Ventura County
Watershed Protection District

Santa Clara River Levee (SCR-1) Evaluation and Rehabilitation Study

Ventura County, California

Economic Analysis Report

January 2015

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Irvine, California 92614

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Prepared for:

Ventura County
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Prepared by:

Tetra Tech

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1. INTRODUCTION

The Santa Clara River Levee (SCR-1) system and the Santa Clara River Levee (SCR-3) are located in the city of Oxnard and unincorporated areas of Ventura County, California. They are owned and operated by the Ventura County Watershed Protection District (VCWPD). SCR-1, which is 4.72 miles long, extends from Saticoy on the upstream end to U.S. Highway 101 on the downstream end. SCR-3 extends from Highway 101 to the former Ballard Landfill.

VCWPD plans to implement improvements to these two levee systems in order to reduce the flood risks to the floodplains they protect. To determine the economic support of these levee improvements, VCWPD contracted with Tetra Tech to analyze the expected flood damages in the Santa Clara River floodplains behind SCR-1 and SCR-3. This report documents the methods, assumptions, and conclusions of the economic analysis of conditions in the absence of levee improvements. While this report includes information for the floodplain behind SCR-3, the economic analysis of alternatives only covers SCR-1 levee improvements.

1.1 Scope of Economic Analysis

This economic analysis of flood damages was conducted in accordance with the standards, procedures, and guidance of the U.S. Army Corps of Engineers (Corps). However, because the intent was to perform a more simplified economic analysis, the Corps guidance was not stringently followed. This analysis is meant to provide insight regarding the existing conditions, and much of the compiled and developed data should be useful in the future, for more rigorous flood damage analyses if the Corps decides to move forward with SCR-1 in a feasibility study.

In flood damage reduction studies, most benefits result from a reduction in inundation damages (USACE 1988), which are associated with both physical and nonphysical costs. Physical costs include those related to inundation damage to infrastructure, structures and their contents, and agriculture. Nonphysical costs include flood cleanup costs and the costs of flood fighting, evacuation, and traffic/transportation rerouting (USACE 1988). This analysis quantifies only the physical damages caused by flooding of the Santa Clara River.

This economic analysis of flood damages was performed with the use of Corps guidance for conducting civil works planning studies, as defined in Engineer Regulation [ER] 1105-2-100, with particular focus on Appendix D, Economic and Social Considerations, Amendment 1 (USACE 2000), which serves as the primary source of Corps evaluation methods for use in flood damage reduction studies. ER-1105-2-100 includes the following steps for evaluating "without project" flood damages:

1. Delineate the study area.
2. Determine existing floodplain characteristics (including a floodplain inventory).
3. Estimate existing flood damages.
4. Estimate future flood damages.

For this analysis, only steps 1 through 3 were completed.

1.2 Methodology

The procedures used for this economic analysis of flood damages are the following:

- Review of existing information (i.e., parcel data, floodplains shown on the Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Map (DFIRM), and the results of hydraulic and hydrologic modeling)
- Generation of a parcel database for the study area
- Estimation of values for every structure in the study area
- Calculation of the first floor elevations of each structure in the study area.
- Use of the Corps' risk-based Monte Carlo simulation program (the Hydrologic Engineering Center Flood Damage Analysis [HEC-FDA] model) to estimate expected annual damages (EAD)
- Calculation of a benefit-to-cost (benefit-cost) ratio for each alternative

1.3 General Assumptions

The following assumptions were used in the conceptual-level design alternatives analysis (described in Sections 2 through 7):

- A federal interest rate of 3.50 percent
- All prices in 2013 dollars
- A 50-year period of analysis

The federal interest rate and pricing data used for the conceptual-level design alternatives analysis are no longer current. But the analysis in Sections 2 through 7 is intended to be a snapshot in time that provides decisions-makers with information to compare the conceptual-level design alternatives.

On the basis of the alternatives analysis, one of the conceptual-level design alternatives was selected to proceed to a feasibility-level design. This selected feasibility-level design alternative was subjected to the same economic analysis that was used to analyze the conceptual-level design alternatives, but with the following updated assumptions:

- A federal interest rate of 3.375 percent
- All prices in 2015 dollars
- A 50-year period of analysis.

2. STUDY AREA FOR ECONOMIC ANALYSIS

The study area defined for the economic analysis of flood damages is the potential Santa Clara River floodplain on the southeast bank of the river, beginning at the Vern Freeman Diversion Dam and extending to the Pacific Ocean (Figure 1). The study area includes a buffer around the modeled 500-year flood event to capture enough of the floodplain to ensure that the data collection needs would be met.

The southeast bank of the river (referred to herein as the “left bank”) consists of Ventura County lands and infrastructure and residential and commercial development in the city of Oxnard. There is some agricultural production in this area as well. The right bank is not included in the study area because the levees that require improvement are located on the left bank; therefore, no analysis of the right bank has been performed.

The study area encompasses both SCR-1, which extends from the Vern Freeman Diversion Dam in Saticoy to the downstream side of Highway 101, and SCR-3, which extends from the downstream side of Highway 101 to the eastern edge of the former Ballard Landfill. The study area is thus divided into two reaches based on the two levees. The “upstream” reach consists of the floodplain protected by SCR-1, beginning at Saticoy and ending on the downstream side of Highway 101. The “downstream” reach consists of the floodplain area protected by SCR-3, beginning on the downstream side of Highway 101 and ending at the ocean.

2.1 Upstream Reach

Hydraulic and hydrologic modeling of SCR-1 performed in support of the basis of design for the alternatives indicated that flood event flows would not pass over East Vineyard Avenue or Hwy 101, which are on the southeast side of the study area (Tetra Tech 2015). The upstream reach consists primarily of new residential neighborhoods, including many multifamily residential structures and apartments, as well as a new large-scale shopping center and several schools. The northeastern portion of this reach contains some agricultural lands.

2.2 Downstream Reach

The hydraulic and hydrologic modeling indicated that as the flood waters move west, the floodplains extend farther and farther south as well. However, FEMA floodplain mapping indicates that the flood zones south of West Gonzales Road are not directly attributed to flooding from the Santa Clara River. Thus, no structures or crop lands located south of West Gonzales Road have been included in the study area. The downstream reach also consists primarily of residential structures, along with several high-rise offices, recreational facilities, and commercial and industrial structures.

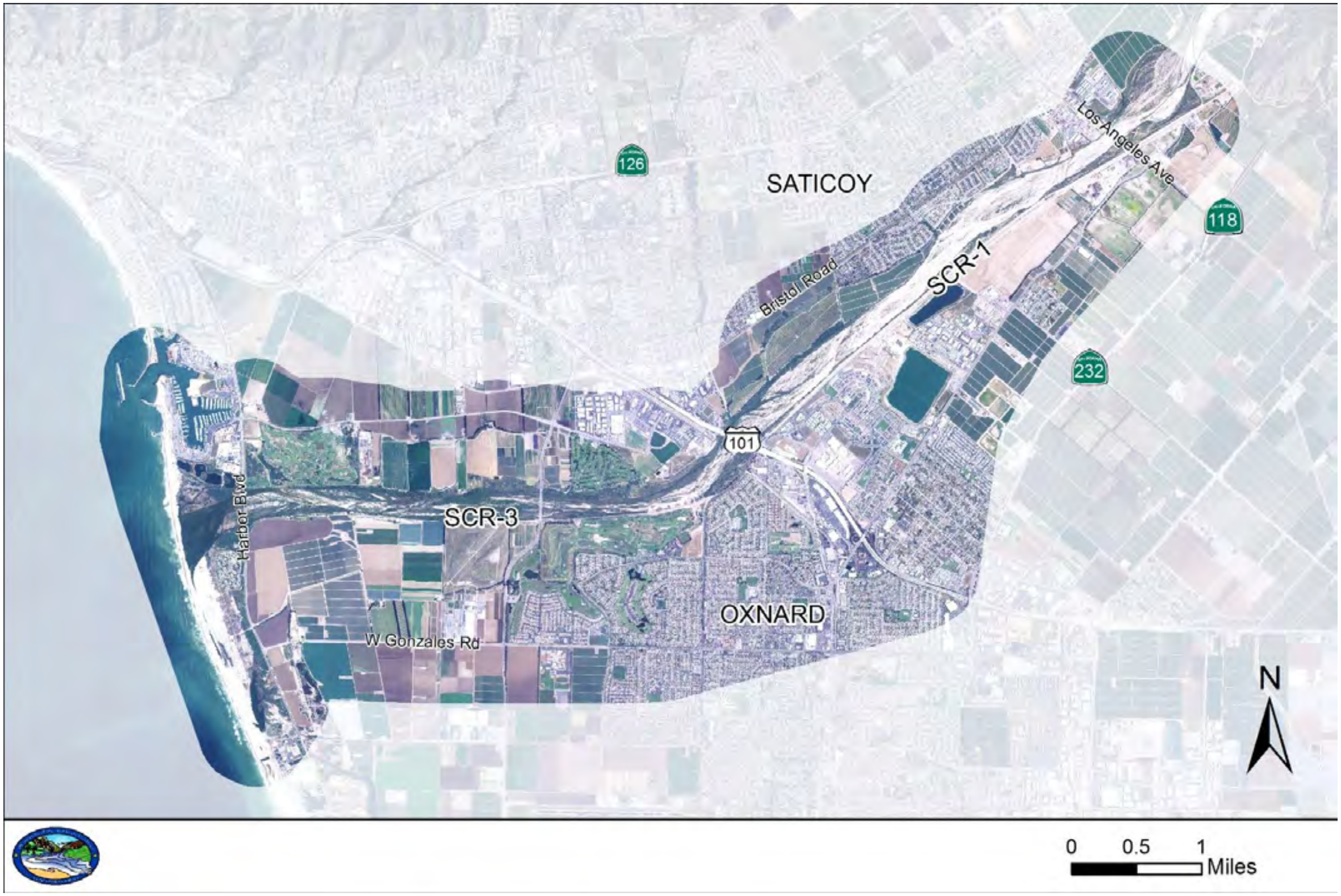

Figure 1 – Study Area for Economic Analysis

3. LAND USE AND STRUCTURAL INVENTORY

3.1 Land Use

Land use and development were reviewed to determine the existing floodplain characteristics within the study area. A primary element of this characterization was an inventory of the structures in the study area and the development of a structures database for use in modeling flood damages. The database was developed with the use of parcel data provided by the County of Ventura. The parcel data were referenced into ArcGIS for analysis and development of the structure database.

