VENTURA COUNTY WATERSHED PROTECTION DISTRICT

ARUNDELL BARRANCA DEFICIENCY STUDY

CH2MHILL

APRIL 2006

VOLUME 1

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Section I - Introduction

Located in Ventura County, Arundell Barranca is a major watercourse in the City of Ventura (see Figure 1) portions of which are owned and maintained by the Ventura County Watershed Protection District (VCWPD). The channelized portion of the watercourse begins downstream of the existing Arundell Barranca debris dam at the Lake Canyon/Sexton Canyon confluence, flows through the City of Ventura and discharges into Ventura Harbor. The channel which is about 26,000 feet long drains a watershed of approximately 7,400 acres. There are four major tributaries to the channel: Reservoir Barranca, Barlow Barranca, Telephone Road Drain and Mills Road Drain as shown on Figure 2.

Portions of the channel have been improved over the years, with the majority of the channel consisting of rectangular or trapezoidal concrete sections. Two improvement projects are currently being planned and constructed within the watershed. First, the channel between Harbor Boulevard and the Railroad Crossing is being reconstructed. Second, the VCWPD is currently designing a new debris dam in Lake Canyon. However, even with these improvements, the channel system is currently inadequate to contain the Q100 flows. A deficiency study was conducted to identify additional channel improvements to provide 100-year flood protection.

The purpose of this report is to document the results of the deficiency study. In particular, this report:

1. Presents the hydrology of the channel system.
2. Describes the existing facilities.
3. Describes the hydraulic analysis of the existing conditions.
4. Identifies the level of protection and deficiency reaches within Arundell Barranca.
5. Provides an updated 100-year floodplain map outlining the expected extent of flooding.
6. Calculates the flood damage under existing conditions for the 100-year storm.
7. Investigates seven alternatives to alleviate flooding.
8. Presents a sediment analysis of the debris production within the watershed.
9. Outlines the preferred alternative for 100-year protection.

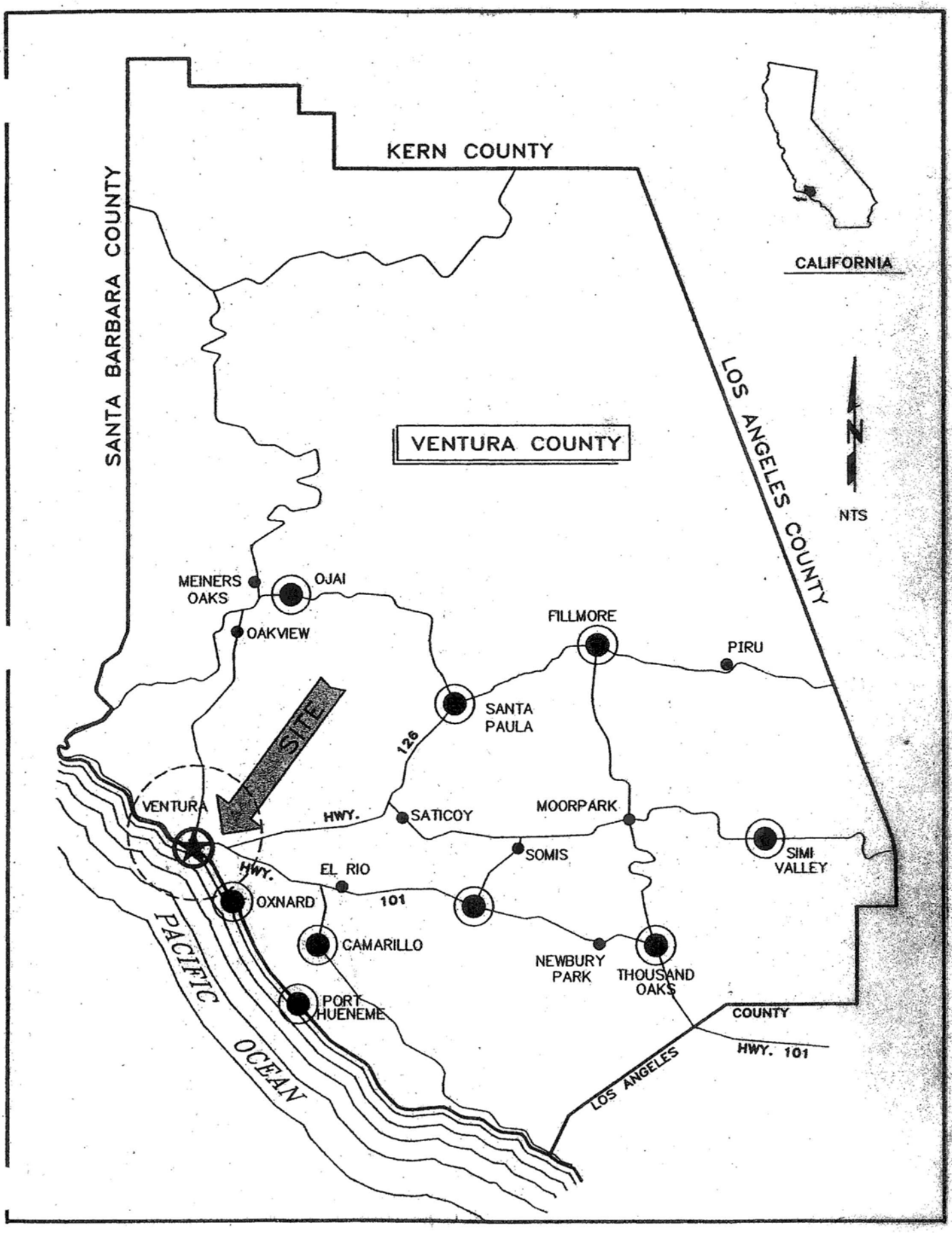


Figure 1. Vicinity Map

Figure 2. Aerial Photograph

Section II - Hydrology

Hydrology for Arundell Barranca was provided by the Ventura County Watershed Protection District. This hydrology assumes construction of Lake Canyon Dam. Table 1 presents the design flows for the 2-, 5-, 10-, 25-, 50-, and 100-year storm along the entire length of Arundell Barranca downstream of the existing Arundell Barranca Dam.

Table 1. Design discharges of Arundell Barranca

	DISCHARGE [cfs]					
LOCATION	Q_2	Q_5	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Dam Outflow	55	154	223	284	342	358
Downstream of North Victoria Crossing	122	342	516	630	760	884
Downstream of Foothills Crossing	160	450	681	831	1,001	1,178
Downstream of Loma Vista Crossing	202	568	858	1,047	1,262	1,502
Downstream of Telegraph Road Crossing	236	664	1,004	1,226	1,477	1,743
Confluence with Reservoir Barranca	329	924	1,397	1,705	2,054	2,418
Confluence with Barlow Barranca	589	1,655	2,501	3,053	3,678	4,302
Arundell at Main Street (Telephone Drain)	809	2,276	3,439	4,197	5,057	5,938
Downstream of Mills Road Drain	939	2,641	3,991	4,872	5,870	6,890
Downstream of Railroad Crossing	1,016	2,858	4,319	5,272	6,352	7,484
Downstream of Harbor Blvd.	1,020	2,868	4,334	5,290	6,373	7,498

Section III - Existing Facilities

The channel begins downstream of the debris dam at the Lake Canyon/Sexton Canyon confluence, flows through the City of Ventura and discharges into Ventura Harbor. For analysis, the channel was separated into 6 reaches. Reach 1 is the most downstream reach, from Ventura Harbor to Harbor Blvd. and is an improved rectangular concrete channel 25 feet wide by 10 feet high. Figure 3 is a typical section within this reach.

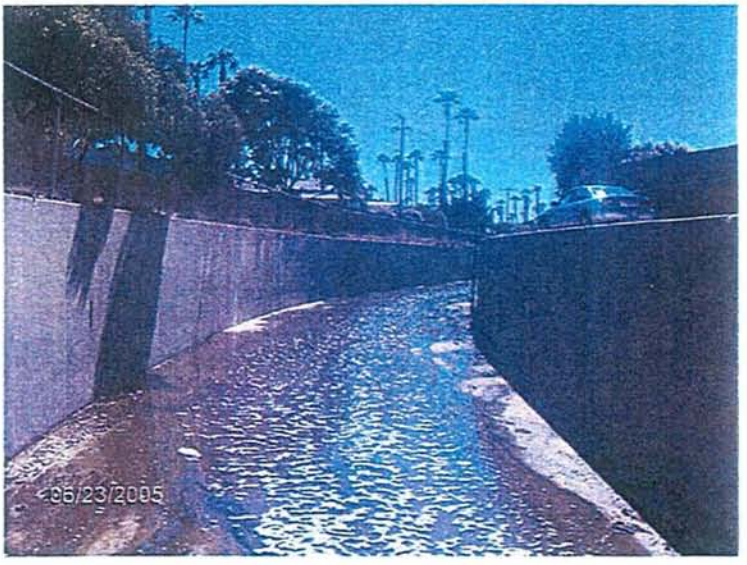


Figure 3. Reach 1, typical improved section.

Reach 2 is from Harbor Blvd to the railroad crossing, and is generally an improved concrete compound channel 20 feet wide with vertical walls that flatten to sloping walls. Construction is underway to modify this channel to a 24-foot wide by 11-foot high RCC. However, for purposes of this report the existing condition was the current compound channel and the RCC is one of the alternatives. Figure 4 is a typical channel section within this reach.

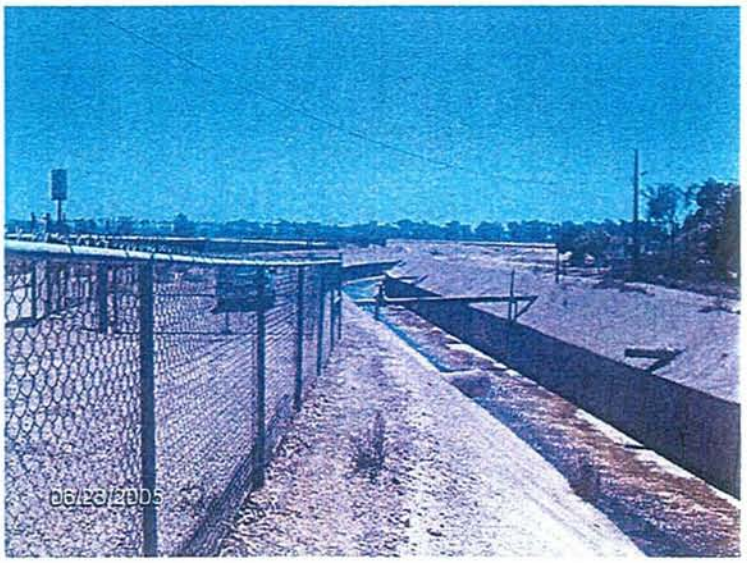


Figure 4. Reach 2, downstream of railroad.

Reach 3 is from the railroad crossing to the junction with Mills Road Drain. This reach is generally an improved rectangular concrete channel. Most of the reach is a 20-foot wide by 8-foot high RCC. Figure 5 shows the Mills Road Drain confluence with Arundell Barranca.

Figure 5. Reach 3, Mills Road Drain confluence with Arundell Barranca

Reach 4 is from Mills Road Drain to Highway 101, and is comprised of various improved channels, including a rectangular concrete box, a rectangular concrete channel, and a reinforced concrete pipe that goes under Highway 101. The RCP under 101 has a diameter of 16 feet. The RCC has a typical width of 15 to 20 feet, with a height varying from 7.5 to 18 feet. Figure 6 shows the channel transition from an RCB to an RCC, just downstream of Main Street.

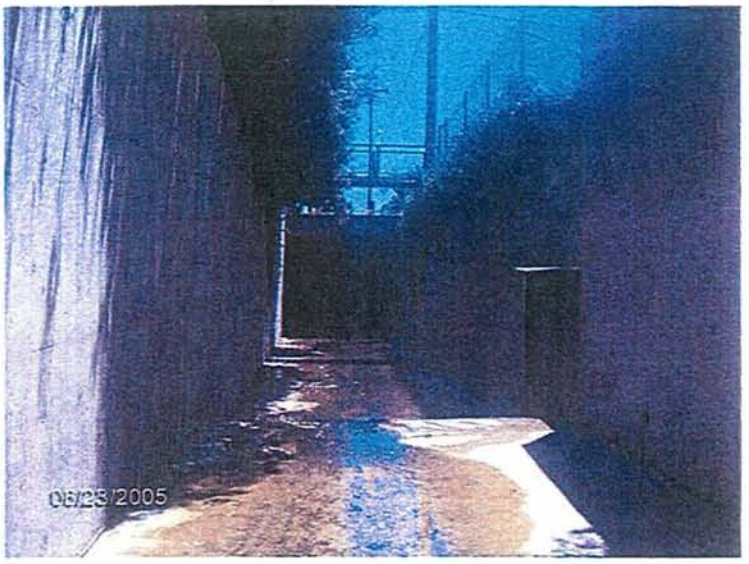


Figure 6. Reach 4, Just downstream of Main Street.

Reach 5 is from Highway 101 to Estate St. This reach is generally a rectangular concrete box. The box is typically 8 feet wide, and the height varies from 9.5 to 12 feet.

Reach 6, the final reach, is from Estate St. to the Lake Canyon/Sexton Canyon confluence. This reach is comprised of numerous channel types, including natural channels, RCCs, RCBs, and trap channels. Figure 7 shows the improved channel downstream of Foothills Crossing. More specific descriptions of the existing channel facilities are given in Table 2 for all the reaches.

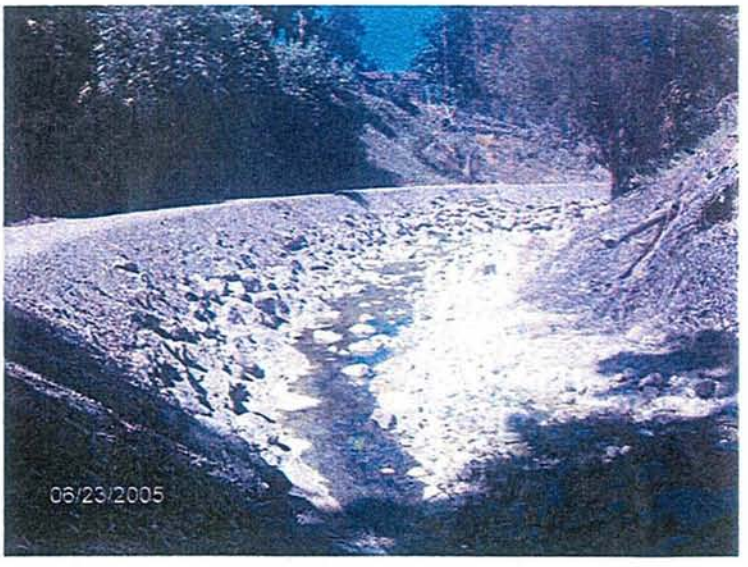


Figure 7. Reach 6, Typical improved channel downstream of Foothills Crossing.

