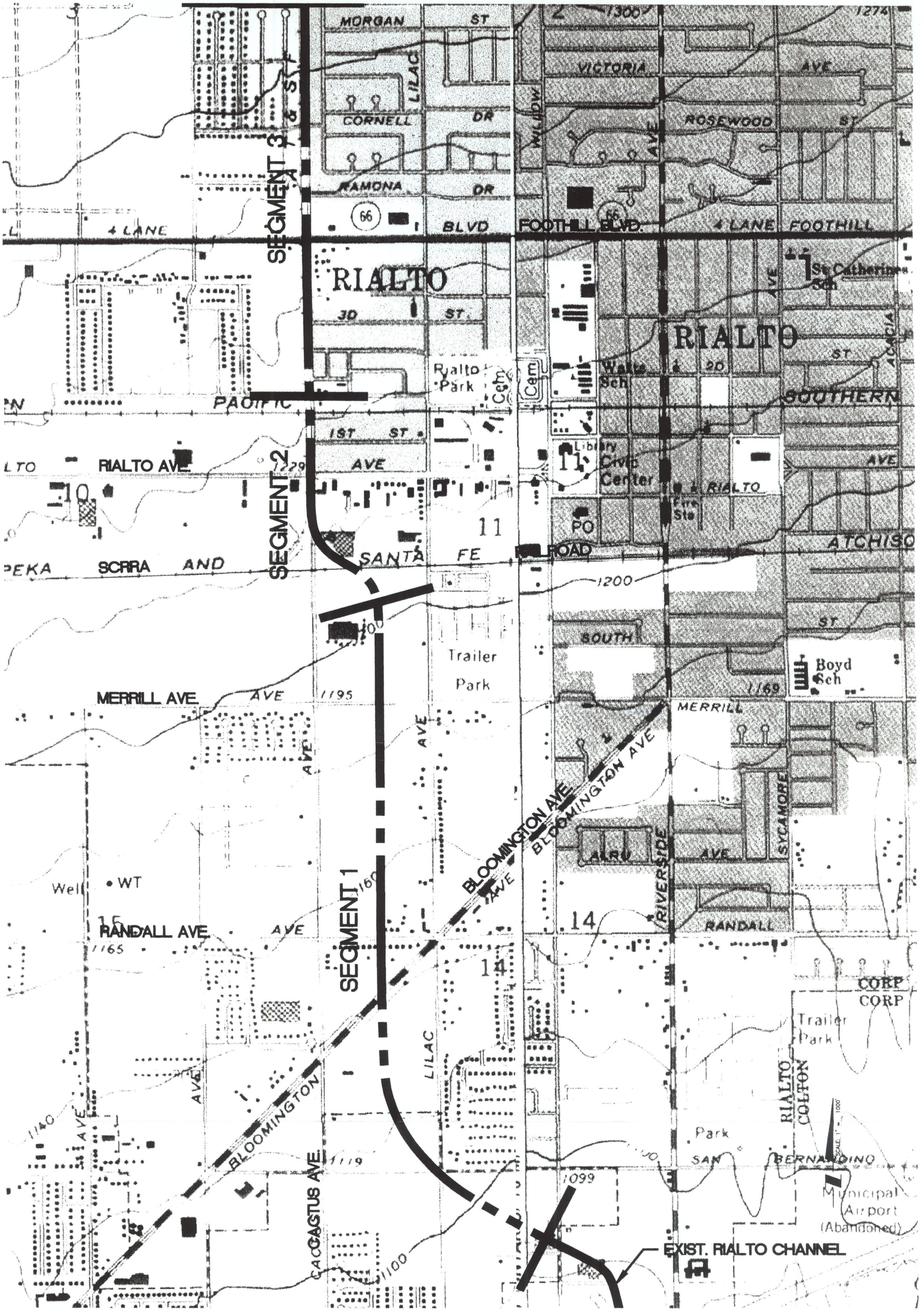


FIGURE 2

FIGURE 2: PROJECT VICINITY MAP



PROJECT VICINITY MAP

FIGURE 2

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