The first step in developing the database was to determine which parcels contained actual structures. This determination was made using mapping programs such as ArcGIS and Google Earth. The presence of structures was determined with the use of aerial photographs, as well as Google Earth's "Streetview" photographs. Any parcels that did not contain a structure were removed from the database.

For each parcel that included a structure, the structure was identified as either residential or nonresidential. This distinction is necessary because the method of valuation is different for each category. The residential and nonresidential structures included in this analysis for both the upstream and downstream reaches are shown in Figures 2 and 3.

3.2 Structural Categories

After the structures within each reach were placed into one of the two primary categories of residential and nonresidential, the nonresidential structures were further categorized into four subcategories on the basis of a more detailed survey of the nonresidential structures:

- Commercial
- Industrial
- Public
- Farm buildings

The total number of structures in each of the five structural categories are shown by reach in Table 1.

Table 1 – Number of Structures in Each Category by Reach

Reach	Commercial	Farm	Industrial	Public	Residential	Total
Upstream	56	3	23	7	1,312	1,401
Downstream	98	5	2	9	3,766	3,880
Totals	*154*	*8*	*25*	*16*	*5,078*	*5,281*

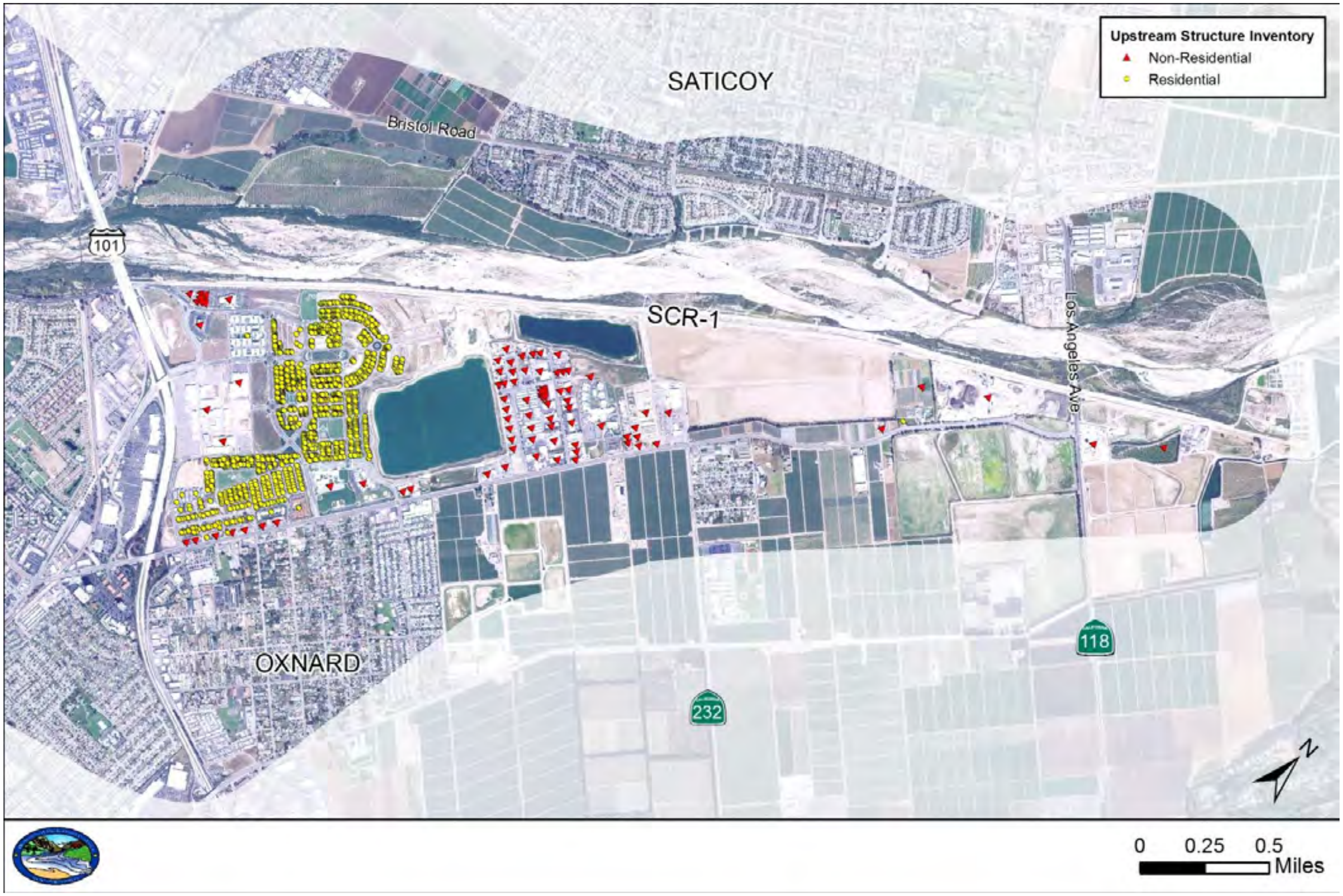

Figure 2 – Residential and Nonresidential Structures Included in Economic Analysis (Upstream)

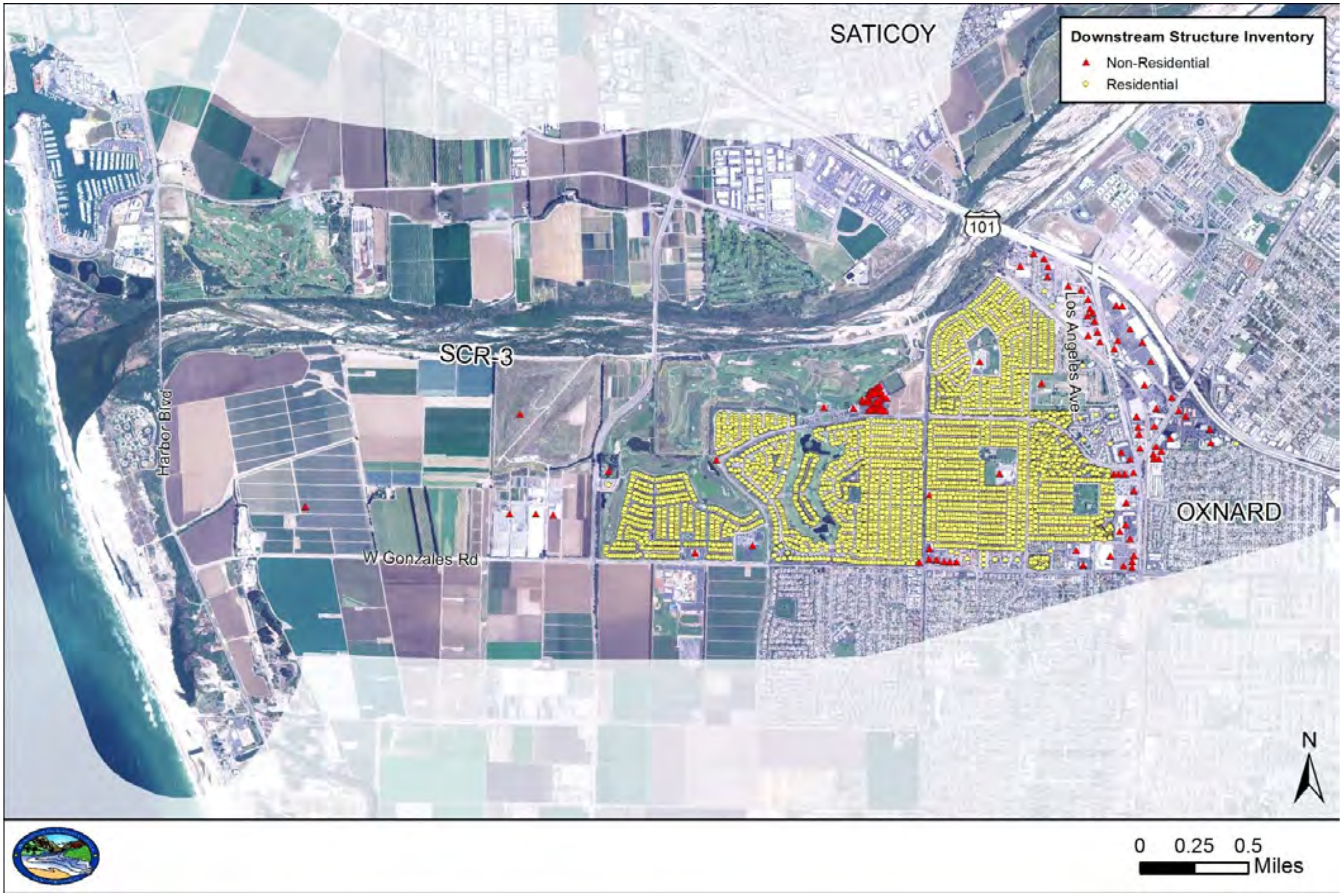

Figure 3 – Residential and Nonresidential Structures Included in Economic Analysis (Downstream)

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4. STRUCTURAL AND AGRICULTURAL VALUATION

The methods used for the valuation of residential structures, nonresidential structures, and agricultural land are different. The valuation of residential structures is performed by a random sample of parcels, whereas the valuation for nonresidential structures requires a survey of 100 percent of the structures. The valuation of agricultural land is based on the crops that are grown on the land.

4.1 Residential Structural Values

For residential structures, one in five parcels was sampled to derive representative values for each structure. The sampled structures were chosen in a systematic random approach. Subsequently, data were obtained for 1,184 residential structures (roughly 20 percent of all the residential structures). During the sampling, structural attributes (building class, building type, and building condition) and estimated foundation heights were obtained using Google Earth's "Streetview." The structural attributes were then used to calculate values per square foot based on the Marshall & Swift cost database (Marshall & Swift 2007). The square foot values and foundation heights resulting from the sampling were then applied to the unsampled residential structures to complete the structure valuation for the study area.