Table 2. Inventory of channel reaches in Arundell Barranca

Channel Reach	Reach #	Station	Channel Type[2]	Channel Condition[3]	Width [ft]	Height [ft]	Average Channel Slope [ft/ft]
Dam outlet to Plainview Street	6	26222 - 24452	NAT/TRAP	N/A	varies	varies	0.023
Plainview Street Crossing	6	24452 – 24402	RCB	A	16	8	0.0066
Plainview Street to Canon Street	6	24402 - 23542	TRAP	A	8	6	0.016
Canon Street Crossing	6	23542 – 23492	RCB	A	12	8	0.02
Canon Street to North Victoria Street	6	23492 - 22501	TRAP	A	8	6	0.045
North Victoria Street Crossing	6	22501 – 22347	RCB	A	8	8.5	0.05
North Victoria Street to Foothills Road	6	22347 - 20571	TRAP/NAT	A/N	varies	varies	0.036
Foothills Crossing	6	20571 – 20316	RCB	A	10	10	0.067
Foothills Road to Brevard Street	6	20316 - 20013	RCC	A	10	10	0.015
Brevard Street Crossing	6	20013 – 19933	RCB	A	10	8	0.021
Brevard Street to grade control structure	6	19933 - 19783	RCC	A	10	8.5	0.040
Grade control structure to Loma Vista Road	6	19783 - 19046	ELC/RR	N/C	varies	varies	0.038
Loma Vista Crossing	6	19046 – 18451	RCB	A	10	8	0.024
Loma Vista Road to Telegraph Road	6	18451 - 16574	ELC/RR	N/C	varies	varies	0.014
Telegraph Culvert	6	16574 – 16284	RCB	A	10	10.5	0.048
Telegraph Road to Box Culvert	6	16284 - 16180	RCC	A	11	9	0.069
Box Culvert d/s of Telegraph Crossing	6	16180 – 15580	RCB	A	12	10	0.027
Box Culvert to Estate Street	6	15580 - 13978	ELC/NAT	N	varies	varies	0.017
Estate Street Culvert	5	13978 - 10016	RCB	A	8 - 12	9.5- 12	0.018
Estate Street to Highway 101/126	5	10016 - 9955	TRAP	A	18	14	0.048
Highway 101/126 Culvert	4	9955 – 9305	CMP	A	-	16	0.0093

Channel Reach	Reach #	Station	Channel Type[2]	Channel Condition[3]	Width [ft]	Height [ft]	Average Channel Slope [ft/ft]
Highway 101/126 to Main Street	4	9305 - 9185	RCC	A	15	18	0.030
Main Street Culvert	4	9185 – 9035	RCB	A	15	12.5	0.065
Main Street to Market Street	4	9035 - 7066	RCC	A	20	7.5 – 9.5	0.0103
Market Street Crossing	3	7066 - 6991	RCB	A	20	8	0.0103
Arundell Court Crossing	3	6239 – 6179	RCB	C	20	8	0.0103
Market Street to Mill Street	3	6991 - 5999	RCC	A	20	8	0.0103
Mill Street Crossing	3	5999 – 5979	RCB	C	20	8	0.0375
Mill Street to Railroad Crossing	3	5979 - 5715	CCC	C	20	varies	0.0142
10 inch water line	3	5856	CCC	C	20	6.5	0.0095
10 inch water line	3	5756	CCC	C	20	6.5	0.0095
Railroad Crossing	3	5735 – 5715	RCB	C	20	8.75	0.0095
10 inch water line	2	5565	CCC	C	20	6.5	0.0095
Railroad Crossing to Ocean Drive	2	5715 - 2083	CCC	C	20	varies	0.009
Ocean Drive Crossing	2	2083 – 2068	RCB	C	20	12.5	0.0109
Harbor Blvd. Crossing[1]	2	2038 – 1998	RCB	C	23	11.5	0.0109
Harbor Blvd. to Beachmont Street	1	1998 - 210	RCC	A	25	10	0.0082
Beachmont Street Crossing	1	210 - 150	RCB	A	25	10	0.0063

1. Harbor Blvd. has a single pier 1 foot in width.
2. RCB: Rectangular Concrete Box: CMP: Corrugated Metal Pipe; RCC: Rectangular Concrete Channel; TRAP: Concrete Trapezoid Channel; CCC: Concrete Compound Channel (rectangular channel of variable height with trapezoidal side slopes above); NAT: Natural Channel; ELC: Earth Lined Channel with sloping banks; RR: rip rap channel.
3. A: recent construction in good condition; C: older construction in need of repair; N: unimproved channel.

Section IV – Hydraulic Analysis of Existing Conditions

Hydraulic analysis of existing conditions was modeled using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS), with updated design flows, provided by VCWPD. Water Surface Pressure Gradient (WSPG) hydraulic analysis program was also used to model various sections.

The channel hydraulic model was created from the following data sources:

1) As-built drawings

2) Topographic map surveyed in 2005

3) Field investigation on June 23, 2005

4) Design flows obtained for Q_2 through Q_{100}.

5) Ventura County Flood Control District (VCFCD) Design Manual (1968)

The channel as-built drawings were obtained from VCWPD and the City. The existing channel geometry for the improved channel areas was taken from these drawings. A recent (1991) survey of benchmark monuments indicated that a datum adjustment of 2.46 feet had to be added to the as built drawings to match the 2005 topographic maps.

A current (2005) topographic map of Arundell Barranca watershed, typically illustrating 1 foot contour lines (2 foot contour lines were available for the most upstream reaches of the Arundell Barranca from the dam outlet to the Foothills Street crossing) was provided by VCWPD. These topographic maps provided a general description of the un-improved channel and the overbank topography.

A field investigation was conducted on June 23, 2005. The project team walked the entire length of Arundell Barranca. Major channel geometry and the inlet and outlet dimensions of each culvert or street crossing were measured. Field estimates of channel roughness (in terms of Manning's n values) were also noted and a number of photographs were taken to assist in model development. Visual estimates of Manning's n values were also compared to the suggested values from the VCFCD Design Manual and were nearly identical.

The USACE River Analysis System HEC-RAS program was used to compute water surface profiles. A total of 21 culverts, mid-channel utility line crossings or crossings are described in the HEC-RAS model of existing conditions. Bridge crossings were modeled as broad-crested weirs with the default value of 2.6 for the weir coefficient. The bridge approach was modeled using the energy method for low flows (i.e., flows not influenced by bridge deck), except for Harbor Boulevard, where the momentum equation was used to account for a pier (assumed drag coefficient of 1.2), and were modeled assuming pressure and/or weir flow for high flows (i.e., flows influenced by bridge deck). Bridge approaches under high flow conditions were modeled using default values for both the sluice and orifice coefficients (table values depending upon degree of submergence and 0.8, respectively). Assumed values of channel roughness (Manning's n) by channel type are presented in Table 3.

Table 3. Assumed channel roughness by channel type

Channel Type	Manning's 'n'
Flood plain	0.04 – 0.065
Concrete Channel	0.015
Rip rap channel/side slope	0.035
Natural channel	0.04 – 0.05

Based on discussions with HEC-RAS technical assistance, due to the high flow conditions and relatively constant channel geometry within the semi-improved reaches, the default expansion/contraction coefficients of 0.1 and 0.3 were reduced to 0.01 and 0.03, respectively, to limit losses of velocity head between cross sections. Upstream boundary conditions were set to normal flow depth (slope of 0.0267). From recent conversations with the USACE we set the downstream boundary conditions to the known water surface elevation of the mean higher high water surface elevation (M.H.H.W.). Channel as built drawings from 1967 indicate the M.H.H.W. elevation is equal to 2.65 feet (or 5.11 feet after adjusting for datum differences).

WSPG was used to model the reach between Mills Road Drain and Estate Street to account for losses due to the junctions and also to model the culvert between the 101 freeway and Estate Street. Flows not contained within the box culvert were subtracted from the overall flow rate and then modeled by normal depth methods to determine the floodplain. HEC-RAS and WSPG out put of existing conditions are presented in Appendix A.

Section V - Level of Protection and Deficiency Areas

The 100-year flow is contained within the existing channel from the outlet of the existing dam to the Estate Street culvert. Flows above a 25-year storm will overtop the culvert at Estate Street. In addition, flows will backup from the junction of Telephone Road Drain at Main Street and will overtop the channel upstream of Main Street. Between the outlet of the Highway 101/126 culvert and the Market Street bridge three major tributaries drain into Arundell Barranca: 1) Barlow Barranca, 2) Telephone Road Drain and 3) Mills Road Drain. The combination of these three tributaries increases the Q_{100} discharge from 2,418 cfs to 6,890 cfs. Every crossing downstream of the Mills Road drain is deficient. For example, the design flow for the most downstream crossing (i.e., Beachmont Street) is only 4,600 cfs (the estimated Q50 as of 1967). In comparison, the current estimate of Q_{50} is 6,373 cfs, which is approximately 40% larger then the design discharge.

To estimate the level of protection provided within each reach, HEC-RAS simulations were run using a mixed flow regime with the various crossings removed. Simulated water elevations were compared to the low chord of the each crossing. It was determined that the existing channel provides protection for those flows able to pass under each crossing. WSPG was also utilized to identify deficient areas between Estate Street and Mills Road drain to account for losses due to the junctions and also to model the culvert between the 101 freeway and Estate Street.

Five of the six channel reaches contain deficiencies. Table 4 summarizes the level of protection offered by each deficiency reach. The most downstream deficiency is associated with the Beachmont Street crossing. This section of Arundell Barranca can currently pass flows up to the Q_{25} (i.e., approximately 5,300 cfs). The next deficiency is immediately upstream of the Harbor Blvd. and Ocean Drive crossings, followed by the reach from the railroad crossing to the Mills Road Drain confluence. The next two deficiency areas are associated with the Telephone Road Drain junction at Main Street and the RCB under the park south of Estate Street which is unable to convey the Q_{100} or the Q_{50} with freeboard.

Table 4. Level of Protection in deficient reaches

Reach	Level of Protection (return frequency)
1. Beachmont Street to Harbor Blvd.	Q_2, Q_5, Q_{10}, Q_{25}
2. Harbor Blvd./Ocean Drive to Railroad Crossing	Q_2, Q_5, Q_{10}, Q_{25}
3. Railroad Crossing to Mills Road Drain	Q_2, Q_5
4. Mills Road Drain to 101 Freeway	Q_2, Q_5, Q_{10}, Q_{25}
5. 101 Freeway to Estate Street	Q_2, Q_5, Q_{10}, Q_{25}

Section VI - Flooding and Cost of Damages

Based on the results of the existing conditions hydraulic analysis described in Section V, the extent of the 100-year flooding limits and the 1, 2 and 3 foot contours of depth are shown in Figures 8, 9, and 10. These figures have flooding zones similar to those identified in the current FEMA Flood Maps (Appendix E). However, there are some differences between the two sets of flood maps. The FEMA Flood Maps indicate that flooding will occur along Victoria Ave, from Foothill Ave. to Viewcrest Dr. The existing conditions analysis did not show this flooding, possibly due to the assumption that the Lake Canyon Dam is constructed. The next difference occurs at Estate St. The hydraulic analysis performed indicates that flooding occurs at the Estate St culvert. The FEMA Flood Maps do not indicate flooding will occur in this area. When Arundell Barranca flows under Harbor Blvd., the hydraulic analysis indicates that more extensive flooding will occur than what is designated in the FEMA Flood Maps, especially to the south of Arundell Barranca

Flood damage costs were estimated using FEMA's State and Local Mitigation Plan, How-to Guide (August 2001). The VCWPD provided average house sizes and cost per square foot for residential, commercial, and agricultural land. The total area of flooding is approximately 263 acres. Approximately 112 acres, or 43 percent of the entire flooded area is agricultural land. Total damages to agricultural land are estimated at $33,754,000. Approximately 100 acres, or 38 percent if the flooded area is residential area. There are 427 residential structures in the flooded area. Property damage due to flooding is estimated at $22,093,000. Approximately 51 acres, or 19 percent of the flooded area is commercial area. An estimated 35 commercial structures are in the flooded area. Property damage to commercial structures is estimated at $20,730,000. The total flood damage cost for agricultural, residential, and commercial areas is $76,578,000 (See Appendix D for Calculations).