4.2 Nonresidential Structural Values

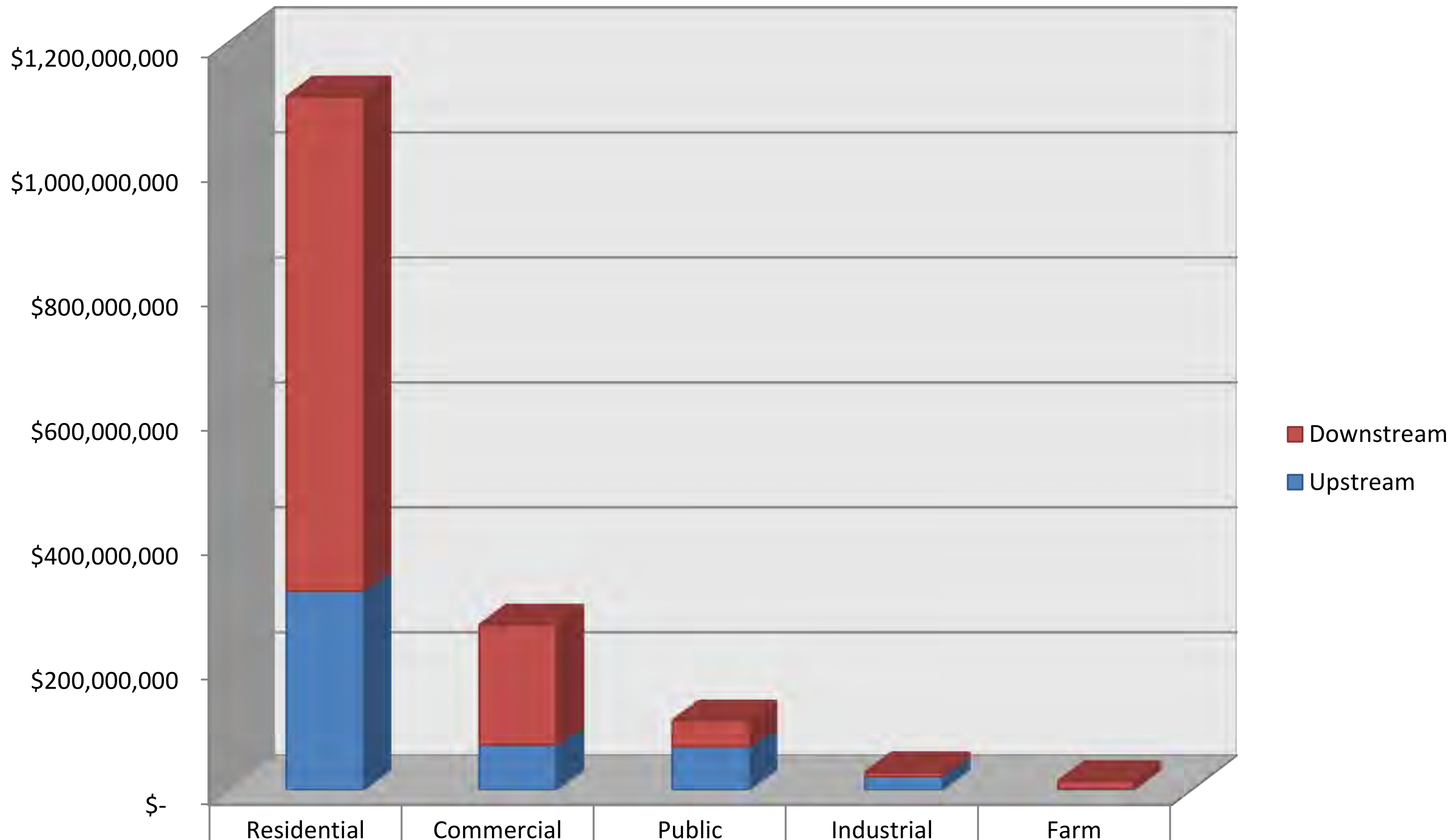
A 100 percent inventory valuation was performed on all nonresidential structures, resulting in a unique value for each structure. The structural values were estimated on the basis of the Marshall & Swift cost database, which relies on attributes from the structure database to generate a value per square foot (Marshall & Swift 2007). The attributes used to develop this value included building use, building class, building type, and building condition. The building square footage was developed from the Ventura County parcel database where applicable; for structures that had no square footage in the database, square footage was determined with the use of a geographic information system (GIS).

4.3 Total Structural Valuation

After the development of the structures database, a preliminary valuation of all 5,281 parcels with structures was performed, identifying over 18,264,920 square feet of structures with an estimated depreciated replacement value in excess of $1.5 billion in the study area. A breakdown of structural values in the study area is provided in Figure 4.

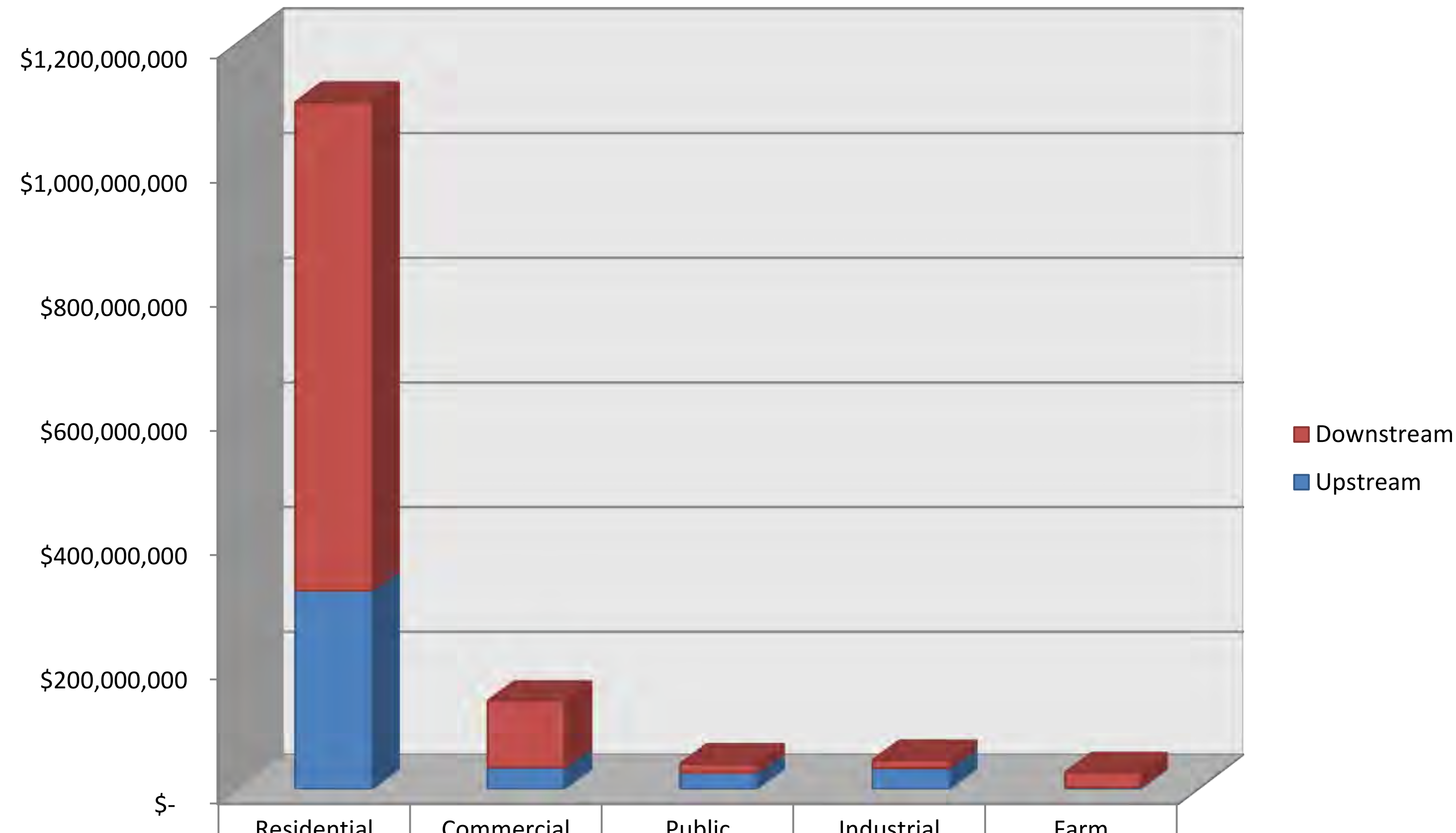
4.4 Content Valuation

Content values are estimated as a direct function of structural value. These values are calculated in HEC-FDA and are designed to estimate content damage as a percentage of structural value. The percentages used in this analysis were obtained from Folsom Dam Modifications and Folsom Dam Raise Project, Final Economic Reevaluation Report (USACE 2008). The percentages vary by structure type. The total content value of structures in the study area is provided in Figure 5.



	Residential	Commercial	Public	Industrial	Farm
Downstream	$791,250,260	$194,364,030	$42,925,240	$7,010,230	$13,073,370
Upstream	$321,840,650	$73,268,240	$70,051,770	$21,919,420	$1,213,510

Figure 4 – Total Estimated Structural Value for All Structures in Study Area



	Residential	Commercial	Public	Industrial	Farm
Downstream	$783,417,790	$108,475,266	$14,896,946	$12,877,867	$24,577,936
Upstream	$321,840,650	$35,022,288	$26,274,503	$34,093,132	$2,281,399

Figure 5 – Total Estimated Content Value for All Structures in Study Area

4.5 Agricultural Land Valuation

The Planning Guidance Notebook, ER 1105-2-100 (USACE 2000) has specific rules for the treatment of agricultural crops. Agricultural crops are divided into two categories: basic crops and other crops. Basic crops (rice, cotton, corn, soybeans, wheat, milo, barley, oats, hay, and pasture) are crops that are grown throughout the United States in quantities such that no water resources project would affect the price and, thereby, cause transfers of crop production from one area to another.

The guidance indicates that the loss of income applies only basic crops and that damages to other crops is limited to the variable costs (the direct production investment) before the damage was incurred (USACE 1987). This analysis included the variable costs of other crops only for the reasons discussed in the following subsections. Costs for post-flood cleanup, land restoration, and other costs incurred have not been included.