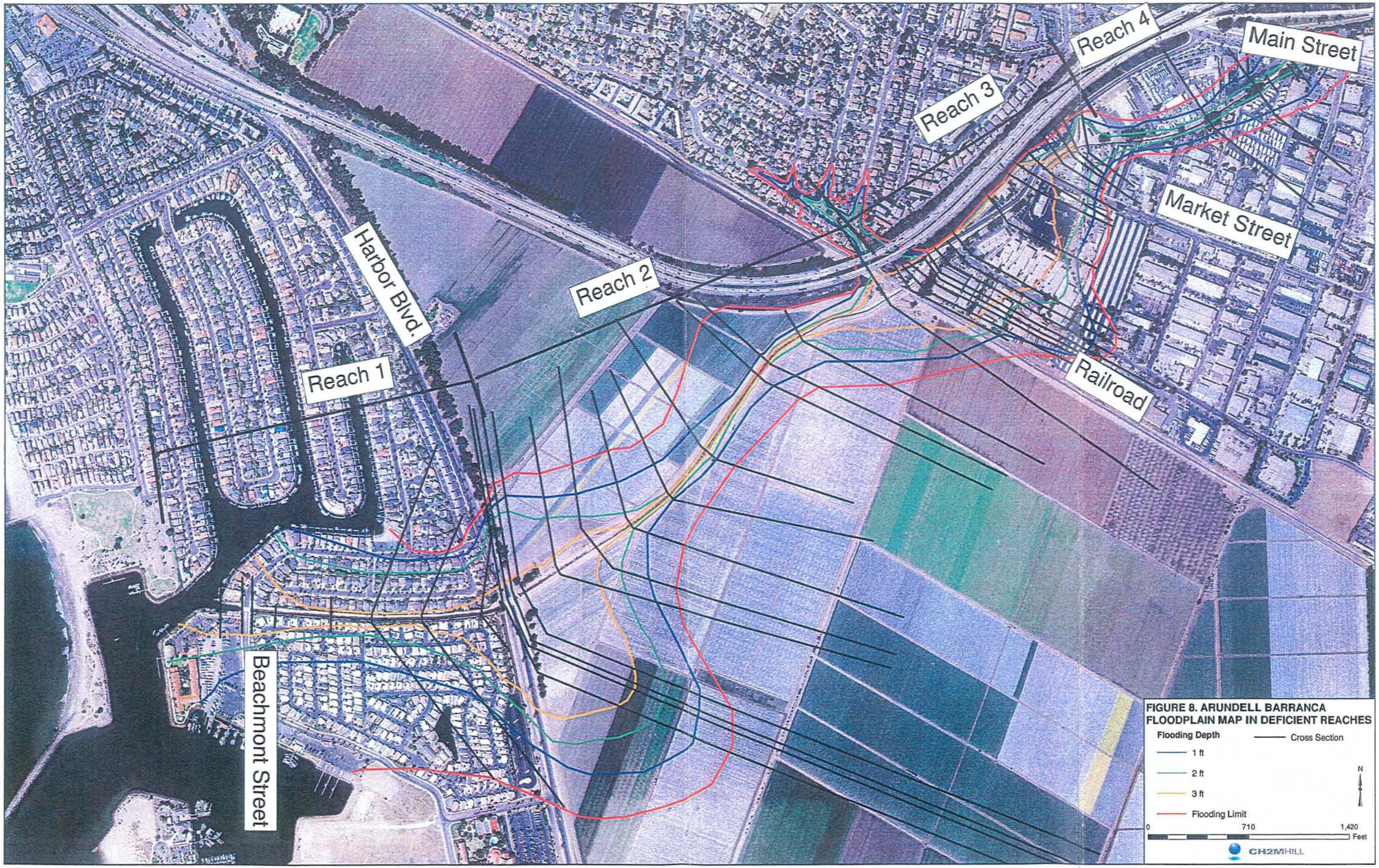


FIGURE 8. ARUNDELL BARRANCA FLOODPLAIN MAP IN DEFICIENT REACHES

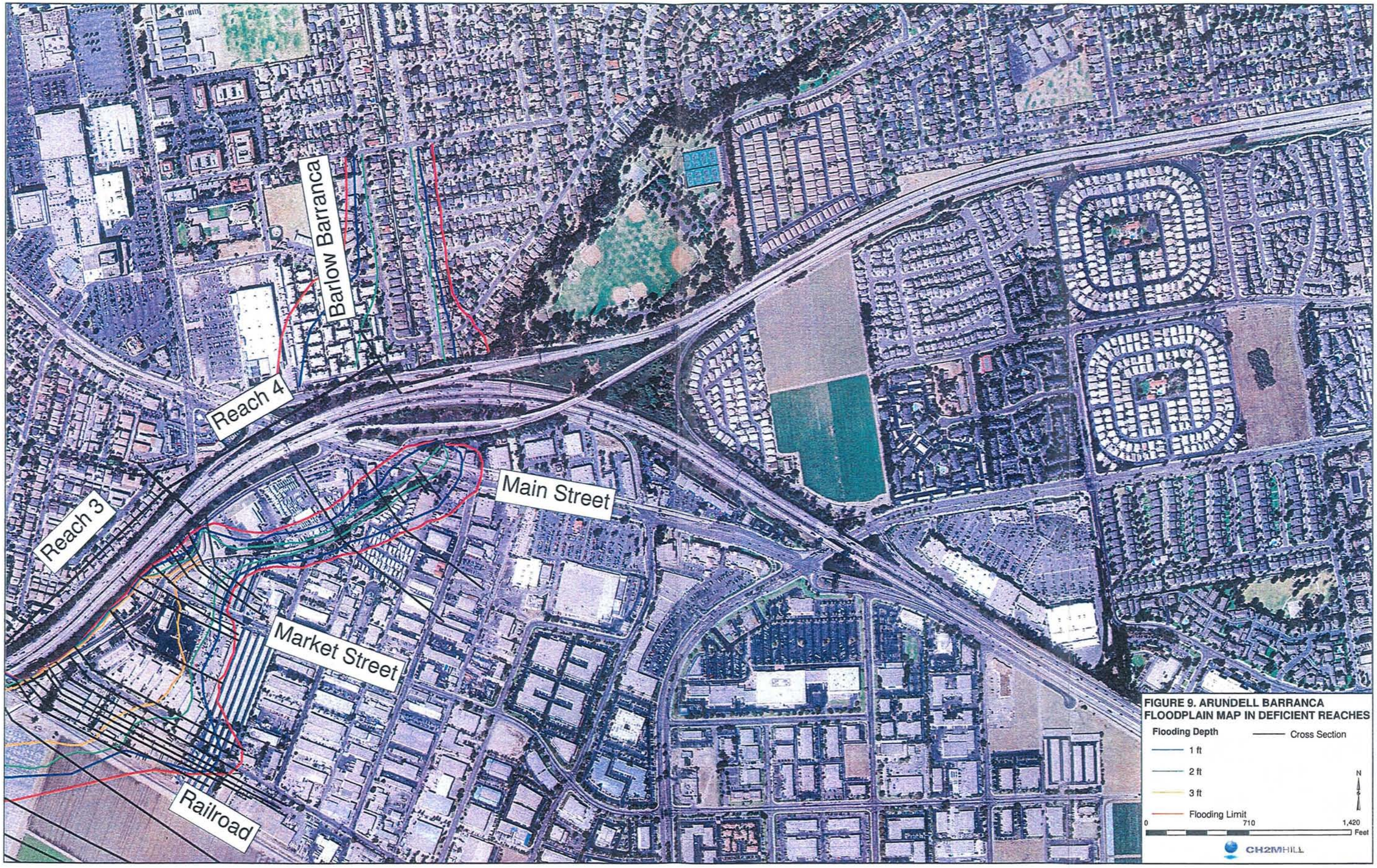
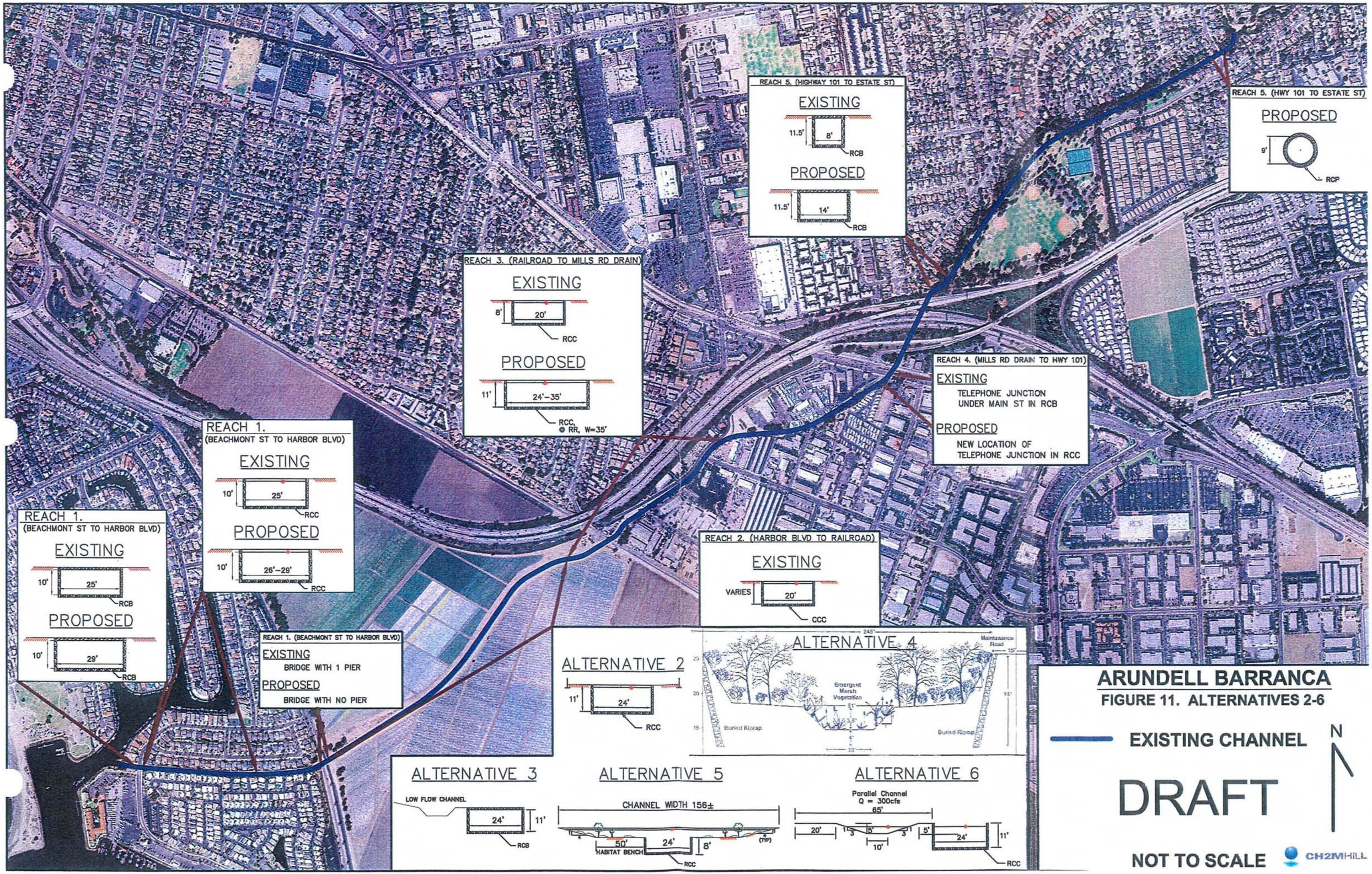
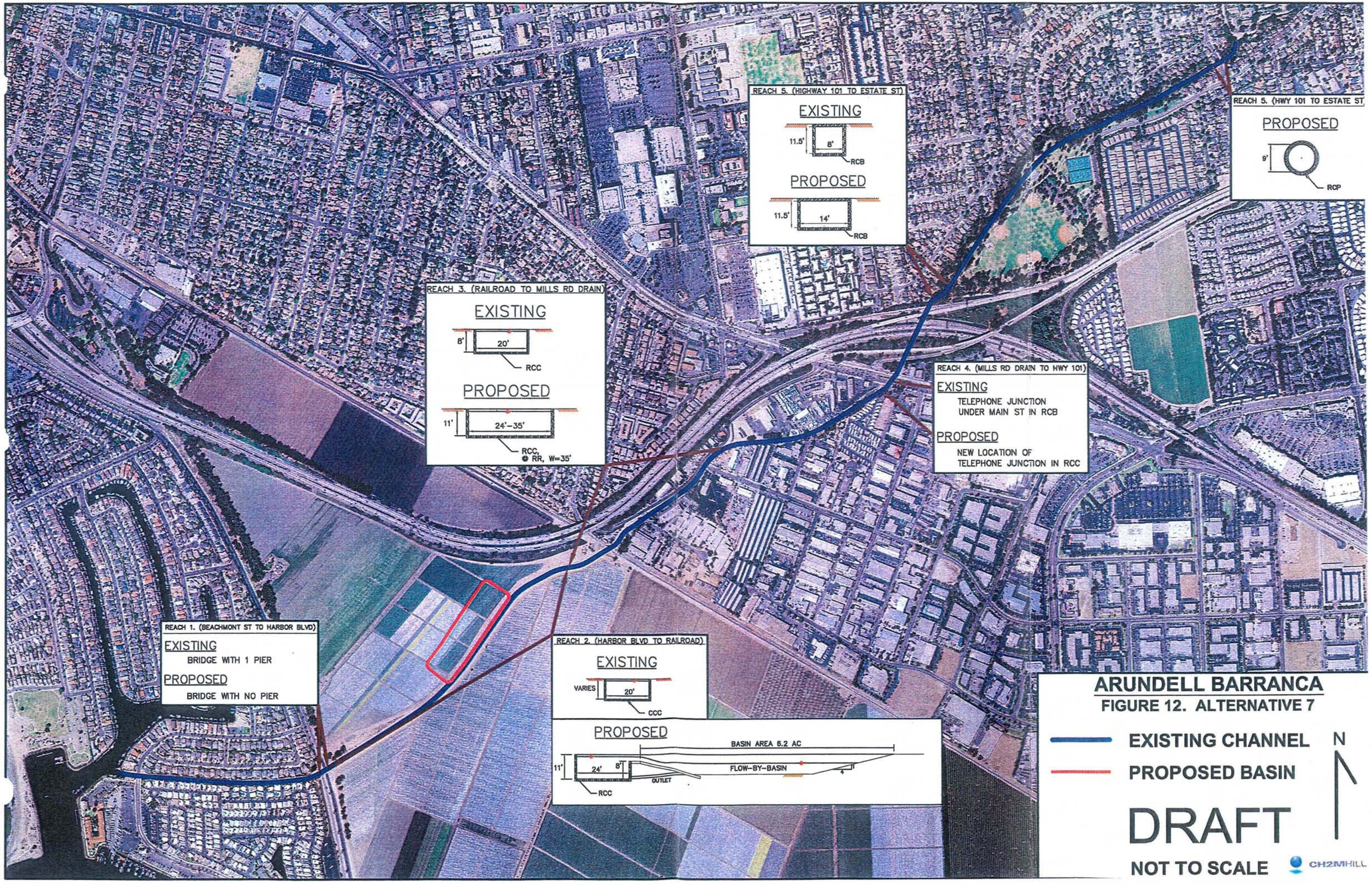


FIGURE 9. ARUNDELL BARRANCA FLOODPLAIN MAP IN DEFICIENT REACHES

FIGURE 10. ARUNDELL BARRANCA FLOODPLAIN MAP IN DEFICIENT REACHES


REACH 5. (HIGHWAY 101 TO ESTATE ST)
EXISTING
11.5'
8'
RCB
PROPOSED
11.5'
14'
RCB
REACH 5. (HWY 101 TO ESTATE ST)
PROPOSED
9'
RCP
REACH 3. (RAILROAD TO MILLS RD DRAIN)
EXISTING
8'
20'
RCC
PROPOSED
11'
24'-35'
RCC,
RR, W=35'
REACH 4. (MILLS RD DRAIN TO HWY 101)
EXISTING
TELEPHONE JUNCTION
UNDER MAIN ST IN RCB
PROPOSED
NEW LOCATION OF
TELEPHONE JUNCTION IN RCC
REACH 1.
(BEACHMONT ST TO HARBOR BLVD)
EXISTING
10'
25'
RCC
PROPOSED
10'
26'-29'
RCC
REACH 1.
(BEACHMONT ST TO HARBOR BLVD)
EXISTING
10'
25'
RCB
PROPOSED
10'
29'
RCB
REACH 2. (HARBOR BLVD TO RAILROAD)
EXISTING
VARIES
20'
CCC
REACH 1. (BEACHMONT ST TO HARBOR BLVD)
EXISTING
BRIDGE WITH 1 PIER
PROPOSED
BRIDGE WITH NO PIER
ALTERNATIVE 2
11'
24'
RCC
ALTERNATIVE 4
245'
Maintenance Road
Emergent Marsh Vegetation
Buried Riprap
Buried Riprap
ALTERNATIVE 3
LOW FLOW CHANNEL
24'
11'
RCB
ALTERNATIVE 5
CHANNEL WIDTH 156±
50'
HABITAT BENCH
24'
8'
RCC
ALTERNATIVE 6
Parallel Channel
Q = 300cfs
65'
20'
5'
10'
5'
24'
11'
RCC
ARUNDELL BARRANCA
FIGURE 11. ALTERNATIVES 2-6
EXISTING CHANNEL
N
DRAFT
NOT TO SCALE
CH2MHILL


REACH 5. (HIGHWAY 101 TO ESTATE ST)
EXISTING
11.5'
8'
RCB
PROPOSED
11.5'
14'
RCB
REACH 5. (HWY 101 TO ESTATE ST)
PROPOSED
9'
RCP
REACH 3. (RAILROAD TO MILLS RD DRAIN)
EXISTING
8'
20'
RCC
PROPOSED
11'
24'-35'
RCC,
RR, W=35'
REACH 4. (MILLS RD DRAIN TO HWY 101)
EXISTING
TELEPHONE JUNCTION
UNDER MAIN ST IN RCB
PROPOSED
NEW LOCATION OF
TELEPHONE JUNCTION IN RCC
REACH 1. (BEACHMONT ST TO HARBOR BLVD)
EXISTING
BRIDGE WITH 1 PIER
PROPOSED
BRIDGE WITH NO PIER
REACH 2. (HARBOR BLVD TO RAILROAD)
EXISTING
VARIES
20'
CCC
PROPOSED
BASIN AREA 6.2 AC
11'
24'
8'
FLOW-BY-BASIN
OUTLET
RCC
ARUNDELL BARRANCA
FIGURE 12. ALTERNATIVE 7
EXISTING CHANNEL
PROPOSED BASIN
N
DRAFT
NOT TO SCALE
CH2MHILL

Section VII – Alternative Analysis

Description of Alternatives

The goal of the alternative analysis is to provide 100-year protection with no freeboard and 50-year protection with freeboard throughout Arundell Barranca in a cost-effective and environmentally sound manner. For example, through upstream detention the current deficiencies may be addressed without the need to improve the channel. However, where the channel is in need of repair, it may be more cost effective to replace existing structures with wider cross sections to allow for greater conveyance. Seven different alternatives were analyzed, and are discussed below. Alternative 3 has two variations 3a and 3b. The improvements for each alternative are outlined in Figures 11 and 12.

Alternative 1

Alternative 1 is to take no action, and leave the channel as is.

Alternative 2

Alternative 2 is an all channel alternative. This alternative will require replacement of deficient facilities with channels capable of conveying the necessary flows. In Reach 1, the Beachmont St culvert will have to be replaced with a 28 foot x 10 foot RCB. Also, the channel will have to be widened from STA 1350 to the culvert.

In Reach 2, the existing concrete compound channel will be replaced with a 24-ft x 11-ft rectangular concrete channel which is currently being constructed. The entire length of Reach 2 needs to be replaced. Super-critical flow conditions will be maintained under the Harbor Blvd and Ocean Drive crossings by removing the 3 foot drop immediately downstream of Harbor Blvd and maintaining an average channel gradient of approximately 0.0139 ft/ft. Additionally, the bridge at Harbor Blvd will be reconstructed to remove the pier.

In Reach 3, the existing rectangular concrete channel will be replaced with a larger rectangular concrete channel. The proposed replacement channel has a height of 11 feet, and the width varies from 24 feet to 35 feet. The channel width will expand from 24 feet to 35 feet under the railroad crossing.

In Reach 4, it is proposed that the Telephone Road Drain be moved. Currently, the Telephone Road Drain confluences with Arundell Barranca under Main Street, in a box culvert. The existing confluence angle is 60 degrees. It is proposed that the Telephone Road Drain confluence be moved to just downstream of Main Street. The drain will confluence with the existing rectangular concrete channel at an angle of 35 degrees. The channel will not be replaced.

In Reach 5, there are a few proposed improvements. It is proposed that a 9-foot reinforced concrete pipe be installed under Estate St, next to the existing box culvert. This pipe will convey excess flow into the existing natural channel. A flow restriction plate will be installed in the existing box culvert to limit the flow into the culvert, and produce the

required head needed to push the excess flow through the new pipe. The excess flow will be conveyed in the existing natural channel until just upstream of Highway 101. At this point, the flow will be rerouted back into the channel. There is currently a 4-ft reinforced concrete pipe at this location. This pipe needs to be replaced with an 8-foot reinforced concrete pipe to convey the flow back into the existing channel. The existing channel is an 11.5-ft x 8-ft box culvert where the flow reenters. This box needs to be replaced with a 11.5-ft x 14-ft box culvert.

Reach 6 requires no improvements.

Alternative 3a

Alternative 3a is the same as alternative 2, except for reach 2. In reach 2, the 24-ft x 11-ft rectangular concrete channel currently under construction would be covered. This would be accomplished by constructing a cover that would likely have to be supported by piers or other type of foundation. In addition, a low flow channel will be constructed parallel to the covered channel for habitat enhancement. This channel will capture and convey low flow.

Alternative 3b

Alternative 3b is the same as alternative 3a, except for reach 2. In reach 2, the existing concrete compound channel will be replaced with a 24-ft x 11-ft rectangular concrete channel currently under construction. Additionally, a low flow channel will be constructed parallel to the concrete channel for habitat enhancement. This channel will capture and convey low flow.

Alternative 4

Alternative 4 is the same as Alternative 2, except for Reach 2. In Reach 2, the existing concrete compound channel will be replaced with a restored natural channel. This natural channel will be trapezoidal, with a 30-ft base, 3.5 foot depth, and 3 to 1 side slopes. 80 foot habitat benches will be on each side of the channel to convey flow from large storm events. The habitat benches have side slopes of 2 to 1.