4.5.1 Agricultural Land Inventory

The study area encompasses approximately 1,212 acres of agricultural lands that are subject to flooding. A majority of this land is currently in the downstream reach of the study area. The agriculture area was estimated using the parcel data provided by the County of Ventura and aerial photographs to determine whether the parcels contain active farmlands. The agricultural parcels used in this analysis are shown in Figure 6.

On a map of agricultural land use developed by the County of Ventura, several crop types are visible in the approximate study area (Figure 7). The two prominent crop types are strawberries and lemons. However, the area designated for lemons in Figure 7 appears to be in the upstream reach, where aerial photographs show limited active agricultural land subject to flooding. Thus, for simplicity of analysis and because of the land use shown in Figure 7, all agricultural land in this analysis was assumed to be used for the production of strawberries.

4.5.2 Farm Budget

Farm budgets for strawberry farmland were obtained from the University California, Davis, Agricultural and Resource Economics Department databases (UC Davis 2014). The farm budget analysis for strawberries cultivated in Ventura County that was used for this economic analysis is described in Attachment 1. With strawberries being categorized as other crops, the damage is estimated as the loss in direct production investment, which represents the variable costs incurred from cultivating and harvesting the crop up to the flood event. Once the area is flooded, it is assumed that the crop would be a total loss. This cost is calculated from a weighted average of the cumulative monthly budget costs, and the weights represent the likelihood of flooding in a given month. This calculation is provided in Table 2.

4.5.3 Inundated Area

Based on the varying flood events, the total area of inundated agricultural land would stay the same from the 10-year event up to the 500-year event. This is because only the downstream agricultural land would be inundated, and the land is located toward the downstream reach of the study area, where flood events tend to cover the same general area due to the low elevations. Thus, the inputs to HEC-FDA for the agricultural land incorporate $10,754 per acre for each event, increasing in magnitude beginning with the 10-year event

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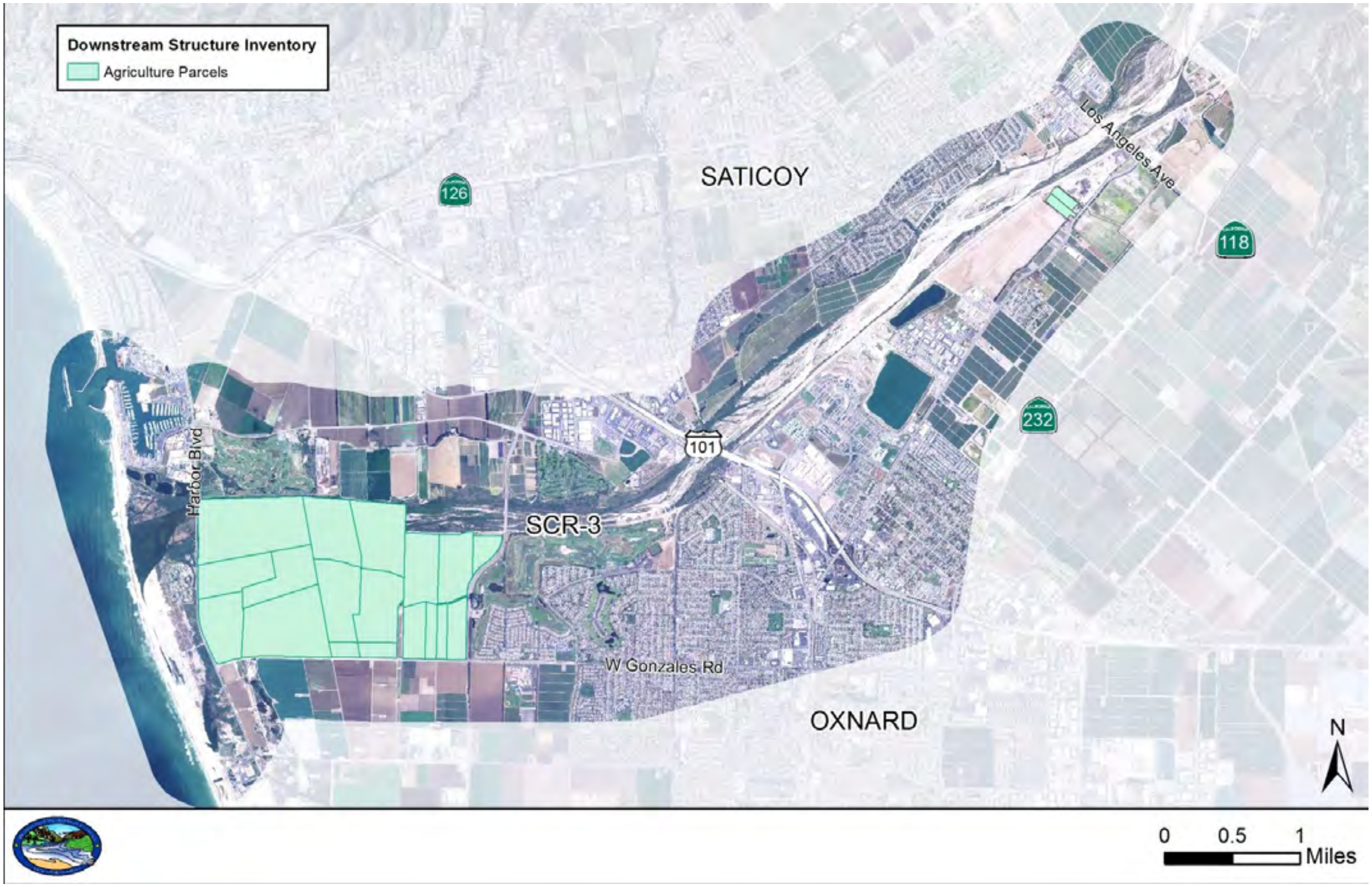
Figure 6 – Total Agricultural Land Used in Economic Analysis



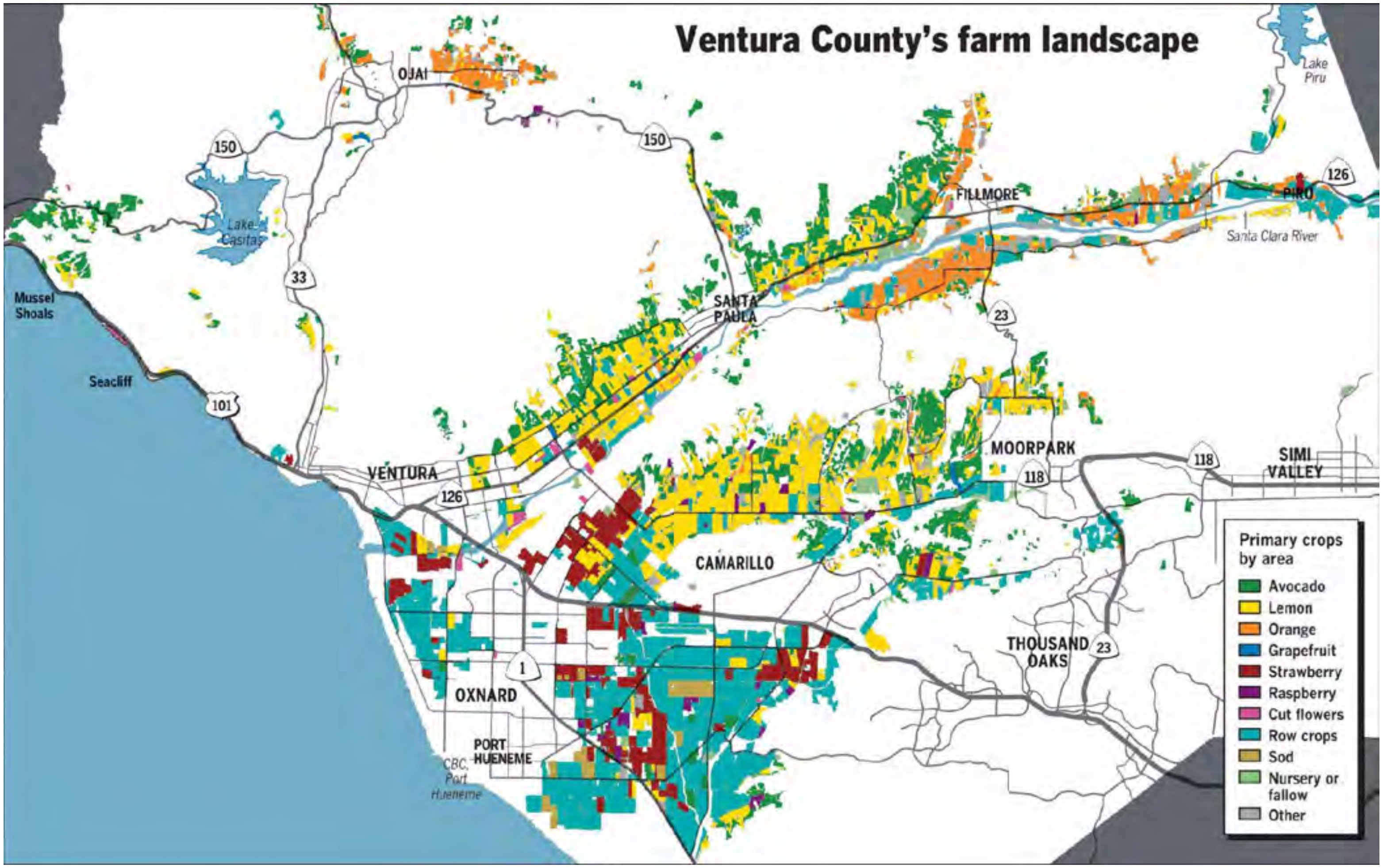


Figure 7 – Ventura County Agricultural Land Use by Crop Type

Table 2 – Strawberry Weighted Loss Calculation

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Marc h	April	May	June	July
Weights			0.10	0.15	0.25	0.25	0.15	0.1				
Cultural Costs	$550	$3,414	$4,157	$546	$68	$553	$394	$776	$527	$654	$184	$667
Harvest Costs	0	0	0	0	0	$1,110	$1,811	$3,249	$4,803	$5,275	$1,998	$820
Other Costs	0	0	0	0	0	$86	$171	$428	$684	$570	0	$3,191
Total Variable Cost	$553	$3,433	$4,195	$587	$110	$1,799	$2,437	$4,536	$6,126	$6,642	$2,336	$4,854
Cumulative Variable Cost	$553	$3,986	$8,181	$8,768	$8,878	$10,677	$13,114	$17,650	$23,776	$30,418	$32,754	$37,608
Weighted Loss			$818	$1,315	$2,220	$2,669	$1,967	$1,765				
Total Weighted Loss	$10,754											
Total Acres (Downstream)	1,193											
Total Inundation Damages	$12,829,522											

Note: Please see Attachment 1 for a full breakout of cultural, harvest, and other costs.