Alternative 5

Alternative 5 is the same as Alternative 2, except for Reach 2. In Reach 2, the existing concrete compound channel will be replaced with 24-ft x 8-ft rectangular concrete channel. A 50-ft habitat bench on each side of the channel will convey excess flow during a large storm event. The habitat benches have side slopes of 4 to 1.

Alternative 6

Alternative 6 is the same as Alternative 2, except for Reach 2. In Reach 2, the existing concrete compound channel will be replaced with a 24-ft x 11-ft rectangular concrete channel. Additionally, a parallel channel will be constructed along the concrete channel. This channel will capture and convey excess flow during large storm events.

Alternative 7

Alternative 7 is the same as alternative 2, except for reaches 1 and 2. To reduce the flow to Reach 1, a detention basin will be constructed upstream in reach 2 along the channel. This basin will capture excess runoff during major storm events, and allow Reach 1 to be left as

is. In Reach 2, the existing concrete compound channel will be replaced with a 24-ft x 11-ft rectangular concrete channel which is currently being constructed.

Cost Estimates

Order of magnitude cost estimates were prepared for each alternative. Costs include construction, right-of-way, engineering and design, and construction administration. Table 5 shows the cost estimate for each alternative. Alternative 2, the all channel alternative is the least costly alternative at $22,430,000. The most expensive alternative is Alternative 4, natural channel, at $32, 390,000. Detailed cost estimates for each alternative are in Appendix C.

Table 5 Cost estimates

Alternative	Cost
Alternative 1. No Action	$ -
Alternative 2. All Channel	$ 22,430,000
Alternative 3a. Low Flow Channel/Box	$ 27,740,000
Alternative 3b. Low Flow Channel/Channel	$ 23,410,000
Alternative 4. Natural Channel	$ 32,390,000
Alternative 5. Channel/Habitat Bench	$ 27,030,000
Alternative 6. Channel/Parallel Channel	$ 24,600,000
Alternative 7. Channel/Basin	$ 23,160,000

Alternative Analysis

Each of the alternatives was evaluated based on a number of factors and ranked in accordance with the criteria outlined in the District's Integrated Watershed Protection Plan Fiscal Year 2005 Zone I ranking criteria. The criteria are divided into five categories as outlined below.

1. Public Health and Safety related to flooding (flooding of buildings, streets, agricultural resources)
2. Environmental Impacts (streambank and habitat protection, water quality and regulatory issues)
3. Effect on Community Components (construction impacts, recreation and socio-economic benefits)
4. Project Costs (benefit/cost ratio, ease of maintenance and property acquisition, and funding)
5. Associated Projects (adjacent projects)

The criteria are assigned weighting factors of 1 through 6 based on the assigned importance of the category to the District, the public, and the environment. Each item was ranked from 0 to 5 with 5 indicating that this component adds to the priority of the project or does not make it difficult to construct. A score of 0 indicates that the component makes it difficult to construct or does not make the project a higher priority for construction.

The alternative that received the highest ranking as shown in Table 5 is Alternative 7, Channel/Basin. This alternative had a score of 231. Alternative 5, Channel Habitat Bench, was only one point different with a score of 230. Alternative 2, the all channel alternative, was also close with a score of 229. Because each of these alternatives are closely ranked, any of them would be a potentially good alternative. They each have their advantages and disadvantages. The advantage to for Alternative 7 is the channel downstream of Harbor Boulevard and the Beachmont Street Bridge would not need to be reconstructed. However, right-of-way will need to be acquired to build the detention basin. The advantage for Alternative 5 is that habitat improvements in the reach between the railroad and Harbor Boulevard are provided. However, right-of-way would need to be acquired to construct the habitat bench. The advantage for Alternative 2 is right-of-way acquisition is significantly less than Alternatives 5 and 7. However, no habitat improvements are provided and the channel downstream of Harbor Boulevard and the Beachmont Street Bridge would need to be reconstructed.

Alternatives 3a, 3b, and 6 scored significantly lower than Alternatives 2, 5, and 7 and should be eliminated from further consideration. Alternative 4 scored a little lower than Alternatives 2, 5, and 7. Alternative 4 is similar to Alternative 5 with habitat improvements. However, Alternative 5 uses a portion of the concrete channel that is currently being constructed to convey the 25-year flow and requires less right-of-way acquisition than Alternative 4. Alternative 1 is the do nothing alternative and received the lowest score because it does nothing to improve the flooding impacts relative to public health and safety.

Table 6. Alternatives Matrix

Ranking Criteria	Weighting Factor (1-6)	Alt 1. No Action		Alt 2. All Channel		Alt 3a. Low Flow Channel/Box		Alt 3b. Low Flow Channel/Channel		Alt 4. Natural Channel		Alt 5. Channel/Hab.Bench		Alt 6. Channel/Parallel Channel		Alt 7. Channel/Basin	
		Category Rank (0-5)	Category Score	Category Rank (0-5)	Category Score	Category Rank (0-5)	Category Score	Category Rank (0-5)	Category Score	Category Rank (0-5)	Category Score	Category Rank (0-5)	Category Score	Category Rank (0-5)	Category Score	Category Rank (0-5)	Category Score
Public Health and Safety																	
Flooding of Public Right of Way	4	0	0	5	20	5	20	5	20	5	20	5	20	5	20	5	20
Flooding of Buildings	6	0	0	5	30	5	30	5	30	5	30	5	30	5	30	5	30
Flooding of Agricultural Resources	2	0	0	5	10	5	10	5	10	5	10	5	10	5	10	5	10
Frequency of Flooding	4	0	0	3	12	3	12	3	12	3	12	3	12	3	12	3	12
Rehabilitation of Existing District Facilities	6	0	0	4	24	4	24	4	24	4	24	4	24	4	24	4	24
Environmental																	
Streambank Protection	4	0	0	1	4	1	4	1	4	3	12	3	12	1	4	2	8
Habitat Improvement	4	0	0	3	12	3	12	3	12	4	16	5	20	3	12	4	16
Water Quality	3	0	0	1	3	1	3	2	6	3	9	3	9	2	6	3	9
Water Conservation	4	0	0	0	0	0	0	0	0	2	8	2	8	0	0	3	12
Regulatory Issues	3	5	15	3	9	3	9	3	9	4	12	4	12	3	9	3	9
Sediment Equilibrium	2	0	0	1	2	2	4	2	4	3	6	4	8	2	4	2	4
Community Components																	
Construction Related Impacts	6	5	30	3	18	3	18	3	18	3	18	2	12	3	18	2	12
Recreation Opportunities	1	0	0	2	2	2	2	2	2	3	3	3	3	2	2	3	3
Socio-Economic Opportunities	5	0	0	4	20	4	20	4	20	4	20	4	20	4	20	4	20
Life Cycle Costs																	
Benefit/Cost	6	0	0	4	24	3	18	4	24	2	12	3	18	4	24	4	24
Maintenance Level	6	3	18	5	30	3	18	3	18	2	12	2	12	3	18	3	18
Property Acquisition	3	5	15	3	9	0	0	0	0	0	0	0	0	0	0	0	0
Project Agreements/Grant Funding	5	0	0		0		0		0		0		0		0		0
Project Dependencies																	
Project Coordination/Phasing	6	4	24		0		0		0		0		0		0		0
Project Total			102		229		204		213		224		230		213		231

Section VIII - Sedimentation Analysis

This section details the methodology and results used to estimate debris production within the Arundell Barranca watershed upstream of Foothills Blvd. Significant maintenance dredging is required within Ventura Harbor. The purpose of this work is to identify critical locations for potential debris basins upstream of Foothills Blvd. to reduce the amount of debris reaching Ventura Harbor.

Method

Watershed wide debris production for a given storm intensity was estimated upstream of the Foothills Blvd. using the Ventura County Watershed Protection District (VCWPD) Manual. This manual provides and summarizes and updates the work of K. Scott and R. Williams (1974). The estimates of debris production were limited to those areas upstream of Foothills Blvd. because this method is only applicable to predominately undeveloped landscapes. The formula developed by K. Scott and R. Williams (1974) and updated by the VCWPD to estimate debris production for various storm events is:

$$SY = 17.54(A)^{0.828} \times (ER)^{1.382} \times (FF)^{0.214} \times (SF)^{0.375} \times (K)^{0.840} \quad (1)$$

where SY is sediment yield in cubic yards; A is watershed area in square miles; ER is the watershed elongation ratio produced by dividing the diameter of a circle with an area equal to that of the watershed by the maximum watershed length measured in a straight line parallel to the main channel; FF is the fire factor which represents the percentage of non-recovery of vegetative cover in the burned watershed; SF is the area of the watershed that is prone to slipping in acres per square mile; and K is the dimensionless rainfall factor.

Parameterizing Equation 1

The Arundell Barranca watershed upstream of Foothills Blvd. was divided into seven sub-watersheds illustrated in Figure 10. The coefficients described above were determined for each sub-watershed illustrated in Figure 13 and are summarized in Table 7. The values of K, dimensionless rainfall factor are storm dependent and summarized in Table 8.

The Design Fire Factor (FF) coefficient was assumed equal to 20. A value of 20 represents a general watershed vegetative cover 4 years post-fire and is assumed to be characteristic of the long-term average condition (Scott and Williams, 1974).

The areas prone to failure within each watershed was calculated from a GIS coverage of unstable slopes provided by the VCWPD and are shown in Figure 14.

Values of K representing the 2-year, 5-year, 10-year, 50-year and 100-years were calculated following the procedure outlined in the VCWPD Manual using data provided by Mark Bandurraga.

Table 7. Summary of Equation 1 coefficients by sub-watershed.

Sub-Watershed	A (sq. mi.)	ER	FF (%)	SF (acre/sq. mi.)
Mill Drain	0.33	1.208	20	60.48
Barlow Barranca	1.26	0.538	20	88.77
Reservoir Barranca #2	0.23	1.232	20	6.00
Reservoir Barranca #8	0.46	0.618	20	29.61
Arundell d/s of Reservoir	0.51	0.660	20	10.33
Lake Canyon	1.12	0.415	20	77.00
Sexton Canyon	1.59	0.467	20	44.39

Table 8. Dimensionless rainfall factor for storms of various return periods.

Return Period	K
2-year	42.1
5-year	130.9
10-year	251.6
50-year	624.6
100-year	866.7

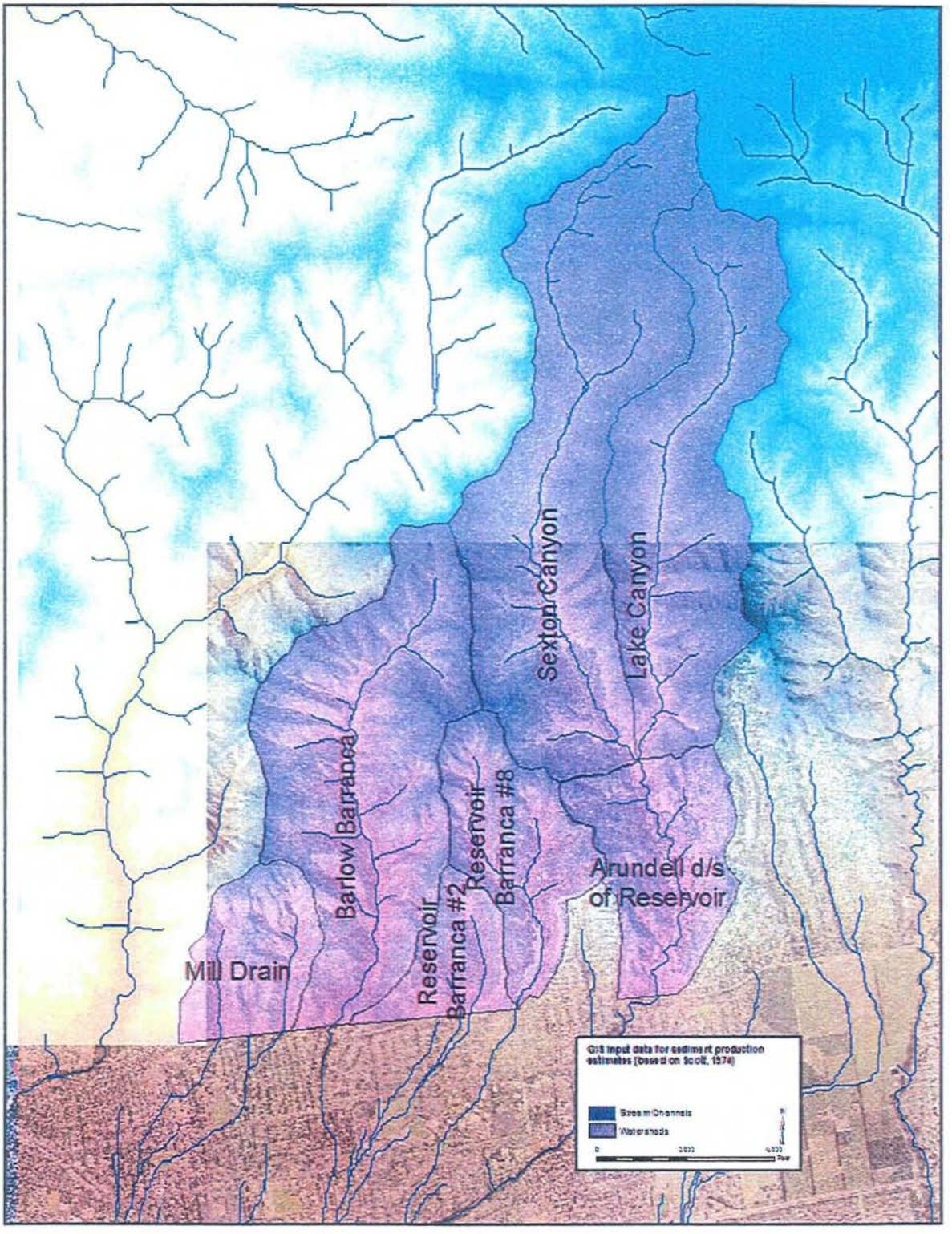


Figure 13. Boundaries of seven sub-watershed used to estimate sediment production in the Arundell Barranca watershed upstream of Foothills Blvd.

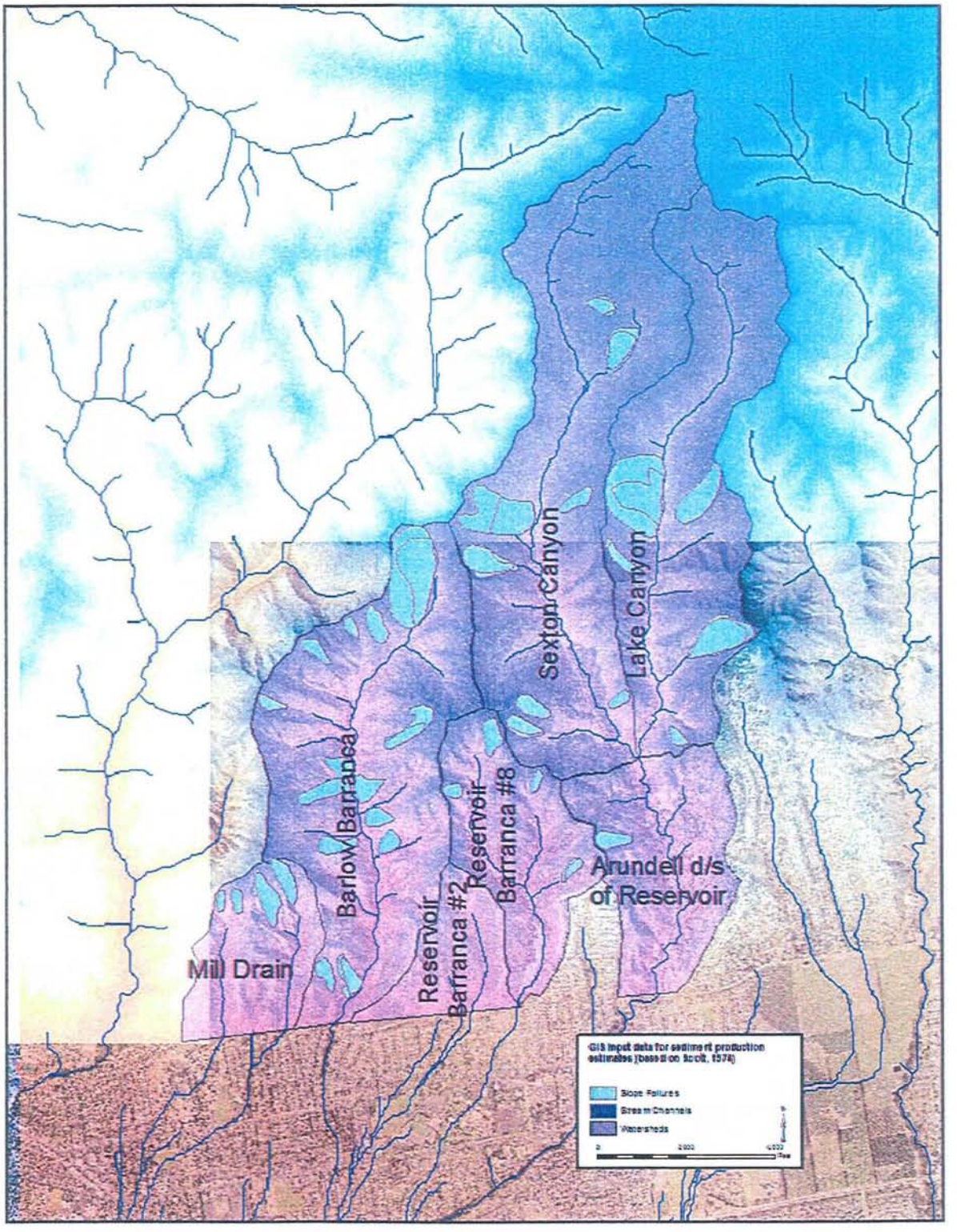


Figure 14. Areas of unstable slopes within each sub-watershed.

Results

Estimated debris production rates from storms of varying return periods are summarized in Table 8 for each of the seven sub-watersheds. Both the Lake and Sexton Canyon sub-watersheds are upstream of an existing debris basin, however, sediment input into the Arundell Barranca may be greatly reduced by constructing a debris basin at the downstream end of the remaining six sub-watersheds. As shown in Table 9, both Mill Drain #3 and Barlow Barranca #9 produce the greatest amount of debris.

Table 9. Debris production rates for storms of various return frequencies.

	Return Period					
Sub-watershed	**2-yr**	**5-yr**	**10-yr**	**50-yr**	**100-yr**	**2.33-yr (Average Annual)**
Mill Drain	2596	6715	11663	25033	32961	3049
Barlow Barranca	2975	7697	13369	28693	37781	3495
Reservoir Barranca #2	832	2153	3739	8024	10566	977
Reservoir Barranca #8	1036	2681	4656	9994	13159	1217
Arundell Barranca D/S of Reservoir	833	2156	3744	8036	10582	979
Lake Canyon	1790	4631	8044	17264	22732	2103
Sexton Canyon	2225	5755	9996	21455	28250	2613

Equation Validation

Long-term dredging records provided by the VCWPD from the existing debris basin immediately downstream of the Lake and Sexton Canyon confluences and within Ventura Harbor provide two data points with which to validate Equation 1.

Excluding disaster debris, the average annual cleanout rates of the Lake/Sexton Canyon debris basin between 1991 and 1995 was approximately 4,004 yd^3. Estimated rates of debris production rates within Lake Canyon and Sexton Canyon is approximately 4,716 yd^3 as shown by Table 8.

The average annual dredging rate within Ventura Harbor between 1993 and 2005 was approximately 41,350 yd^3. Table 8 indicates that the estimated average annual rate of debris production within the Arundell Barranca watershed upstream of Foothills Blvd. (excluding Lake/Sexton Canyons) is approximately 10,000 yd^3, which is only 25% of the observed dredging volume. However, between 1993 and 2005 a series of extreme flood events occurred which produced debris at a rate significantly greater than the long-term average, consequently, estimates of debris production rates using Equation 1 (assuming a 2.33-year return period storm) significantly under-predict the observed dredging rates within Ventura Harbor. For instance, if we assumed two 100-yr return period storms occurred during this time period (in addition to 10 2.33-year return period storms) the average annual estimate of debris production increases to approximately 26,000 yd^3.

Section IX - Conclusions and Recommendations

The Arundell Barranca provides 100-year flood protection from the outlet of the Lake Canyon/Sexton Canyon Dam to Estate Street. Downstream of Estate Street the channel is deficient for conveying the Q50 and Q100 flows. Several alternatives were investigated for improving the channel. Based on the alternatives analysis the recommended alternative is Alternative 7 which consists of the improvements listed below. Figures 15 through 20 show plans and profiles of the proposed improvements.

Reach 1 – No improvements required.

Reach 2 - To reduce the flow to Reach 1, a detention basin will be constructed along the channel. The existing concrete compound channel will be replaced with a 24-ft x 11-ft rectangular concrete channel which is currently being constructed. The 3 foot drop immediately downstream of Harbor Blvd will be removed and the bridge at Harbor Blvd will be reconstructed to remove the pier.

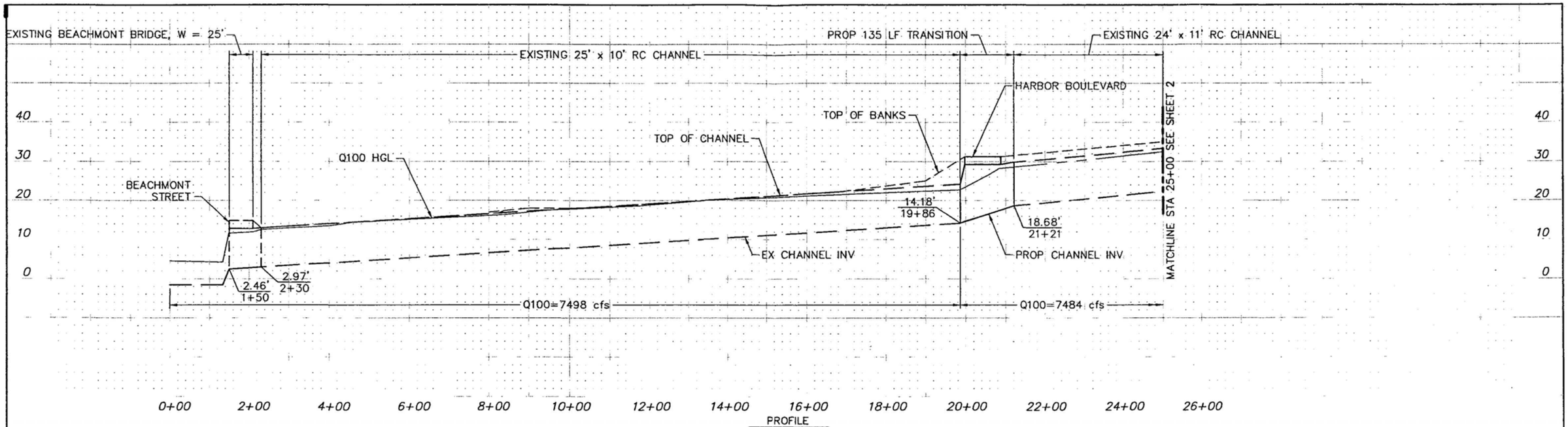
Reach 3 - The existing rectangular concrete channel will be replaced with a channel that has a width that varies from 24 feet to 35 feet and a height of 11 feet.

Reach 4 - The confluence of Telephone Road junction will be moved to just downstream of Main Street.

Reach 5 - A 9-foot reinforced concrete pipe be installed under Estate St, next to the existing box culvert to convey excess flow into the existing natural channel. The excess flow will be conveyed in the existing natural channel until just upstream of Highway 101 where the flow will be rerouted back into the channel. A new 8-foot RCP junction to the channel will be required and the existing box culvert will be replaced with a 11.5-ft wide x 14-ft high box culvert.

Reach 6– No improvements required.

The total cost to construct Alternative 7 is $23,160,000.



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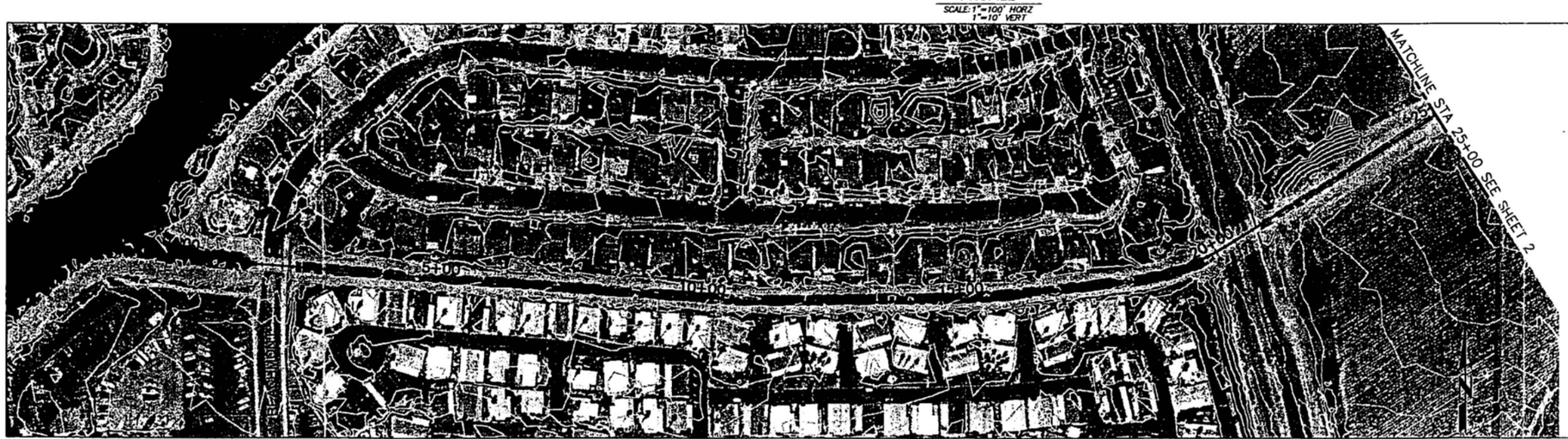

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1. THE RC CHANNEL BETWEEN STA 21+21 AND 55+65 IS ASSUMED TO BE BUILT IN 2006.

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VENTURA COUNTY WATERSHED PROTECTION DISTRICT

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ARUNDELL BARANCA
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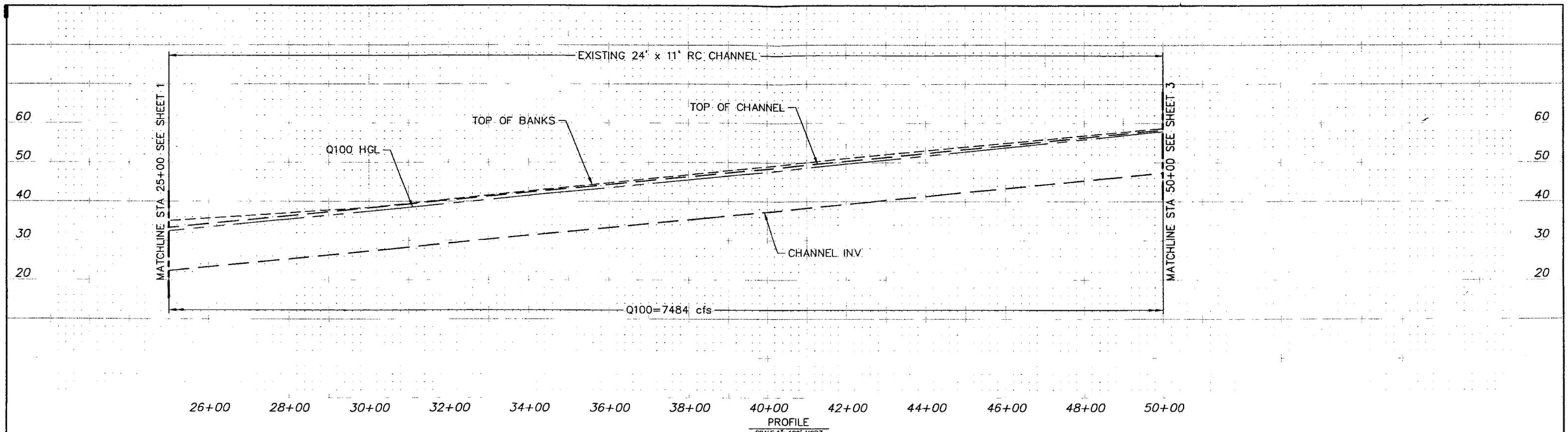

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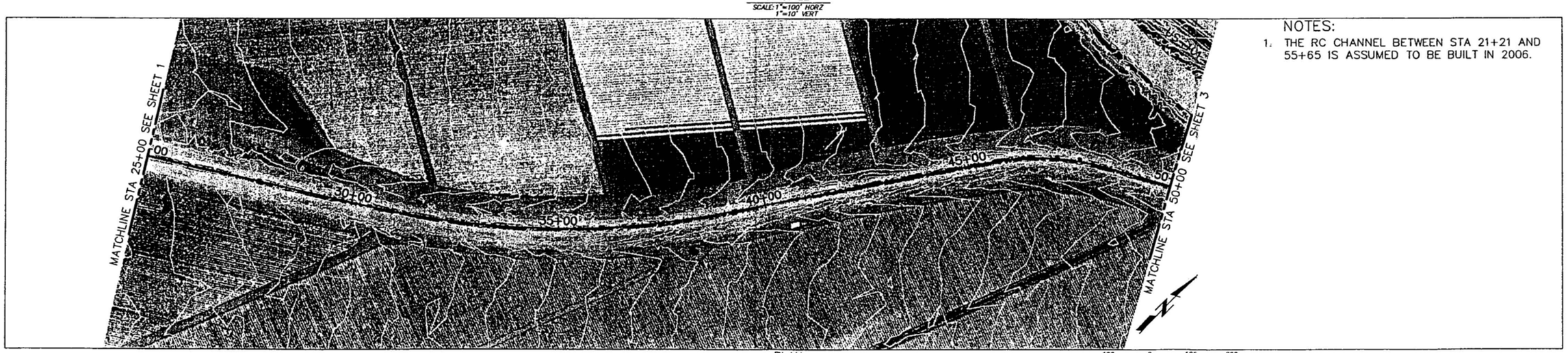

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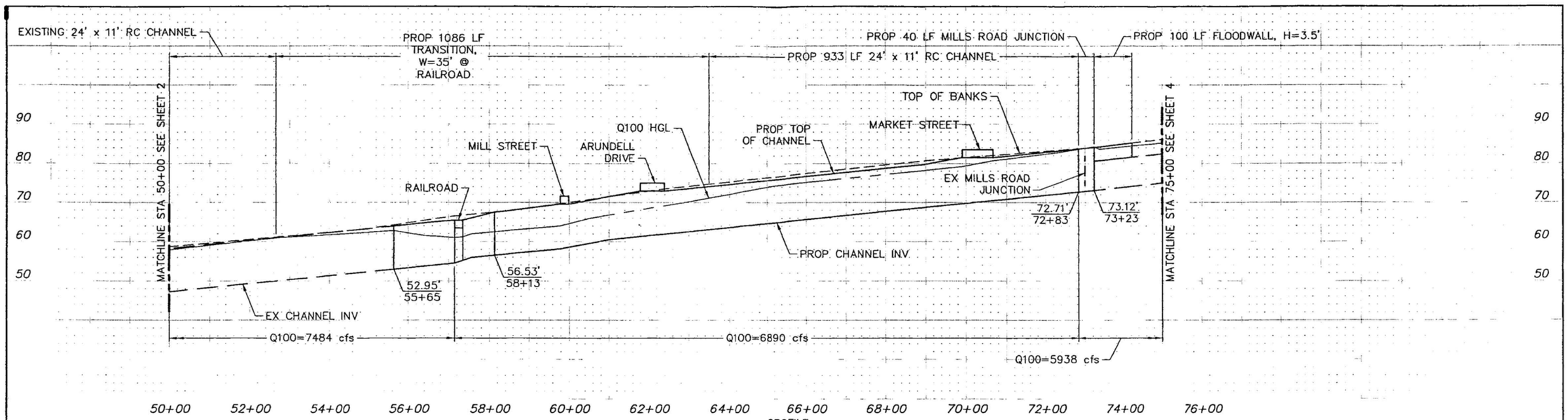