Source: UC Davis, 2014.

5. FLOOD DAMAGE MODEL

For this economic analysis, EAD was estimated with the use of the HEC-FDA model, which integrates available hydrologic, hydraulic, geotechnical, and economic relationships to determine damages, flooding risk, and project performance. Uncertainty is incorporated for each relationship, and the model samples from a distribution for each observation to estimate damage and flood risk.

5.1 Hydraulic and Hydrologic Input

A stage-frequency function describes the maximum water surface elevation (stage) that the flow of water would reach given a particular flood event size. Hydraulic modeling was completed for the study area with the use of the Hydrologic Engineering Center River Analysis System (HEC-RAS) model, and the data from the HEC-RAS models were incorporated into the HEC-FDA program. The HEC-RAS modeling assumed that the two levees (SCR-1 and SCR-3) were not in place. The levees were omitted from the modeling because the basis for this study was completed looking at the FEMA DFIRMs, and the purpose of this economic analysis was to estimate damages for the areas shown in the DFIRMs. The HEC-RAS-modeled profiles for the 100- and 500-year events were thus compared to the flooding extents shown on the FEMA DFIRMs to verify that the assumptions used in the model resulted in areas similar to the DFIRM data. Once this was verified, eight modeled flood events were used in the damage calculations. More detailed discussion of the hydraulic model is provided in Appendix I of the Santa Clara River Levee (SCR-1) Basis of Design Report (Tetra Tech 2015).

For the calculation of EAD, HEC-FDA requires eight flood events: the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year flows. The water surface profile for each of the index stations and flood events used in this economic analysis are indicated in Table 3, and the locations of the stations are shown in Figure 8.

Table 3 – Water Surface Profiles Used in HEC-FDA

		Water Surface Elevation (feet)							
Station No.	Invert (feet)	2-Yr Event	5-Yr Event	10-Yr Event	25-Yr Event	50-Yr Event	100-Yr Event	200-Yr Event	500-Yr Event
2033	5.70	7.51	9.25	11.03	12.98	13.79	14.99	15.86	17.16
2838	6.00	10.10	12.81	14.56	16.22	17.52	18.61	20.01	21.99
3174	6.07	10.73	13.55	15.62	18.38	21.02	24.51	24.56	28.75
3592	6.81	11.58	14.37	16.40	19.11	21.52	24.79	26.69	29.35
4659	8.34	13.86	17.58	19.85	23.00	25.47	28.78	30.74	32.52
5860	10.68	15.40	19.47	22.21	25.96	28.93	30.64	32.93	34.75
7665	14.06	19.24	22.87	25.74	29.67	32.92	35.66	37.14	39.22
8849	17.71	22.35	25.80	28.35	32.05	35.17	37.76	40.50	42.48
10126	20.26	24.87	28.76	31.86	36.22	39.75	43.20	44.81	47.41
11169	21.83	26.71	30.59	33.71	37.40	40.18	43.22	44.61	47.22
11659	22.47	27.27	31.18	34.33	38.21	40.37	43.80	45.57	47.81

		Water Surface Elevation (feet)							
Station No.	Invert (feet)	2-Yr Event	5-Yr Event	10-Yr Event	25-Yr Event	50-Yr Event	100-Yr Event	200-Yr Event	500-Yr Event
13347	25.83	29.95	33.52	36.53	40.53	43.39	45.92	48.24	51.59
14627	28.94	33.34	37.27	40.39	44.31	47.59	48.38	50.73	54.18
15177	29.56	34.45	38.35	41.38	45.26	47.66	48.51	52.86	57.01
15610	31.24	37.35	40.73	44.41	49.14	52.53	57.37	58.42	60.47
16954	33.41	39.15	43.58	47.05	51.78	56.05	58.19	59.64	62.22
18391	36.44	41.48	46.21	49.85	54.12	57.43	59.91	62.16	65.87
19944	39.87	44.95	49.54	53.22	57.99	61.26	64.85	68.05	72.11
21062	43.31	49.08	53.42	57.00	62.09	65.07	67.14	69.72	73.35
22350	45.09	51.90	56.42	59.51	64.19	67.47	70.18	72.88	76.78
23450	47.20	53.21	58.15	61.31	65.49	68.49	71.19	73.83	77.90
23999	49.31	54.16	59.08	62.55	66.86	69.81	72.39	74.70	78.41
24293	49.14	56.67	61.53	64.96	68.27	71.54	76.57	79.06	85.74
24494	49.61	56.96	61.66	65.08	68.41	71.66	76.68	79.21	85.91
24761	52.75	57.81	62.16	65.44	68.81	72.00	76.83	79.33	85.86
24762	52.75	57.81	62.16	65.44	68.81	72.00	76.83	79.33	85.86
25132	54.44	60.42	64.28	67.49	71.24	74.57	77.69	80.51	87.61
26356	60.31	64.07	66.37	69.04	72.83	76.14	79.41	82.51	89.47
27500	64.08	67.52	70.06	72.04	75.23	78.15	81.22	84.29	90.62
28932	67.25	71.92	74.74	76.67	79.15	81.31	83.94	86.80	92.59
30352	69.92	75.68	78.25	80.24	82.85	84.93	87.24	89.76	94.59
31962	73.55	78.53	81.66	83.84	86.61	88.73	90.98	93.34	97.36
33526	79.15	82.27	85.10	87.39	90.43	92.74	95.12	97.50	101.16
34928	81.04	85.53	88.82	91.34	94.64	97.09	99.67	102.32	106.27
36441	85.04	89.18	92.37	94.98	98.56	101.38	104.47	107.50	112.12
37960	88.5	91.92	94.90	97.34	101.00	103.98	107.25	110.49	115.45
39424	91.59	96.16	98.60	100.47	103.36	106.02	109.06	112.22	117.04
40799	95.09	99.02	101.62	103.67	106.51	108.84	111.48	114.20	118.33
42356	97.81	102.13	105.61	108.16	111.49	114.22	117.22	120.70	126.18
43729	101.6	105.82	109.20	111.91	115.81	119.10	122.72	126.62	132.71
44878	105.8	109.13	112.72	115.63	119.68	123.10	126.90	131.35	137.40
45295	105.54	110.31	114.05	116.98	121.33	124.83	128.96	133.38	143.21
45947	107.06	111.65	115.25	118.12	122.31	125.84	129.88	134.29	144.07
48419	114.08	119.66	122.80	124.97	127.67	130.25	133.52	137.41	145.91
48842	115.73	120.89	124.19	126.25	128.70	131.03	134.06	137.57	145.73
49387	116.91	122.34	126.10	127.90	130.29	132.42	135.14	138.37	146.08

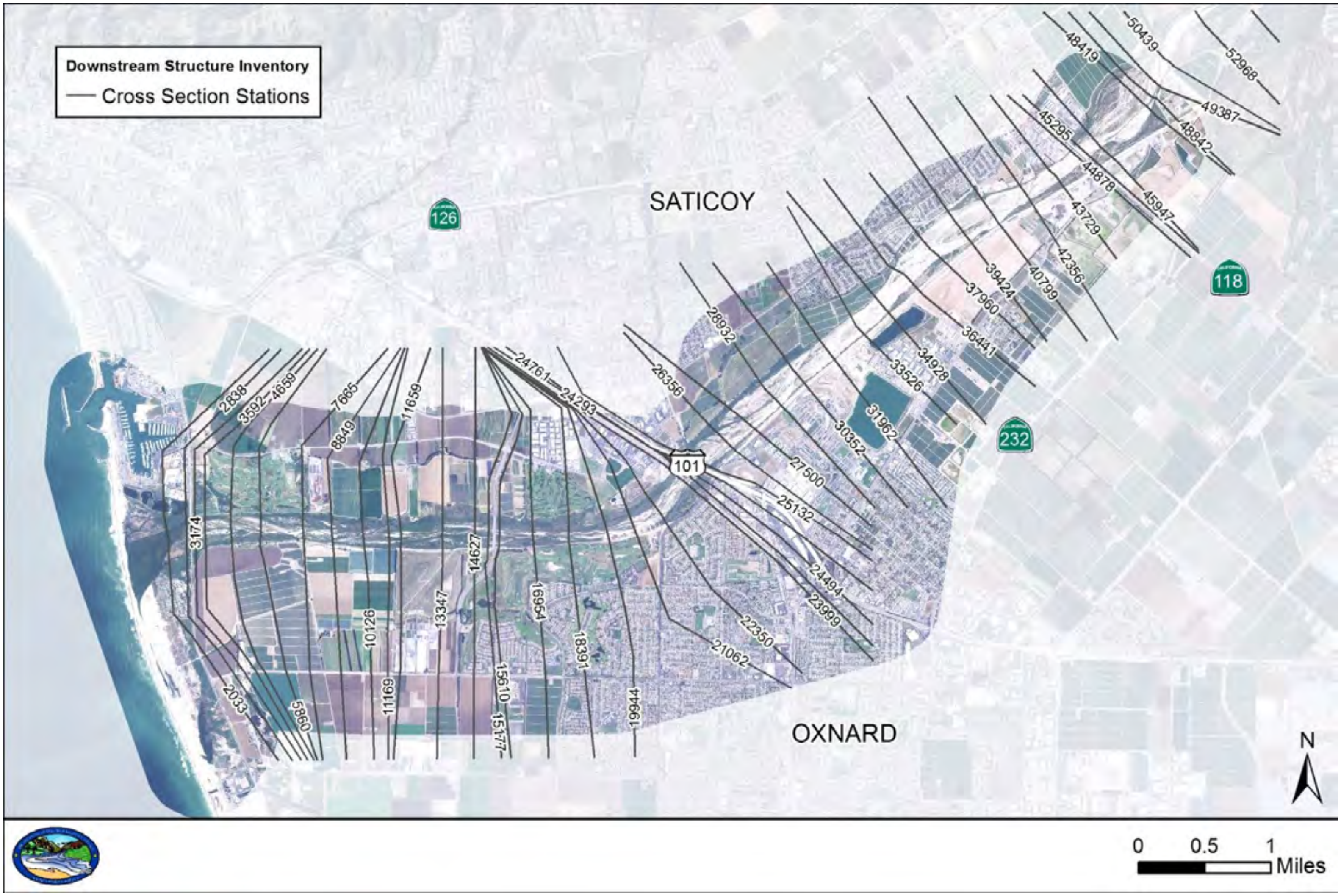


Figure 8 – Cross Section Stations Used in HEC-FDA Model

In order to estimate EAD, the HEC-FDA model also requires an exceedance probability curve. The information for this function was calculated within HEC-FDA from the water surface profile data at the specified index point. The exceedance probability plots for both the upstream and downstream reaches are shown in Figures 9 and 10, respectively.