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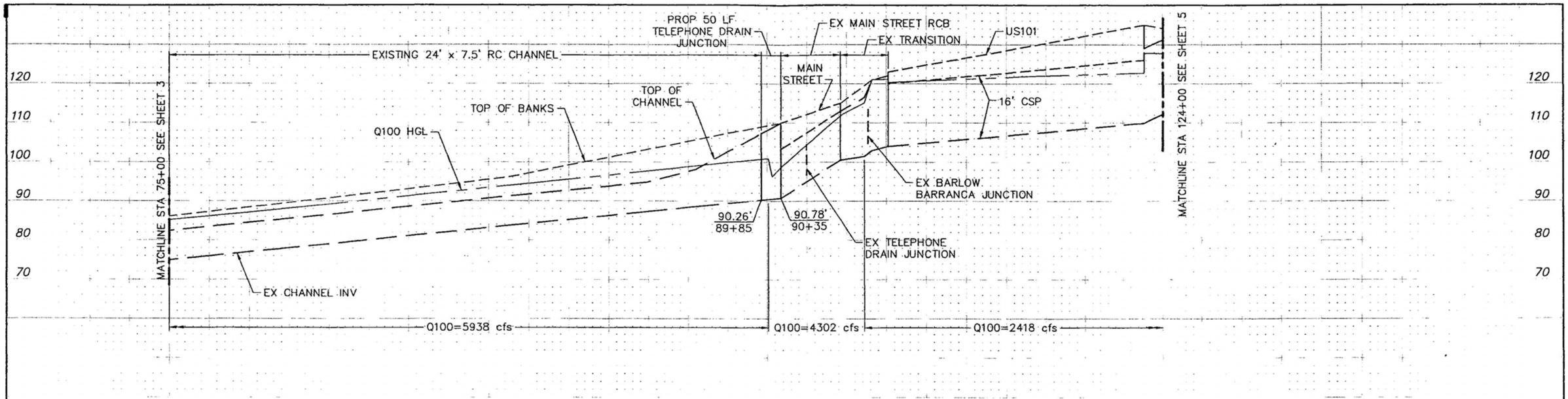

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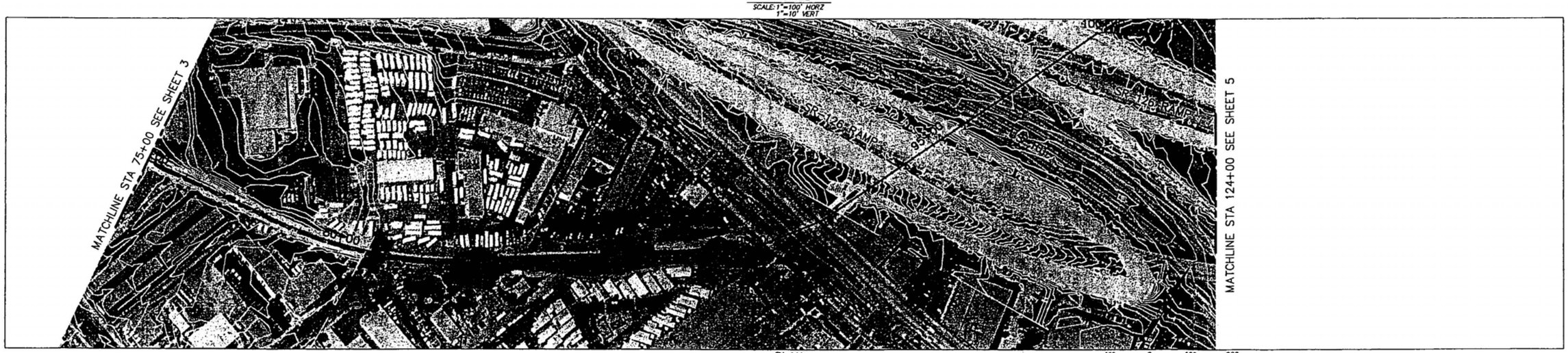

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PLAN AND PROFILE STA 75+00 TO STA 93+00

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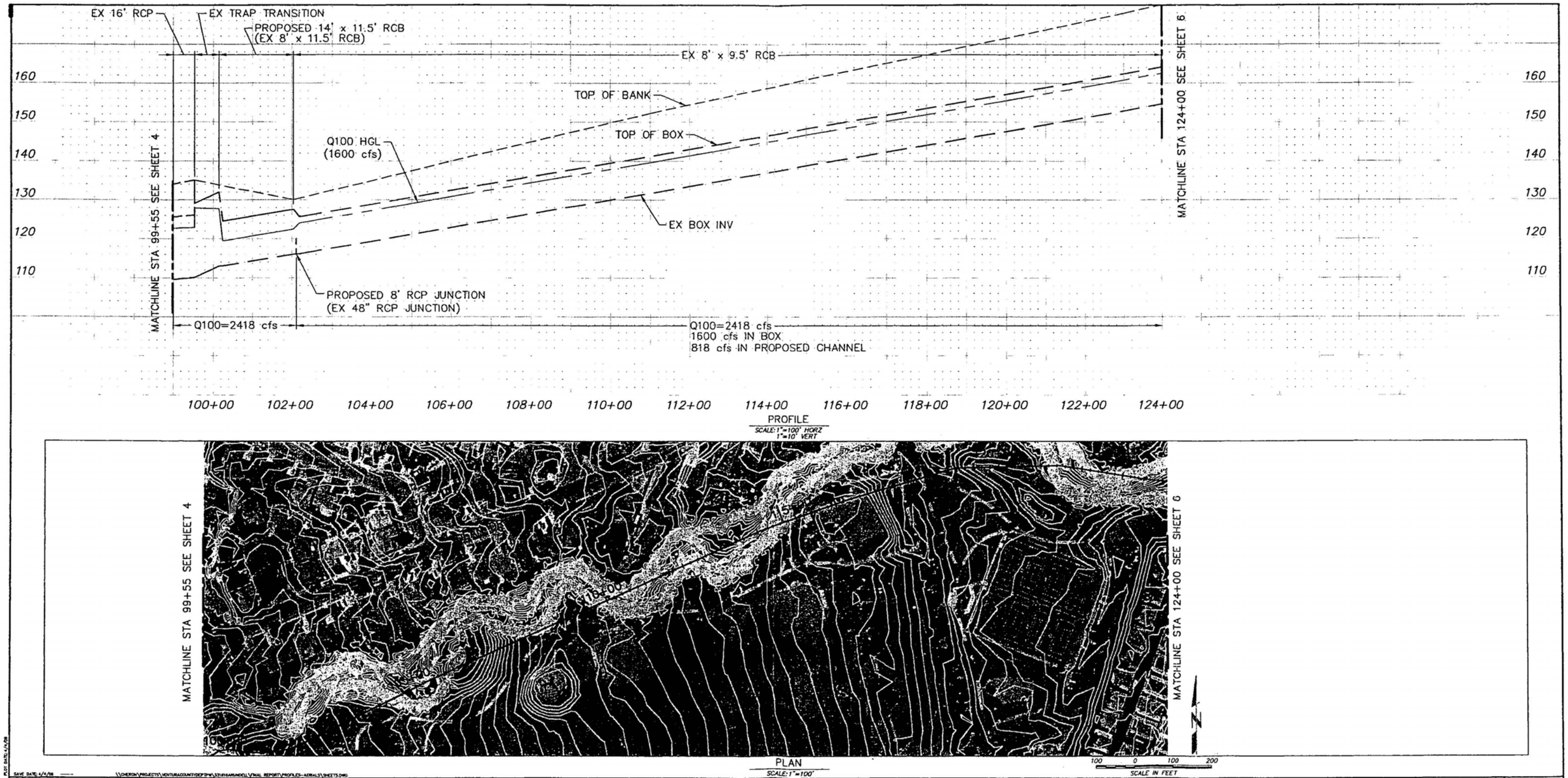

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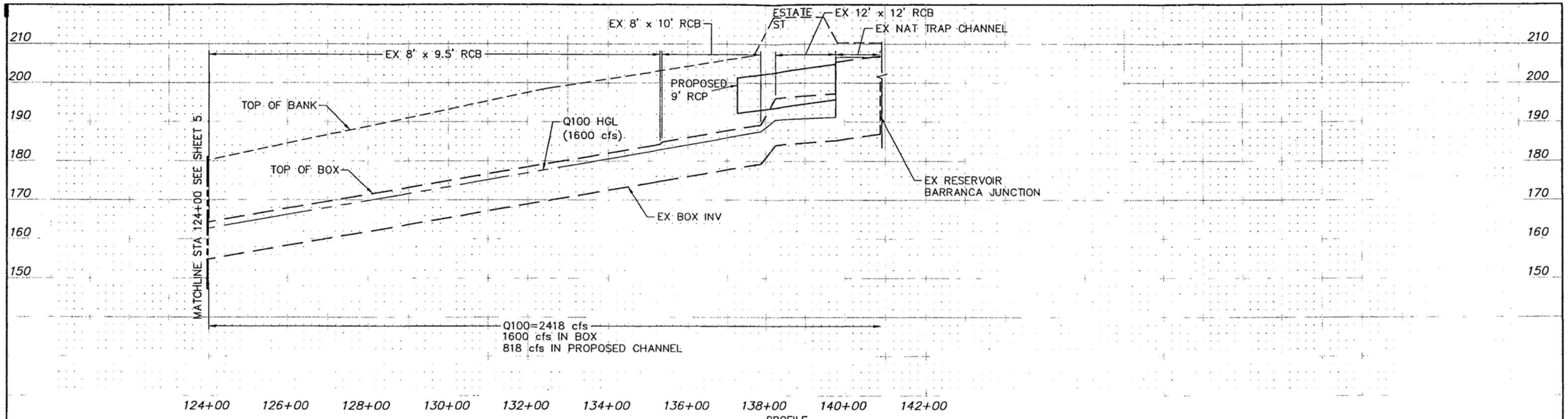

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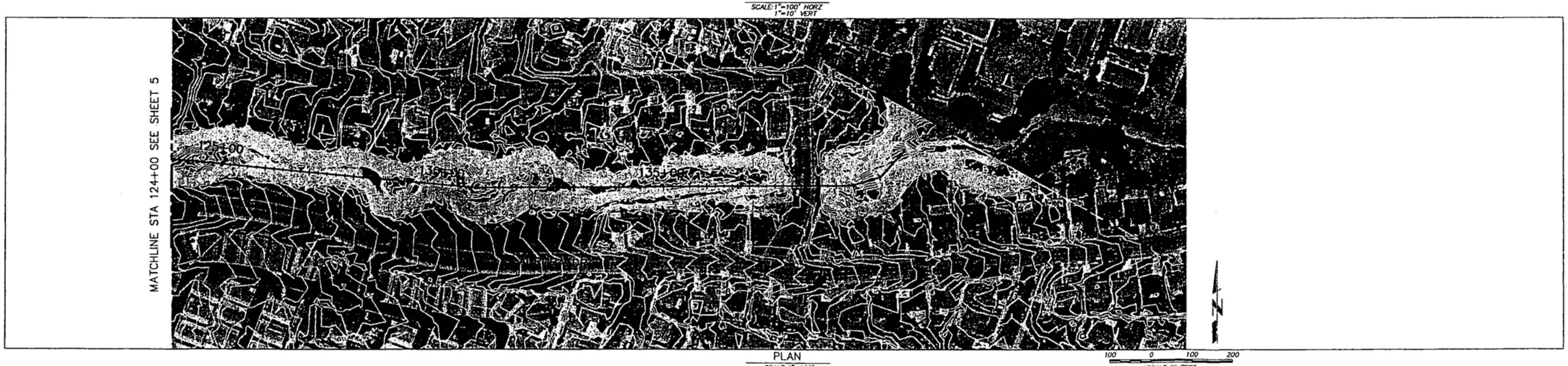

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△	REVISION DESCRIPTION	APP.	DATE

DESIGNED J BARRY | DRAWN C BLACKNEY | CHECKED K HIGGINS
PROJ. ENG. K HIGGINS | RECOMMENDED
REG. NO. | DATE | APPROVED

COUNTY OF VENTURA – PUBLIC WORKS AGENCY
VENTURA COUNTY WATERSHED PROTECTION DISTRICT

SPEC. NO. –
PROJ. NO. –

ARUNDELL BARANCA
DEFICIENCY STUDY
PLAN AND PROFILE STA 124+00 TO STA 142+00

SHEET 6 OF 6
N.R.C.S. DRAWING NO. 1
V.C.W.P.D. DRAWING NO.

References

1. Aspen Environmental Group (2003), Arundell Barranca Phase I Alternatives Analysis.
2. Aspen Environmental Group (2005), Arundell Barranca Restoration Channel Hydraulic Concept Design
3. FEMA (2001), State and Local Mitigation Planning, How-to Guide
4. Hydraulic Engineering Center, U.S. Army Corps of Engineers (2005), HEC-RAS River Analysis System.
5. Los Angeles County Flood Control District (1979), Water Surface and Pressure Gradient Hydraulic Analysis System (WSPG) Program No. F0515P.
6. Omrun Engineering (2005), Arundell Barranca Deficiency Analysis (Supplementary Report).
7. Scott, K.M. and Williams, R.P. (1974) Erosion and sediment yields in mountain watersheds of the transverse ranges Ventura and Los Angeles Counties California – Analysis of rates and processes. U.S. Geological Survey, WRI 47-73. 66 pg.
8. U.S. Geological Survey, Scott, K.M. and Williams, R.P. (1974), Erosion and sediment yields in mountain watersheds of the transverse ranges Ventura and Los Angeles Counties California – Analysis of rates and processes.
9. Ventura County Public Works Agency (1999), Arundell Barranca Deficiency Study.
10. Ventura County Public Works Agency (1999), Barlow Barranca Deficiency Study.
11. Ventura County Watershed Protection District (1968), Design Manual.
12. Ventura Keys and Arundell Barranca Watershed Project Team (1999), Project Alternatives Report.

APPENDIX C – COST ESTIMATES

Arundell Barranca Cost Summary

Description	Cost	Damage Estimate	B/C Ratio	Weighting
Alternative 1. No Action	$ -	-	-	-
Alternative 2. All Channel	$ 22,430,000	$ 76,050,000	3.39	4
Alternative 3a. Low Flow Channel/Box	$ 27,740,000	$ 76,050,000	2.74	3
Alternative 3b. Low Flow Channel/Channel	$ 23,410,000	$ 76,050,000	3.25	4
Alternative 4. Natural Channel	$ 32,390,000	$ 76,050,000	2.35	2
Alternative 5. Channel/Habitat Bench	$ 27,030,000	$ 76,050,000	2.81	3
Alternative 6. Channel/Parallel Channel	$ 24,600,000	$ 76,050,000	3.09	4
Alternative 7. Channel/Basin	$ 23,160,000	$ 76,050,000	3.28	4

Cost Estimates
Alternative 2. All Channel

Reach 1

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Beachmont St Bridge	SF	1800	200.00	360,000.00
2	Harbor Blvd Bridge	SF	4800	200.00	960,000.00
3	RCC	CY	2790	1,450.00	4,045,500.00
4					
5					0.00
-	**Total For Reach 1**	-	-	-	**$5,365,500.00**

Reach 2

Item No.	Item	Unit	Quantity	Unit Price	Total
1	RCC	CY	6300	0.00	0.00
2	RCB	CY	140	0.00	0.00
3	Floodwalls	LF	1000	300.00	300,000.00
4					0.00
5					0.00
-	**Total For Reach 2**	-	-	-	**$300,000.00**

Reach 3

Item No.	Item	Unit	Quantity	Unit Price	Total
1	RCC	CY	4300	1,450.00	6,235,000.00
2	Railroad Bridge	SF	1200	300.00	360,000.00
3	Mills Rd Culvert	CY	240	1,500.00	360,000.00
4	Arundell Ct Culvert	CY	240	1,500.00	360,000.00
5	Market St Culvert	CY	240	1,500.00	360,000.00
6	Right-of-Way	AC	0.25	200,000.00	50,000.00
-	**Total For Reach 3**	-	-	-	**$7,725,000.00**

Reach 4

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Telephone Rd Jxn	LS	1	500,000.00	500,000.00
2					0.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 4**	-	-	-	**$500,000.00**

Reach 5

Item No.	Item	Unit	Quantity	Unit Price	Total
1	8' RCP	LF	100	1,300.00	130,000.00
2	9' RCP	LF	100	1,420.00	142,000.00
3	11.5' x 14' RCB	CY	600	1,400.00	840,000.00
4					0.00
5					0.00
-	**Total For Reach 5**	-	-	-	**$1,112,000.00**

Subtotal	$15,002,500.00
Engineering and Construction Administration	$2,250,375.00
Contingency	$5,175,862.50
Total	**$22,428,737.50**

Cost Estimates
Alternative 3a. Low Flow Channel/Box

Reach 1

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Beachmont St Culvert	SF	1800	200.00	360,000.00
2	Harbor Blvd Culvert	SF	4800	200.00	960,000.00
3	RCC	CY	2790	1,450.00	4,045,500.00
4					0.00
5					0.00
-	**Total For Reach 1**	-	-	-	**$5,365,500.00**