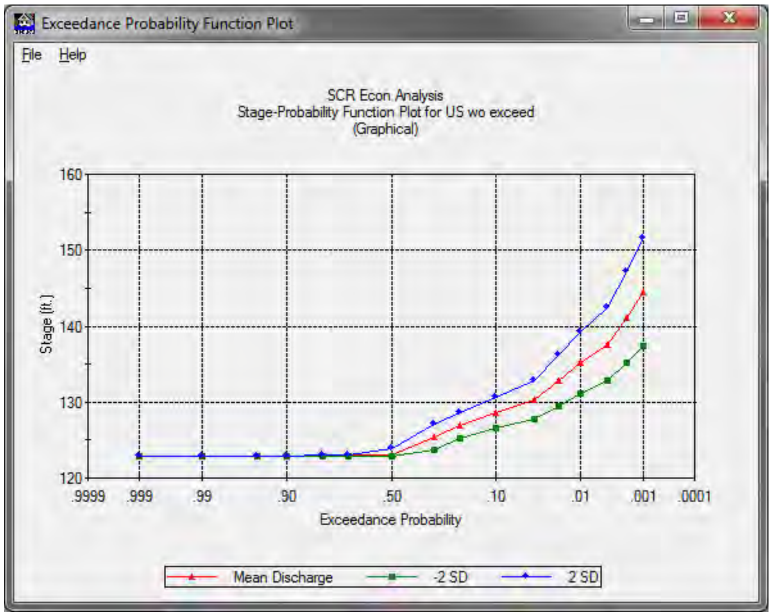


Figure 9 – Upstream Exceedance Probability Plot

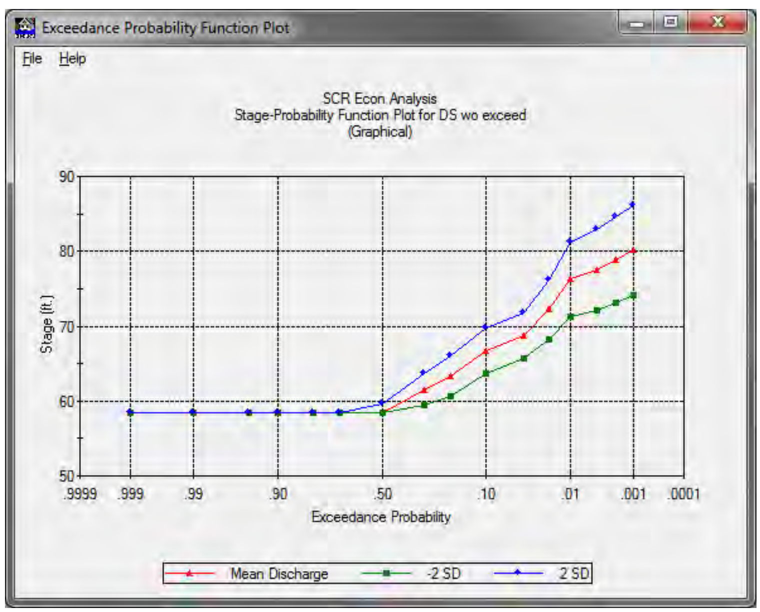


Figure 10 – Downstream Exceedance Probability Plot

5.2 Damages to Structures and Contents

Damages to both structures and content are determined on the basis of flood depth relative to the height of the first floor of the building. In this analysis, each structure was assigned a station that corresponds with the water surface profiles in Table 3. HEC-FDA then calculated the depth of flooding from the water surface profiles and subtracted each individual structure's first floor elevation to calculate the inundation depth. Damages were then estimated as a percentage of the structural and content value using depth-damage functions that were obtained from the Folsom Dam Economic Reevaluation Report (USACE 2008). An example of a depth-damage curve used in the analysis is shown in Figure 11, and all of the depth-damage curves for each type of structure occupancy used in the analysis are provided in Attachment 2.

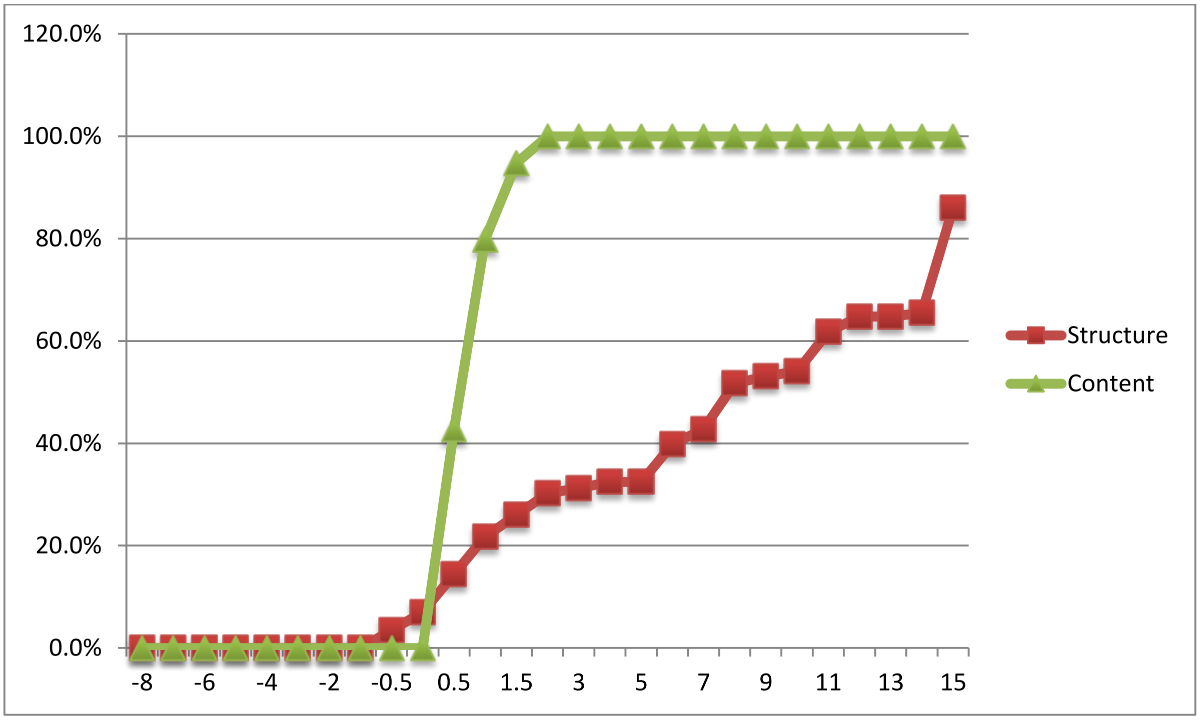


Figure 11 – Sample Depth-Damage Curve

5.3 Agricultural Damages

As previously noted, the agriculture category incorporates the weighted damages to strawberry farmlands assuming that if the parcel is inundated, the entire crop output would be lost for that year. The EAD calculation for agricultural land was performed outside of HEC-FDA for simplicity. The EAD calculation table in the Integrated Regional Water Management, Proposition 1E grant application package was used. The EAD calculation for the downstream reach only (no farmland would be inundated in the upstream reach) is provided in Table 4. Based on the hydraulic modeling, damages for structures in the downstream reach start with the 10-year event; thus agricultural damages were also assumed to start with the 10-year event.

Table 4 – Expected Annual Damage Calculation for Agricultural Land

Hydrologic Event	Event Exceedance Probability	Event Damage	Probability of Flooding	Expected Event Damage	Interval Probability	Average Damage in Interval	Average Damage in Interval Multiplied by Interval Probability
2-year	0.5	0	0	0			
5-year	0.2	0	0	0	0	0	0
10-year	0.1	$12,829.5	1	$12,829.5	.1	$6,414.75	$641.48
25-year	0.04	$12,829.5	1	$12,829.5	0.06	$12,895.5	$773.73
50-year	0.02	$12,829.5	1	$12,829.5	0.02	$12,895.5	$256.59
100-year	0.01	$12,829.5	1	$12,829.5	0.01	$12,895.5	$128.30
200-year	0.005	$12,829.5	1	$12,829.5	0.005	$12,895.5	$64.15
500-year	0.002	$12,829.5	1	$12,829.5	0.003	$12,895.5	$38.49
						Expected Annual Damages	**$1,902.74**
Note: All values are in thousand dollars.							

6. RESULTS OF FLOOD DAMAGE ANALYSIS

As previously mentioned, residential, nonresidential, and agricultural damages by event frequency were correlated to stage and entered into the HEC-FDA model by reach. The overall results of this modeling are presented in Table 5. Total EAD from the model is estimated at $18.0 million.

Table 5 – Expected Annual Damages for Without-Project Conditions

Reach	COM	FARM	IND	PUB	RES	AG	TOTAL
Upstream	$185	$1.8	$82.4	$408	$1,313	$0	$1,991
Downstream	$1,356	$3,116	$25.9	$414	$9,279	$1,903	$16,093
Totals	*$1,541*	*$3,118*	*$108*	*$823*	*$10,592*	*$1,903*	*$18,093*
Note: All values are in thousand dollars.							