Reach 2

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Low Flow Channel	CY	7800	50.00	390,000.00
2	RCB	CY	2900	1,000.00	2,900,000.00
3	Right-of-way	AC	2.8	200,000.00	560,000.00
4					0.00
5					0.00
-	**Total For Reach 2**	-	-	-	**$3,850,000.00**

Reach 3

Item No.	Item	Unit	Quantity	Unit Price	Total
1	RCC	CY	4300	1,450.00	6,235,000.00
2	Railroad Bridge	SF	1200	300.00	360,000.00
3	Mills Rd Culvert	CY	240	1,500.00	360,000.00
4	Arundell Ct Culvert	CY	240	1,500.00	360,000.00
5	Market St Culvert	CY	240	1,500.00	360,000.00
6	Right-of-Way	AC	0.25	200,000.00	50,000.00
-	**Total For Reach 3**	-	-	-	**$7,725,000.00**

Reach 4

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Telephone Rd Jxn	LS	1	500,000.00	500,000.00
2					0.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 4**	-	-	-	**$500,000.00**

Reach 5

Item No.	Item	Unit	Quantity	Unit Price	Total
1	8' RCP	LF	100	1,300.00	130,000.00
2	9' RCP	LF	100	1,420.00	142,000.00
3	11.5' x 14' RCB	CY	600	1,400.00	840,000.00
4					0.00
5					0.00
-	**Total For Reach 5**	-	-	-	**$1,112,000.00**

Subtotal	$18,552,500.00
Engineering and Construction Administration	$2,782,875.00
Contingency	$6,400,612.50
Total	**$27,735,987.50**

Cost Estimates

Alternative 3b. Low Flow Channel/Channel

Reach 1

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Beachmont St Culvert	SF	1800	200.00	360,000.00
2	Harbor Blvd Culvert	SF	4800	200.00	960,000.00
3	RCC	CY	2790	1,450.00	4,045,500.00
4					0.00
5					0.00
-	**Total For Reach 1**	-	-	-	**$5,365,500.00**

Reach 2

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Low Flow Channel	CY	7800	50.00	390,000.00
2	Right-of-way	AC	2.8	200,000.00	560,000.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 2**	-	-	-	**$950,000.00**

Reach 3

Item No.	Item	Unit	Quantity	Unit Price	Total
1	RCC	CY	4300	1,450.00	6,235,000.00
2	Railroad Bridge	SF	1200	300.00	360,000.00
3	Mills Rd Culvert	CY	240	1,500.00	360,000.00
4	Arundell Ct Culvert	CY	240	1,500.00	360,000.00
5	Market St Culvert	CY	240	1,500.00	360,000.00
6	Right-of-Way	AC	0.25	200,000.00	50,000.00
-	**Total For Reach 3**	-	-	-	**$7,725,000.00**

Reach 4

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Telephone Rd Jxn	LS	1	500,000.00	500,000.00
2					0.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 4**	-	-	-	**$500,000.00**

Reach 5

Item No.	Item	Unit	Quantity	Unit Price	Total
1	8' RCP	LF	100	1,300.00	130,000.00
2	9' RCP	LF	100	1,420.00	142,000.00
3	11.5' x 14' RCB	CY	600	1,400.00	840,000.00
4					0.00
5					0.00
-	**Total For Reach 5**	-	-	-	**$1,112,000.00**

Subtotal	$15,652,500.00
Engineering and Construction Administration	$2,347,875.00
Contingency	$5,400,112.50
Total	**$23,400,487.50**

Cost Estimates
Alternative 4. Natural Channel

Reach 1

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Beachmont St Culvert	SF	1800	200.00	360,000.00
2	Harbor Blvd Culvert	SF	4800	200.00	960,000.00
3	RCC	CY	2790	1,450.00	4,045,500.00
4					0.00
5					0.00
-	**Total For Reach 1**	-	-	-	**$5,365,500.00**

Reach 2

Item No.	Item	Unit	Quantity	Unit Price	Total
1				0.00	0.00
2				0.00	0.00
3	Natural Channel	LS	1	6,960,000.00	6,960,000.00
4					0.00
5					0.00
-	**Total For Reach 2**	-	-	-	**$6,960,000.00**

Reach 3

Item No.	Item	Unit	Quantity	Unit Price	Total
1	RCC	CY	4300	1,450.00	6,235,000.00
2	Railroad Bridge	SF	1200	300.00	360,000.00
3	Mills Rd Culvert	CY	240	1,500.00	360,000.00
4	Arundell Ct Culvert	CY	240	1,500.00	360,000.00
5	Market St Culvert	CY	240	1,500.00	360,000.00
6	Right-of-Way	AC	0.25	200,000.00	50,000.00
-	**Total For Reach 3**	-	-	-	**$7,725,000.00**

Reach 4

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Telephone Rd Jxn	LS	1	500,000.00	500,000.00
2					0.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 4**	-	-	-	**$500,000.00**

Reach 5

Item No.	Item	Unit	Quantity	Unit Price	Total
1	8' RCP	LF	100	1,300.00	130,000.00
2	9' RCP	LF	100	1,420.00	142,000.00
3	11.5' x 14' RCB	CY	600	1,400.00	840,000.00
4					0.00
5					0.00
-	**Total For Reach 5**	-	-	-	**$1,112,000.00**

Subtotal	$21,662,500.00
Engineering and Construction Administration	$3,249,375.00
Contingency	$7,473,562.50
Total	**$32,385,437.50**

Cost Estimates
Alternative 5. Channel/Habitat Bench

Reach 1

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Beachmont St Culvert	SF	1800	200.00	360,000.00
2	Harbor Blvd Culvert	SF	4800	200.00	960,000.00
3	RCC	CY	2790	1,450.00	4,045,500.00
4					0.00
5					0.00
-	**Total For Reach 1**	-	-	-	**$5,365,500.00**

Reach 2

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Channel	CY	25000	75.00	1,875,000.00
2	Right-of-way	AC	7.5	200,000.00	1,500,000.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 2**	-	-	-	**$3,375,000.00**

Reach 3

Item No.	Item	Unit	Quantity	Unit Price	Total
1	RCC	CY	4300	1,450.00	6,235,000.00
2	Railroad Bridge	SF	1200	300.00	360,000.00
3	Mills Rd Culvert	CY	240	1,500.00	360,000.00
4	Arundell Ct Culvert	CY	240	1,500.00	360,000.00
5	Market St Culvert	CY	240	1,500.00	360,000.00
6	Right-of-Way	AC	0.25	200,000.00	50,000.00
-	**Total For Reach 3**	-	-	-	**$7,725,000.00**

Reach 4

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Telephone Rd Jxn	LS	1	500,000.00	500,000.00
2					0.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 4**	-	-	-	**$500,000.00**

Reach 5

Item No.	Item	Unit	Quantity	Unit Price	Total
1	8' RCP	LF	100	1,300.00	130,000.00
2	9' RCP	LF	100	1,420.00	142,000.00
3	11.5' x 14' RCB	CY	600	1,400.00	840,000.00
4					0.00
5					0.00
-	**Total For Reach 5**	-	-	-	**$1,112,000.00**

Subtotal	$18,077,500.00
Engineering and Construction Administration	$2,711,625.00
Contingency	$6,236,737.50
Total	**$27,025,862.50**

Cost Estimates
Alternative 6. Channel/Linear Basin

Reach 1

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Beachmont St Culvert	SF	1800	200.00	360,000.00
2	Harbor Blvd Culvert	SF	4800	200.00	960,000.00
3	RCC	CY	2790	1,450.00	4,045,500.00
4					0.00
5					0.00
-	**Total For Reach 1**	-	-	-	**$5,365,500.00**

Reach 2

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Parallel Channel	CY	15000	50.00	750,000.00
2	Right-of-way	AC	5	200,000.00	1,000,000.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 2**	-	-	-	**$1,750,000.00**

Reach 3

Item No.	Item	Unit	Quantity	Unit Price	Total
1	RCC	CY	4300	1,450.00	6,235,000.00
2	Railroad Bridge	SF	1200	300.00	360,000.00
3	Mills Rd Culvert	CY	240	1,500.00	360,000.00
4	Arundell Ct Culvert	CY	240	1,500.00	360,000.00
5	Market St Culvert	CY	240	1,500.00	360,000.00
6	Right-of-Way	AC	0.25	200,000.00	50,000.00
-	**Total For Reach 3**	-	-	-	**$7,725,000.00**

Reach 4

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Telephone Rd Jxn	LS	1	500,000.00	500,000.00
2					0.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 4**	-	-	-	**$500,000.00**

Reach 5

Item No.	Item	Unit	Quantity	Unit Price	Total
1	8' RCP	LF	100	1,300.00	130,000.00
2	9' RCP	LF	100	1,420.00	142,000.00
3	11.5' x 14' RCB	CY	600	1,400.00	840,000.00
4					0.00
5					0.00
-	**Total For Reach 5**	-	-	-	**$1,112,000.00**

Subtotal	$16,452,500.00
Engineering and Construction Administration	$2,467,875.00
Contingency	$5,676,112.50
Total	**$24,596,487.50**

Cost Estimates
Alternative 7. Channel/Basin

Reach 1

Item No.	Item	Unit	Quantity	Unit Price	Total
1					
2	Harbor Blvd Culvert	SF	4800	200.00	960,000.00
3					
4					0.00
5					0.00
-	**Total For Reach 1**	-	-	-	**$960,000.00**

Reach 2

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Basin	CY	50000	75.00	3,750,000.00
2	Right-of-way	AC	7.2	200,000.00	1,440,000.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 2**	-	-	-	**$5,190,000.00**

Reach 3

Item No.	Item	Unit	Quantity	Unit Price	Total
1	RCC	CY	4300	1,450.00	6,235,000.00
2	Railroad Bridge	SF	1200	300.00	360,000.00
3	Mills Rd Culvert	CY	240	1,500.00	360,000.00
4	Arundell Ct Culvert	CY	240	1,500.00	360,000.00
5	Market St Culvert	CY	240	1,500.00	360,000.00
6	Right-of-Way	AC	0.25	200,000.00	50,000.00
-	**Total For Reach 3**	-	-	-	**$7,725,000.00**

Reach 4

Item No.	Item	Unit	Quantity	Unit Price	Total
1	Telephone Rd Jxn	LS	1	500,000.00	500,000.00
2					0.00
3					0.00
4					0.00
5					0.00
-	**Total For Reach 4**	-	-	-	**$500,000.00**

Reach 5

Item No.	Item	Unit	Quantity	Unit Price	Total
1	8' RCP	LF	100	1,300.00	130,000.00
2	9' RCP	LF	100	1,420.00	142,000.00
3	11.5' x 14' RCB	CY	600	1,400.00	840,000.00
4					0.00
5					0.00
-	**Total For Reach 5**	-	-	-	**$1,112,000.00**

Subtotal	$15,487,000.00
Engineering and Construction Administration	$2,323,050.00
Contingency	$5,343,015.00
Total	**$23,153,065.00**

Reach 1 Channel		Quantitiy	Unit Price	Total
Mobilization	LS	1	350000	$ 350,000.00
Clearing and Grubbing	LS	1	100000	$ 100,000.00
Diversion of Water	LS	1	200000	$ 200,000.00
Water Pollution Control	LS	1	10000	$ 10,000.00
Excavation Safety	LS	1	20000	$ 20,000.00
Excavation	CY	17,500	20	$ 350,000.00
Fill and Backfill	CY	10000	30	$ 300,000.00
Temporary Fence	LF	2500	5	$ 12,500.00
Steel	LBs	280000	2	$ 560,000.00
Concrete	CY	2800	400	$ 1,120,000.00
Filter Material	CY	2200	100	$ 220,000.00
Subdrain Pipe	LF	4000	20	$ 80,000.00
CL Fence	LF	2500	15	$ 37,500.00
Shoring	LS	1	200000	$ 200,000.00
Misc Structures	LS	1	350000	$ 350,000.00
Landscaping	LS	1	50000	$ 50,000.00
				$ 3,960,000.00
			Cost per CY	$ 1,414.29

Reach 2 Basin		Quantitiy	Unit Price	Total
Mobilization	LS	1	220000	$ 220,000.00
Clearing and Grubbi	LS	1	100000	$ 100,000.00
Diversion of Water	LS	1	50000	$ 50,000.00
Water Pollution Con	LS	1	10000	$ 10,000.00
Excavation Safety	LS	1	20000	$ 20,000.00
Excavation	CY	50,000	50	$ 2,500,000.00
Fill and Backfill	CY	5000	30	$ 150,000.00
Temporary Fence	LF	2500	5	$ 12,500.00
Steel	LBs	10000	2	$ 20,000.00
Concrete	CY	200	400	$ 80,000.00
Filter Material	CY	0	100	$ -
Subdrain Pipe	LF	0	20	$ -
CL Fence	LF	2500	15	$ 37,500.00
Shoring	LS	1	50000	$ 50,000.00
Misc Structures	LS	1	350000	$ 350,000.00
Landscaping	LS	1	100000	$ 100,000.00
				$ 3,700,000.00
			Cost per CY	$ 74.00

APPENDIX D – FLOOD DAMAGES

Flood Da Costs

Type of Structure (Occupancy Class)	Number of Structures in Hazard Area	Structure Size (SF)	Total Area (SF)	Structure Area (SF)	Value per SF	Value of Structures in Hazard Area
Residential	427	2,600	4,351,604	1,110,200	$ 92.00	$ 102,138,400
Commercial	35	12,000	2,219,000	420,000	$ 60.00	$ 25,200,000
Agricultural	1	4,899,000	4,899,000	4,899,000	$ 6.89	$ 33,754,110
Total	463	-	11,469,604	6,429,200	-	$ 161,092,510

Flood Building Loss Estimation Table (Residential)

Flood Depth (feet)	Number of Residential Structures	Total Structural Area (SF)	Replacement Value of Structure	Structure Loss (% Damage)	Loss to Structure	Replacement Value of Contents	Contents Loss (% Damage)	Loss to Contents	TOTAL Flood Damage Cost
1	222	577,200	$ 53,102,400	9	$ 4,779,216	$ 26,551,200	13.5	$ 3,584,412	$ 8,363,628
2	82	213,200	$ 19,614,400	13	$ 2,549,872	$ 9,807,200	19.5	$ 1,912,404	$ 4,462,276
3	123	319,800	$ 29,421,600	18	$ 5,295,888	$ 14,710,800	27	$ 3,971,916	$ 9,267,804
Total	427	1,110,200	$102,138,400	-	$ 12,624,976	$ 51,069,200	-	$ 9,468,732	$ 22,093,708

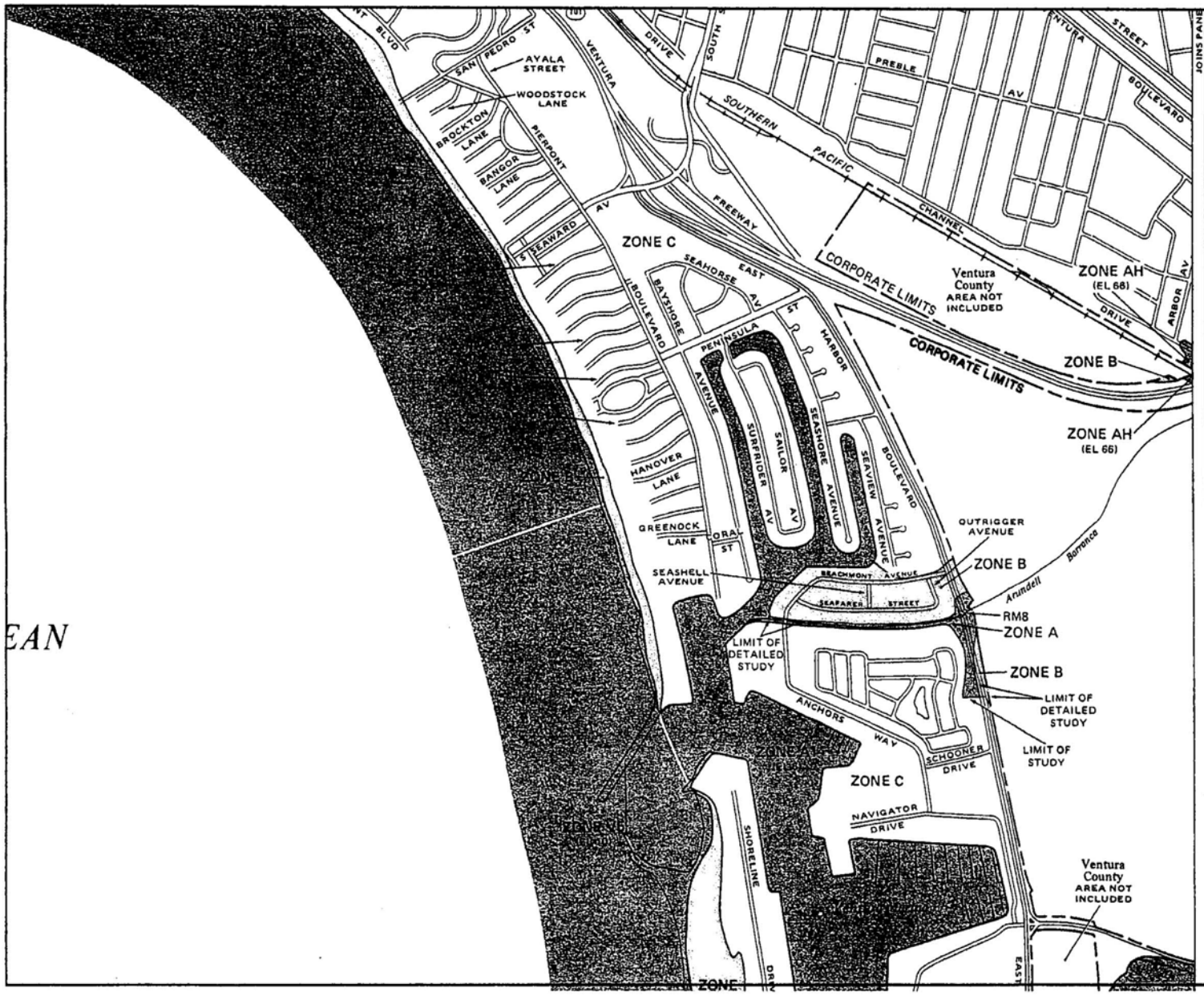
Flood Building Loss Estimation Table (Commercial)