The estimated damages by flood event for both the upstream and the downstream reach are provided in Tables 6 and 7, respectively. The total damages by flood event for agricultural land and each structural category are shown in Figure 12.

Table 6 – Total Damages by Event – Upstream Reach

Event	COM	FARM	IND	PUB	RES	AG	TOTAL
2-year	-	-	-	-	-	-	-
5-year	-	-	-	-	-	-	-
10-year	-	-	-	-	-	-	-
25-year	-	-	-	-	$543	-	$543
50-year	-	-	-	-	$9,838	-	$9,838
100-year	$4,822	-	-	$18,231	$30,462	-	$53,515
200-year	$9,860	-	$2,594	$22,992	$66,820	-	$102,266
500-year	$19,795	-	$14,608	$49,186	$124,685	-	$208,274
Note: All values are in thousand dollars.							

Table 7 – Total Damages by Event – Downstream Reach

Event	COM	FARM	IND	PUB	RES	AG	TOTAL
2-year	-	-	-	-	-	-	-
5-year	-	$1,225	-	-	-	-	$1,225
10-year	$536	$11,353	-	-	$114	$12,830	$24,832
25-year	$6,161	$24,105	-	$376	$33,494	$12,830	$76,509
50-year	$17,413	$30,022	$37	$10,923	$157,488	$12,830	$228,551
100-year	$32,736	$30,974	$370	$17,124	$251,502	$12,830	$345,534
200-year	$41,943	$31,691	$383	$18,152	$352,950	$12,830	$457,949
500-year	$52,330	$32,631	$401	$21,107	$479,941	$12,830	$599,239
Note: All values are in thousand dollars.							

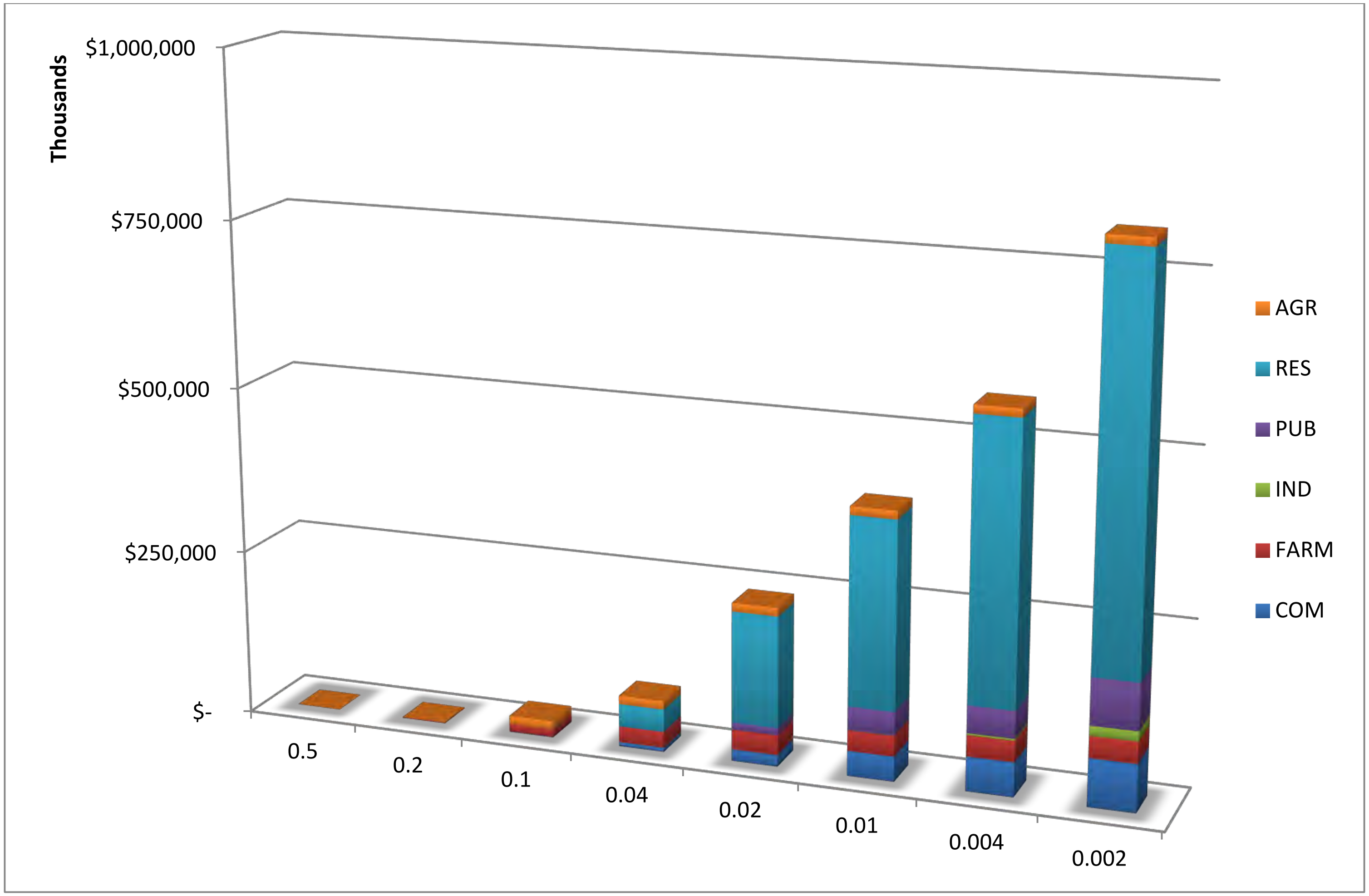


Figure 12 – Total Damages by Flood Event

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7. BENEFIT-COST ANALYSIS

A benefit-cost analysis has been completed for the SCR-1 improvements (project) to compare the construction costs for three conceptual-level design alternatives (each with two different design flows, for a total of six alternatives) with the estimated annual benefits in the upstream reach. This analysis included only the estimated annual benefits in the upstream reach because it is assumed that SCR-3 will be constructed and certified to contain the flood flows in the downstream reach and flood flows from the upstream reach are not predicted to flow across Hwy 101.

7.1 Estimated Benefits

For this analysis, the benefits to the project have been estimated as the present value of future benefits (PVFB), which is derived from the EAD under without-project conditions minus the EAD under with-project conditions. The without-project EAD is referred to in the discussions above. However, the with-project EAD has been estimated on the basis of a general assumption, because hydrologic and hydraulic modeling of the alternatives is not currently included in the scope of work for this economic analysis. Thus, for the purpose of the economic analysis and a comparison of the alternatives, it was assumed that each of the conceptual-level design alternatives would be capable of containing flows up to the 200-year event.

Therefore, the HEC-FDA modeling performed for with-project conditions for this analysis used the water surface profile data from the without-project models for the 500-year event only. The rest of the water surface profile data for the other seven events, required to run HEC-FDA, were input as non-damaging because the actual construction of each conceptual alternative would provide protection up to the 200-year flows. The estimated with-project EAD totals, generated within HEC-FDA, by category for the upstream reach are shown in Table 8.

Table 8 – Expected Annual Damages for With-Project Conditions

Reach	COM	FARM	IND	PUB	RES	AG	TOTAL
Upstream	$109	$3.7	$61.5	$102	$390	$0	$667
Note: All values are in thousand dollars.							

To calculate the total PVFB, the current discount rate of 3.50 percent and the project life span must be incorporated. The project life span is currently assumed to be 50 years. The calculation of the PVFB for the upstream reach used the EAD under without-project conditions and the EAD under with-project conditions to generate one PVFB for the project (Table 9).

Table 9 – Calculation of Present Value of Future Benefits – Upstream Reach

Present Value of Future Benefits – Upstream			
(a)	Expected Annual Damage Without Project		**$1,991,000**
(b)	Expected Annual Damage With Project		**$666,690**
(c)	Expected Annual Benefit	(a) – (b)	**$1,324,310**
(d)	Present Value Coefficient		**23.46**
(e)	**Present Value of Future Benefits**	**(c) x (d)**	**$31,062,509**

7.2 Estimated Construction Costs

Construction and operation and maintenance (O&M) costs for the six conceptual-level design alternatives were developed for this analysis. Three of the alternatives were designed to provide protection for a flood flow with a water surface elevations up to that of a design event of 250,000 cfs (100-year +10 percent), and three of the alternatives were designed with the same construction components but to provide protection for a flood flow with a water surface elevations up to that of the 200-year event. However, with the freeboard accounted for in the design, all the alternatives ended up containing the modeled 200-year flows. Full descriptions of the alternatives and breakdowns of the cost estimates are provided in the Basis of Design Report (Tetra Tech 2015). The total construction and O&M costs for each alternative are provided in Table 10.

Table 10 – Total First and O&M Costs

Alternative	First Costs[1]	Annual O&M Costs
Alternative 1 *(Design Q)*	$98,841,400	$81,300
Alternative 1 *(COE 200-yr Q)*	$101,644,200	$83,900
Alternative 2 *(Design Q)*	$151,735,600	$246,800
Alternative 2 *(COE 200-yr Q)*	$156,910,200	$257,500
Alternative 3 *(Design Q)*	$138,269,900	$117,700
Alternative 3 *(COE 200-yr Q)*	$147,285,000	$128,300
[1]Note: Includes construction costs and interest during construction.		

7.3 Calculation of Benefit-Cost Ratios

The previously mentioned benefits and costs were used to generate benefit-cost ratios. The benefit-cost ratios were calculated by dividing the PVFB, as estimated previously, by the present value of discounted costs (PVDC). The calculation of PVDC is similar to that of PVFB, in that the calculation of PVDC also uses the current discount rate of 3.5 percent and the design life of 50-years. The PVDC calculation uses discount rates to account for the annual costs of O&M during the project design life and also discounts the first costs in the year in which they are proposed to be incurred. Detailed PVDC spreadsheets are provided in Attachment 3, and the estimated PVFB, PVDC, and benefit-cost ratios for each of the six conceptual design alternatives are provided in Table 11.

Table 11 – Benefit-Cost Ratios

Alternative	Present Value of Future Benefits	Present Value of Discounted Costs	Benefit-Cost Ratio
Alternative 1 *(Design Q)*	$31,062,509	$73,080,049	0.425
Alternative 1 *(200-year Q)*	$31,062,509	$75,157,248	0.413
Alternative 2 *(Design Q)*	$31,062,509	$114,218,047	0.272
Alternative 2 *(200-year Q)*	$31,062,509	$118,151,188	0.263
Alternative 3 *(Design Q)*	$31,062,509	$102,298,209	0.304
Alternative 3 *(200-year Q)*	$31,062,509	$109,016,665	0.285

7.4 Benefit-Cost Results

The benefit-cost ratios are well below 1.00 for each of the conceptual-level design alternatives. This means that none of the alternatives, as they are currently designed, would provide benefits to the area that would outweigh their construction costs. Some design changes, such as a reduction in the project length, could result in significant increases in the cost-benefit ratios by reducing the construction costs. However, a significant decrease in the scale of the alternatives would be required to approach a benefit-cost ratio in excess of 1.00.

Each conceptual-level design alternative is labeled with “Design Q” and “200-year Q,” which corresponds to the level of protection of the designed. The results of this analysis indicate that the alternatives for the “200-year Q” all have benefit-cost ratios less than the corresponding alternatives for the “Design Q” ratios. This could lead to the elimination of the “200-year Q” alternatives from further analysis. However, due to the general assumptions required for calculating the PVFB for this analysis, all benefits are the same for each alternative. Future analysis into the hydrologic and hydraulic and geotechnical data for the existing and proposed levees would likely generate differences in the PVFB between the alternatives. This could possibly lead to higher benefit-cost ratios for the “200-year Q” alternatives. Thus, it should be stressed that more data and analysis are required if there is desire for a “200-year Q” alternative moves forward.

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8. FEASIBILITY-LEVEL DESIGN BENEFIT-COST ANALYSIS

Alternative 1, from the conceptual-level design alternatives discussed in Section 7, was selected by VCWPD for further study. The alignment of the selected alternative was refined and it was developed to a feasibility-level design, to remediate levee deficiencies and to meet the levee criteria for both FEMA and the Corps. This section discusses the calculation of the benefit-cost ratio for the resulting feasibility-level design.

8.1 Proposed Levee Alignment in Feasibility-Level Design

The economic analyses discussed in Sections 3 through 7 were based on the assumption that SCR-1 extends from the Vern Freeman Diversion Damon the upstream end to Highway 101 on the downstream end of the levee. However, the feasibility-level design for the selected alternative changed the levee alignment. The alignment in the current feasibility-level design plans follows the current levee alignment from Highway 101 upstream to approximately Station 350+00 (near the levee penetration for the Central Avenue Drain). At this point, the levee extends east along the northerly edge of the Central Avenue Drain, and the new levee would tie into high ground near Vineyard Avenue. The remaining upstream portion of the existing levee would remain in place but would no longer be considered part of the SCR-1 system. The proposed levee alignment in feasibility-level design is shown in Figure 13.

8.2 Estimated Benefits of Feasibility-Level Design

The estimated benefits for the feasibility-level design have been calculated with the use of same overall methodology as that discussed previously in this report; however, several changes in the inputs to the HEC-FDA model were required on the basis of design modifications and further analysis:

- Six structures were removed from the structural inventory because they would not be protected by the new levee alignment. All of these structures are located northeast of the proposed levee tie-in section.
- Two new benefit categories have been included in the flood damage analysis: automobile damages and estimated cleanup costs. These two categories were not included in the previous analysis because they were not expected to significantly affect the overall benefit-cost values at that time. However, because of the decrease in scale of the currently proposed levee alignment, inclusion of these costs has been deemed necessary in order to generate a more accurate accounting of the damages incurred by flooding.
- All structural values have been escalated to current prices (1Q15).
- The discount rate has been updated to the current 3.375 percent, as provided by the Federal Office of Management and Budget.

The EAD for the levee alignment in the feasibility-level design under with- and without-project conditions is shown in Table 12.

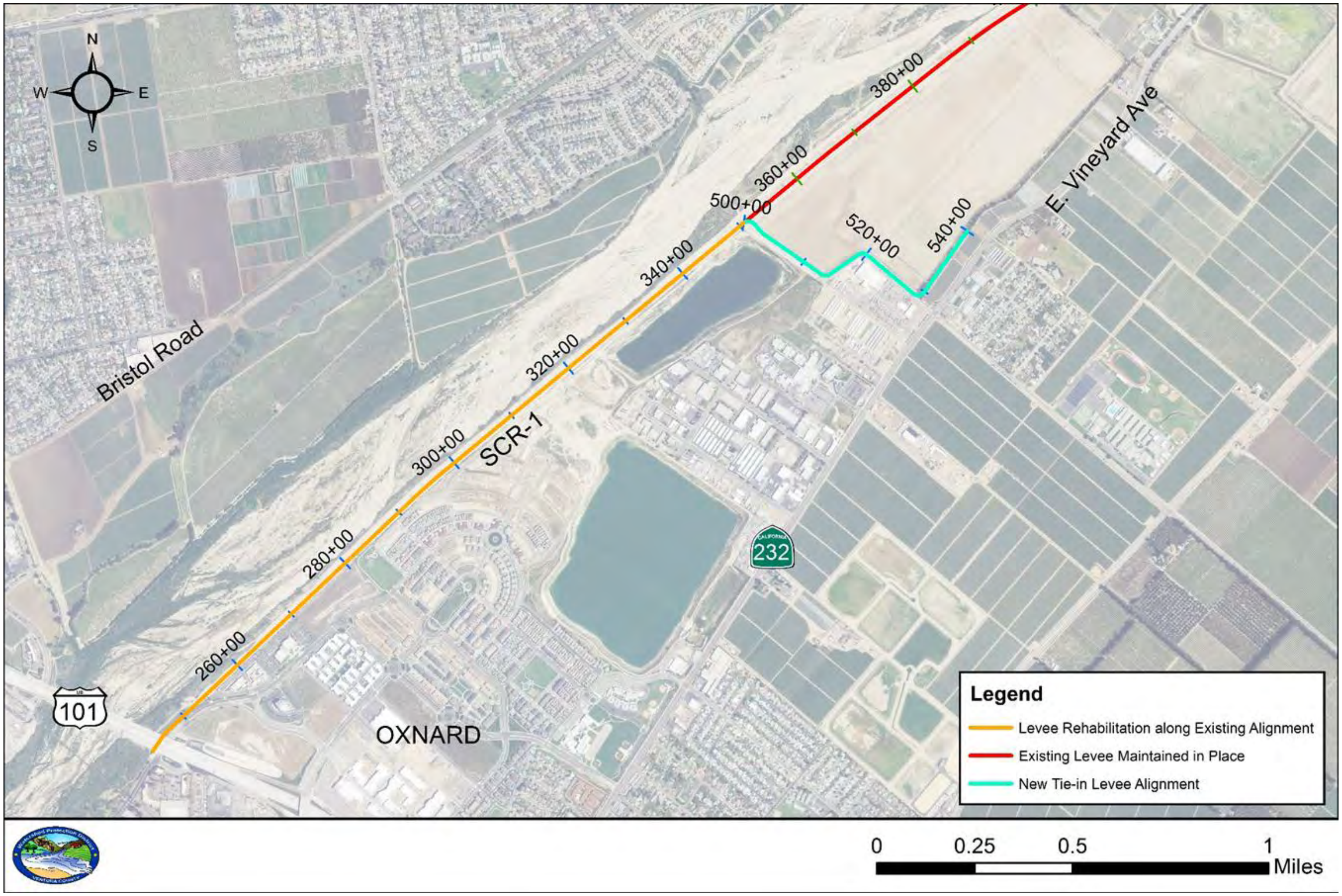

Figure 13 – SCR-1 Alignment in Feasibility-Level Design

Table 12 – Estimated Annual Damages for Feasibility-Level Design

Condition	COM	FARM	IND	PUB	RES	AUTO	CLEANUP	TOTAL
Without project	$197	$0.4	$86.7	$435	$1,388	$61.6	$70.4	$2,239
With project	$116	$0.4	$63.3	$109	$409	$17.4	$13.9	$729
Note: All values are in thousand dollars.								

The PVFB was calculated using the current discount rate and the assumed 50-year project life from the EAD totals under with- and without-project conditions (Table 13).

Table 13 – Calculation of Present Value of Future Benefits

Present Value of Future Benefits – Upstream			
(a)	Expected Annual Damage Without Project		**$2,238,070**
(b)	Expected Annual Damage With Project		**$728,210**
(c)	Expected Annual Benefit	(a) – (b)	**$1,509,860**
(d)	Present Value Coefficient		**23.99**
(e)	**Present Value of Future Benefits**	**(c) x (d)**	**$36,227,431**

8.3 Estimated Construction Costs for Feasibility-Level Design

The estimated construction and O&M costs have been updated to represent the current feasibility-level design plans. A detailed discussion of the construction costs is provided in Section 6 of the Basis of Design Report (Tetra Tech 2015). The O&M costs have been estimated at $100,000 per year on the basis of a detailed table of expenditures associated with routine levee maintenance of SCR-1 from 1998 to 2014, provided by VCWPD. The estimated construction and O&M costs along with the current discount rate were used to calculate the PVDC. A detailed calculation table for the PVDC is provided in Attachment 4. The benefit-cost ratio calculated from the PVFB and PVDC is provided in Table 14.

Table 14 – Benefit-Cost Ratio for Feasibility-Level Design

	Present Value of Future Benefits	Present Value of Discounted Costs	Benefit-Cost Ratio
Feasibility-Level Design	$36,227,431	$31,980,435	1.13

8.4 Benefit-Cost Ratio for Feasibility-Level Design

The benefit-cost ratio for the feasibility-level design is greater than 1.0, which means that the benefits to the area of the current feasibility-level design would outweigh the costs of construction associated with the feasibility-level design. This ratio is based on best available information that was current at the time of this economic analysis and is likely to change as the project progresses and more technical data become available.

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ATTACHMENT 1

Analysis of Strawberry Farm Budget

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ATTACHMENT 2

Stage-Damage Functions by Type of Structural Occupancy

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ATTACHMENT 3

Calculation of Present Value of Discounted Costs for Conceptual-Level Alternatives

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ATTACHMENT 4

Calculation of Present Value of Discounted Costs for Feasibility-Level Design

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