Flood Depth (feet)	Number of Commercial Structures	Total Structural Area (SF)	Replacement Value of Structure	Structure Loss (% Damage)	Loss to Structure	Contents Value	Contents Loss (% Damage)	Loss to Contents	Annual Sales ($ / SF)	Daily Sales	Functional Downtime in Days	Sales Loss	TOTAL Flood Damage Cost
1	12	144,000	$ 8,640,000	14	$ 1,209,600	$ 8,640,000	21	$ 1,814,400	$ 300	$118,356	14	$ 1,656,986	$ 4,680,986
2	9	108,000	$ 6,480,000	22	$ 1,425,600	$ 6,480,000	33	$ 2,138,400	$ 300	$ 88,767	22	$ 1,952,877	$ 5,516,877
3	14	168,000	$ 10,080,000	27	$ 2,721,600	$ 10,080,000	40.5	$ 4,082,400	$ 300	$138,082	27	$ 3,728,219	$ 10,532,219
Total	35	420,000	$ 25,200,000	-	$ 5,356,800	$ 25,200,000	-	$ 8,035,200	-	$345,205	-	$ 7,338,082	$ 20,730,082

Flood Damage Costs	
Residential	$ 22,093,708
Commercial	$ 20,730,082
Agriculture	$ 33,754,110
TOTAL	$ 76,577,900

ARUNDELL BARRANCA

LOCATION	LOT SIZE (SF)	HOUSE SIZE (SF)	PRICE PER SQARE FOOT
ABOVE FOOTHILL ROAD	88427 RESIDENTIAL	3500	$ 170.00
BELOW FOOTHILL, ABOVE TELEGRAPH ROAD	7211 RESIDENTIAL	2500	$ 130.00
BELOW TELEGRAPH ROAD, ABOVE 126 FREEWAY	6300 RESIDENTIAL	1500	$ 130.00
BELOW 126 FREEWAY, ABOVE TELEPHONE ROAD	27360 COMMERCIAL	2000	$ 100.00
BELOW TELEPHONE ROAD, ABOVE RAILROAD	43560 COMMERCIAL	12000	$ 60.00
BELOW RAILROAD, ABOVE HARBOR BLVD	Farm Land $300,000 per Acre		$0.00
BELOW HARBOR BLVD TO OCEAN	5880 RESIDENTIAL	2600	$ 92.00



APPROXIMATE SCALE IN FEET

1000 0 1000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
SAN BUENAVENTURA,
CALIFORNIA
VENTURA COUNTY

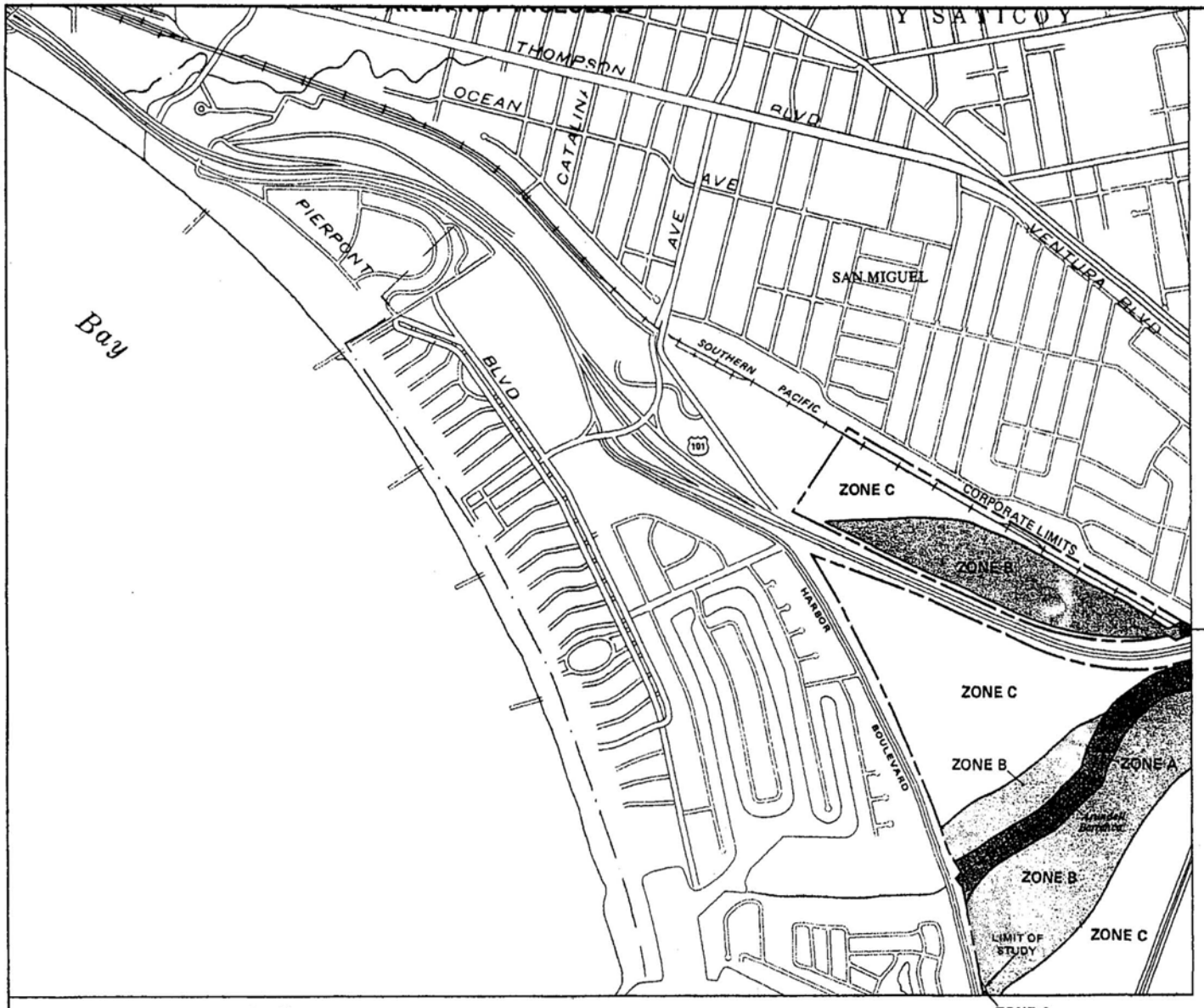
PANEL 5 OF 10
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
060419 0005 B

EFFECTIVE DATE:
SEPTEMBER 29, 1986

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



APPROXIMATE SCALE IN FEET
1000 0 1000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

VENTURA COUNTY, CALIFORNIA
(UNINCORPORATED AREAS)

PANEL 720 OF 1250
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
060413 0720 B

EFFECTIVE DATE:
OCTOBER 31, 1985

Federal Emergency Management Agency

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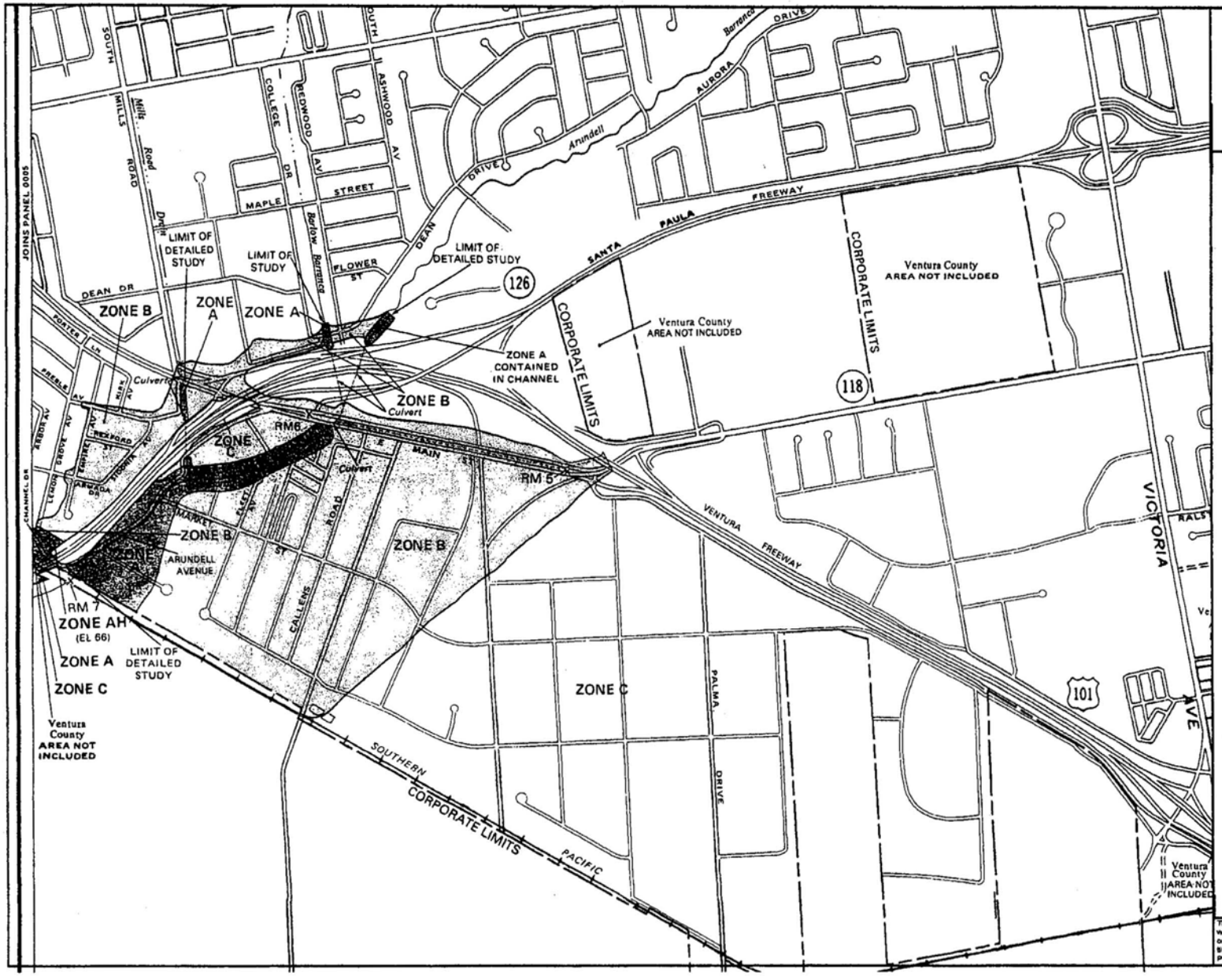
THIS PANEL IS LOCATED WITHIN RANCHO SANTA ANA, RANCHO EX MISSION SAN BUENAVENTURA



APPROXIMATE SCALE IN FEET

1000 0 1000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
SAN BUENAVENTURA,
CALIFORNIA
VENTURA COUNTY

PANEL 10 OF 10
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
060419 0010 C

MAP REVISED:
AUGUST 19, 1987

Federal Emergency Management Agency

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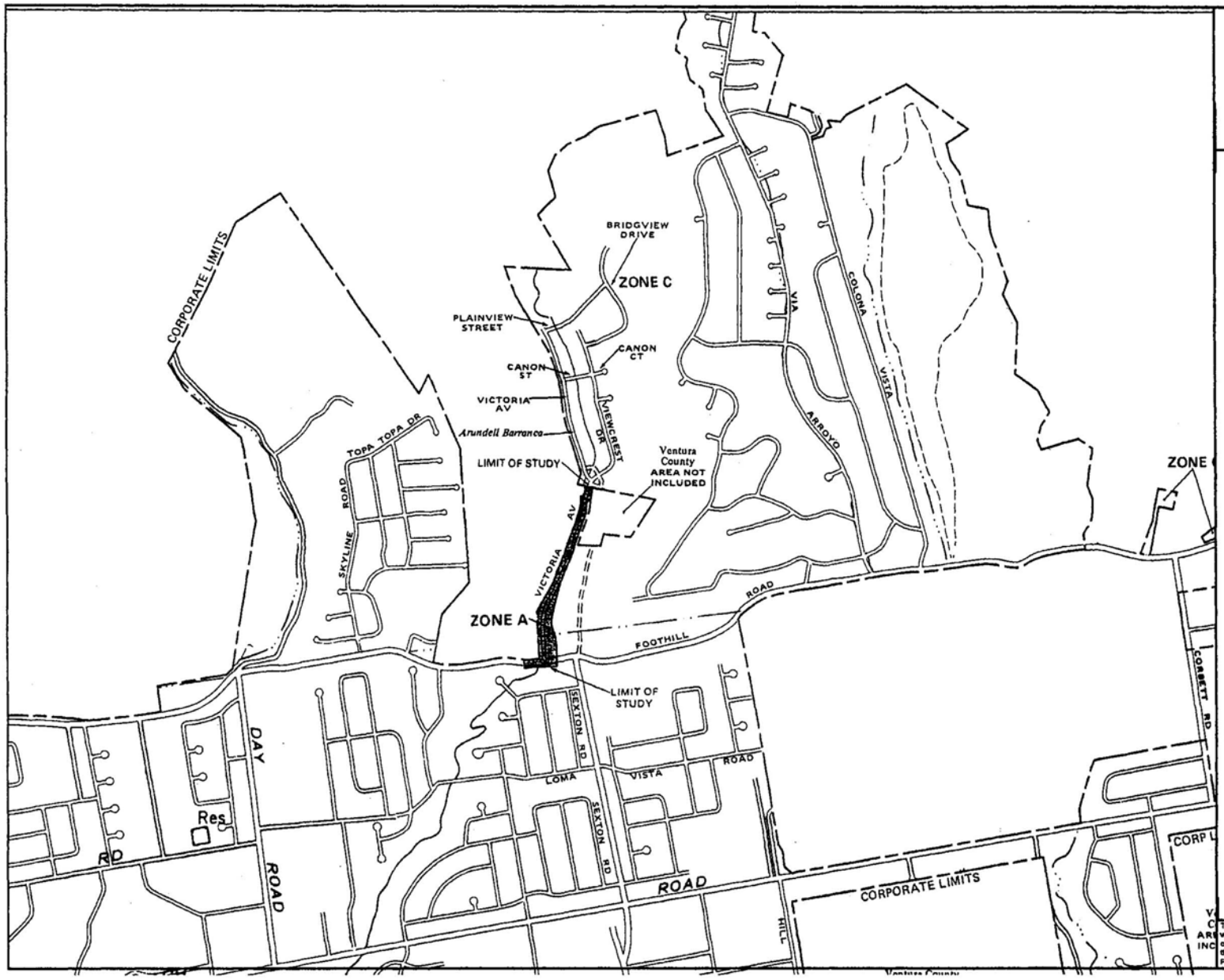

APPROXIMATE SCALE IN FEET

1000 0 1000

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
SAN BUENAVENTURA,
CALIFORNIA
VENTURA COUNTY

PANEL 10 OF 10
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
060419 0010 C

MAP REVISED:
AUGUST 19, 1987

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov