Appendix B
Flood Damage Analysis

REVISED
DRAFT
11/9/04

Colusa Basin Integrated Watershed Management Plan
Flood Damage Analysis

This report summarizes a flood damage assessment performed for the Colusa Basin Integrated Watershed Management Plan. This report focuses on the evaluation of without- and with-project flood damage and the benefits of alternative plans to reduce flood damage. The assessment was based on a 50-year period of analysis, January 2004 price levels, and a federal discount rate of 5 5/8 percent. The earliest the project could become operational is estimated to be in 2007.

Study Area Description

The Study Area includes the City of Willows and the surrounding rural area in western Glenn County. The Study Area is bounded by the foothills of the Coastal range to the west, County Road 30 to the north, and County Road 53 to the south. Willows is located along Interstate 5 (I-5), about 85 miles north of the City of Sacramento. Other major highways include State Highway 99W, which is just to the east and parallel to I-5 and State Highway 162, which runs west/east through Willows. In 2000, Willows had a population of about 6,220 with a median family income of about $35,856 (U.S. Census). Surrounding land use is agricultural, primarily in field crops such as rice, sunflower, alfalfa, wheat, and corn. The Glenn-Colusa Canal extends along the southeast border of the Study Area.

The principal sources of flooding in the Study Area are the creeks that flow east from the coastal foothills towards the valley floor. From the north to the south, these include Walker Creek, Wilson Creek, and South Fork Willow Creek. Flooding from these creeks occurs frequently and is relatively shallow. Northeast of Willows the creeks nearly converge just prior to crossing underneath I-5, Highway 99W, and the Southern Pacific rail line. Although the creek channels do not merge, flood waters from them merge and forms ponds just to the west of I-5 and Highway 99W. Although some of the creeks have unofficial “spot levees” in a few locations, there is no consistent levee plan.

Approximations of inundated area extent and flood depths were developed for the 5-, 25-, 50-, and 100-year flood events as described in the companion memo entitled “Colusa Basin Watershed Management Plan Floodplain Inundation and Hydraulics Analysis of Alternatives for Flood Damage Assessment” prepared by CH2M Hill. For the sake of brevity, this approximated inundated area extent will be referred to generally as “floodplain” throughout the remainder of this document. **However, it is important to note that these approximated inundated areas were developed using a feasibility-level analysis and should not be confused with any official floodplain delineation or interpreted as such.**

Both without-project and with-project floodplains were developed. Figure 1 shows the without-project floodplain for the 100-year event. Most of Willows is outside the 100-year

floodplain except the northeast corner of the community. The 100-year floodplain (without project) encompasses about 22,600 acres. Approximately 1,250 acres are in urban land uses, and about 19,100 acres are in agricultural development. An estimated 710 persons live within the 100-year floodplain[1]. Table 1 summarizes all land uses within the 100-year floodplain by impact areas (discussed below).

Impact Areas

Study areas are typically subdivided into impact areas to facilitate the flood damage assessment by taking into account differing flooding problems and land uses. For this assessment, seven impact areas were identified within the 100-year floodplain:

- Impact Area 1: includes South Fork Willow Creek as it leaves the Coastal foothills and enters the valley floor. The inundated area in this section of the creek separates into two branches, with one heading due east toward the airport and the Glenn-Colusa Canal, and the mainstem heading northeast toward Wilson Creek.
- Impact Area 2: includes Wilson Creek as it leaves the Coastal foothills and heads southeast toward South Fork Willow Creek.
- Impact Area 3: includes Pond Area A to the northeast of Wilson Creek where flood flows from Wilson and Walker Creeks commingle. This impact area also includes the area to the east of I-5 along Walker Creek, including the community of Artois. None of the project alternatives affect this impact area.
- Impact Area 4: includes the downstream portions of both South Fork Willow and Wilson Creeks where flows from both streams commingle and form Pond Area B to the west (upstream) of I-5.
- Impact Area 5: includes the downstream portions of both South Fork Willow and Wilson Creeks where flows from both streams commingle and form Pond Area C between I-5 and Highway 99W.
- Impact Area 6: includes the downstream portion of Walker Creek (south of County Road 43) south to the Glenn-Colusa Canal. At the south end of this impact area, flows from all three creeks—South Fork Willow, Wilson, and Walker—commingle.
- Impact Area 7: includes the primarily residential, northeast, portion of Willows and rural areas just north of the community.

Without- vs. With-Project Conditions

The flood damage assessment is based on the reduction in equivalent annual damage that can be expected to occur with the proposed project compared to without-project conditions. Although future changes in land use and hydrology could be taken into account, this assessment has been limited to include just existing (2004) conditions.

[1] Assuming one residential/farmstead parcel = one household @ 2.83 persons/household.

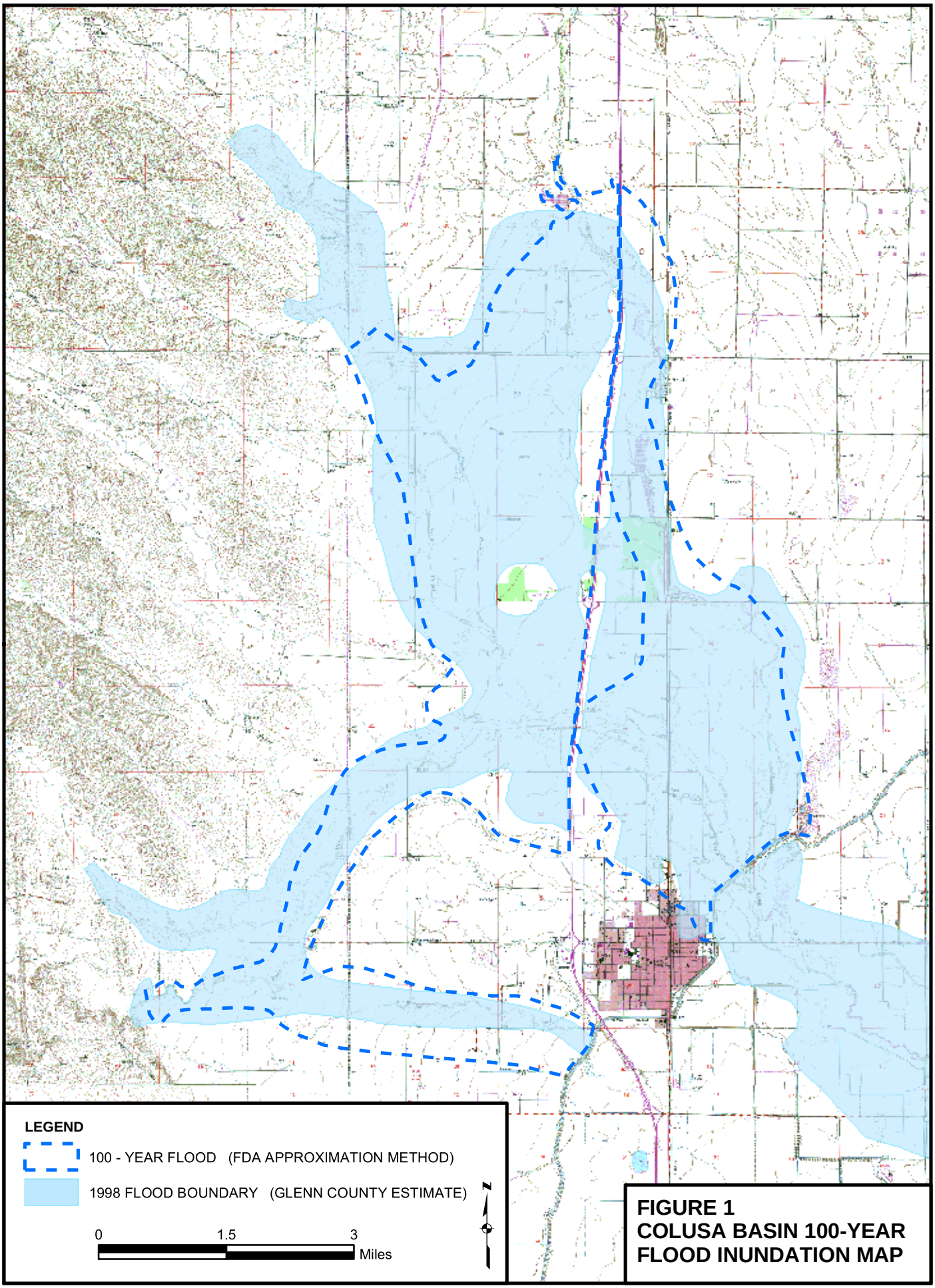


FIGURE 1
COLUSA BASIN 100-YEAR FLOOD INUNDATION MAP

RDD \\LOKI\PROJECTS\RDDGIS\CBDDIWMP\TM_FIG5_FLOOD.MXD FIG1_FLOOD.PDF 12/9/2004 10:28:29

Table 1
Land Use Within the 100-Year Floodplain
Without Project (Existing Conditions)

Land Use Category	Impact Area 1	Impact Area 2	Impact Area 3	Impact Area 4	Impact Area 5	Impact Area 6	Impact Area 7	Total
Agriculture								
Citrus & Subtropical	0	37	154	1	20	36	4	252
Deciduous Fruits & Nuts	275	43	89	45	12	0	2	466
Truck	18	0	0	0	0	7	467	492
Field	1,676	586	1,416	1,103	324	907	2	6,015
Grain & Hay	1,236	416	1,676	372	511	434	58	4,702
Pasture	354	868	806	119	218	304	119	2,787
Rice	542	1,201	714	1,102	0	57	21	3,636
Idle	4	47	140	51	8	191	31	472
Semiagricultural	84	22	73	37	0	29	1	246
Subtotal	4,189	3,219	5,066	2,831	1,094	1,966	704	19,069
Urban								
Residential	13	0	81	1	7	6	320	429
Commercial	0	0	9	0	0	3	0	12
Industrial	34	2	19	16	0	0	0	70
Landscape	0	0	0	88	0	0	13	101
Vacant	104	55	191	199	24	49	17	638
Subtotal	151	57	299	303	31	59	350	1,251
Native								
Native vegetation	223	62	1,093	103	12	158	20	1,672
Riparian vegetation	94	17	284	2	0	26	0	422
Water surface	27	29	92	0	0	48	6	202
Subtotal	345	108	1,469	105	12	232	26	2,297
Total	4,685	3,384	6,835	3,239	1,137	2,256	1,080	22,616

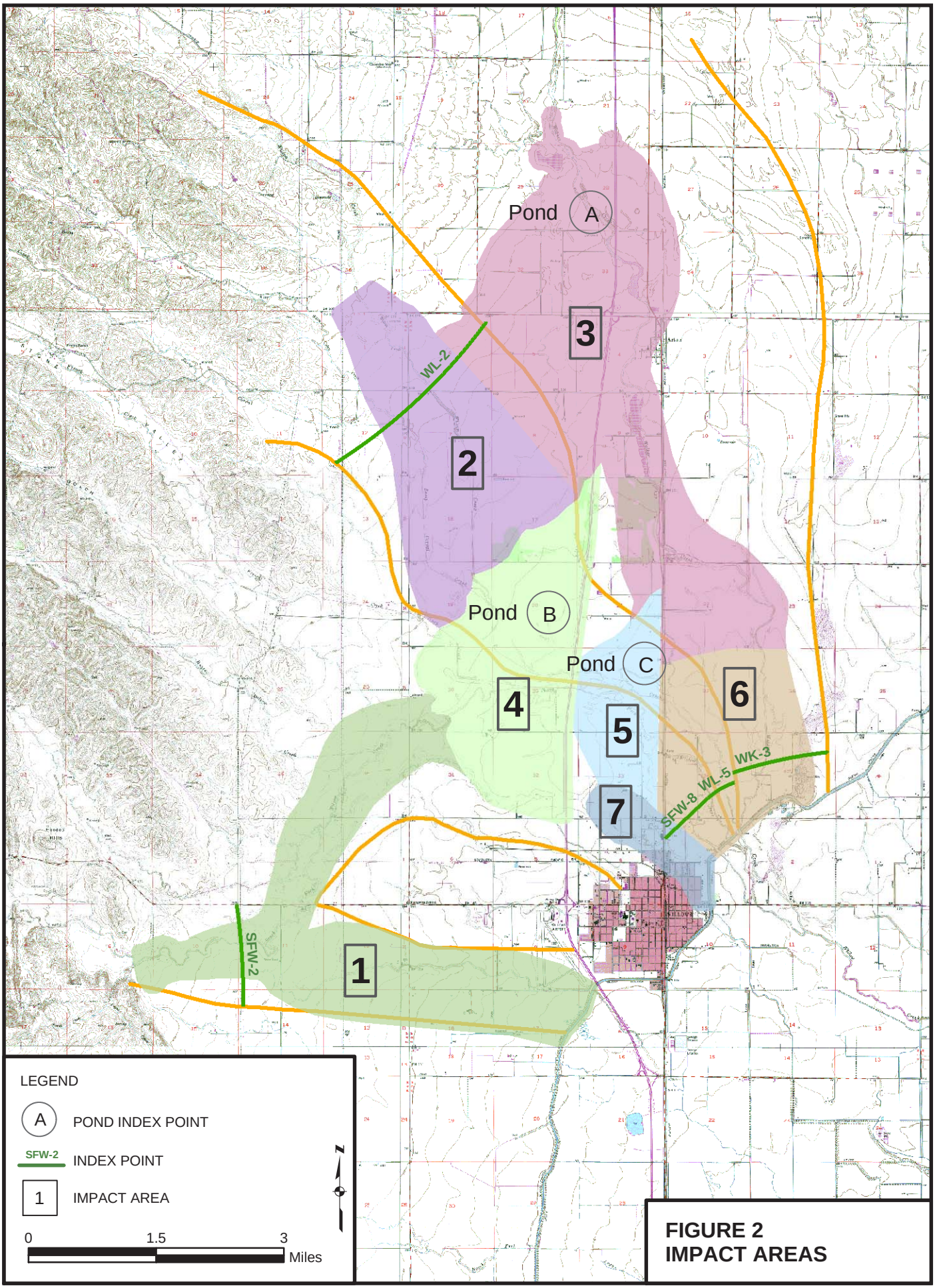


FIGURE 2
IMPACT AREAS

RDD \\LOKI\PROJECTS\RDDGIS\CBDDIWMP\TM_FIG2_IMPACT.MXD TM_FIG2_IMPACT.PDF 12/3/2004 10:38:59

Damage Categories

For analysis purposes, potential flood damage was classified into different land use categories. For each category, damages were estimated for varying magnitudes of flooding based on the 5-, 25-, 50-, and 100-year events. These categories include the following:

- Residential – includes single family and multi-family units, houses, apartments, duplexes, and mobile and manufactured homes. Damage includes physical damage to the structure, clean-up, and damage to contents including household items and personal property.

- Farmsteads – includes rural residential structures with sheds and other outbuildings. Damage includes physical damage to the structure, clean-up, and damage to contents including household items and personal property. However, it does not include farm implements or other equipment (such as irrigation systems).

- Commercial – includes retail stores, restaurants, service stations, and light-repair garages. Damage was computed for both structure and contents including equipment, furniture, supplies, and merchandise.

- Autos – damage to trucks and automobiles. Damages were determined as a percentage loss based on depth of flooding. Most vehicles begin to take measurable damages once water exceeds 1 foot in depth.

- Transportation – additional costs imposed to travelers using I-5 who must use an alternate route (Highway 99 through Chico) because of I-5 flooding closures. A Southern Pacific rail line runs parallel to Highway 99W and is also affected by flooding; however, these costs have not been estimated.

- Crops – includes the loss of cumulative cultivation costs incurred prior to flooding, the current net value of the crop affected by the flood event, the depreciated value of perennial crops lost as a direct result of flooding, and clean-up costs.

- Evacuation Costs – additional costs incurred during flood emergencies for evacuation, temporary housing, medical supplies, food, clothing, and re-occupation. Estimates were based on the number of people displaced, number of days evacuated or occupying temporary housing, and average daily costs (based on averages from other area flood studies.)

- Emergency Response Costs – includes local, state, and federal emergency response costs. This was only computed for Impact Area 7, which has the largest population.

No industrial or public structures are located within the 100-year floodplain.

Structural Inventory

Using Geographic Information System (GIS) tools, Glenn County parcel maps were compared with floodplain maps to identify structures subject to flooding. Assessor's data were gathered using a CD-based database for Glenn County. Characteristics such as land use, structure type, assessed improvement value, and physical features were extracted from the database. The number of parcels is displayed by land use in Table 2. The largest group of parcels was residential (192), most of which were located in northeast Willows (Impact Area 7).

Table 2
Structural Inventory
Existing Conditions

Land Use Type	Number of Parcels
Residential	192
Farmstead	59
Commercial	6
Total	257

Value of Damageable Property

The value of damageable property includes both structure and content values but does not include land values or crop values. All structural values were based on adjusted assessed improvement values to represent depreciated replacement values. An adjustment was made to account for California's Proposition 13, which allows for assessed values to be capped at an annual increase of 2 percent. Assessed values were adjusted based on the sales' recorded date and then compared to increases found in Marshall & Swift Valuation Service. Content values were estimated as a percentage of structure value. For residential and commercial structures, content percentages were set at 50 percent. Table 3 displays values by land use category under existing conditions.

Table 3
Value of Damageable Property
Without Project (Existing Conditions)
(Millions of Dollars; January 2004 Price Levels)

Land Use Category	Structure Value	Content Value	Total Value of Damageable Property
Residential	14.7	7.4	22.1
Farmsteads	8.0	4.0	12.0
Commercial	0.6	0.3	0.9
Total	23.3	11.7	35.0

Value of Crops

Agriculture is a major industry within the Study Area. Approximately 18,400 acres are currently cultivated within the 100-year floodplain (Table 4). The majority of these crops are field crops (over 17,000 acres). Annual crop gross income is about $7.9 million (Table 5).

Table 4
Crop Acres
Without Project (Existing Conditions)

Crops	Impact Area 1	Impact Area 2	Impact Area 3	Impact Area 4	Impact Area 5	Impact Area 6	Impact Area 7	Total
Field	3,808	3.071	4,611	2,697	1,053	1,702	199	17,141
Truck	18	0	0	0	0	7	467	492
Orchard	275	80	243	46	33	36	6	718
Total	4,101	3,151	4.854	2,743	1,086	1,745	672	18,351

Source: California Department of Water Resources, Glenn County land use survey.

Table 5
Gross Crop Income
Without Project (Existing Conditions)
(Thousands of Dollars; January 2004 Price Levels)

Crops	Impact Area 1	Impact Area 2	Impact Area 3	Impact Area 4	Impact Area 5	Impact Area 6	Impact Area 7	Total
Field	1,142	921	1,383	809	316	511	60	5,142
Truck	10	0	0	0	0	4	266	280
Orchard	950	274	837	158	113	125	20	2,477
Total	2,102	1,196	2,220	967	429	640	346	7,899

Source: Sacramento and San Joaquin River Basins Comprehensive Study; based upon UC Extension Service crop budgets.

Structural/Contents Depth - Damage Curves

For most structural damage categories, dollar damage increases as depth of flooding increases. To evaluate potential losses, structural and contents depth, damage curves were entered into the @RISK models described below. For residential structure and content damage, the generic depth-damage relationships developed by the U.S. Army Corps of Engineers' Institute for Water Resources were used. The residential damage depth-damage curve is shown in Table 6.

Table 6
IWR Residential Structural and Contents Depth-Damage Curves
(One-Story Residence)

First Floor Depth (feet)	Structural Depth Damage		Content Depth Damage (1)	
	Mean of Damage	Standard Deviation of Damage	Mean of Damage	Standard Deviation of Damage
-2	0%	0%	0%	3.0%
-1	2.5%	2.7%	2.4%	2.1%
0	13.4%	2.0%	8.1%	1.5%
1	23.3%	1.6%	13.3%	1.2%
2	32.1%	1.6%	17.9%	1.2%
3	40.1%	1.8%	22.0%	1.4%
4	47.1%	1.9%	25.7%	1.5%
5	53.2%	2.0%	28.8%	1.6%
6	58.6%	2.1%	31.5%	1.6%
7	63.2%	2.2%	33.8%	1.7%
8	67.2%	2.3%	35.7%	1.8%
9	70.5%	2.4%	37.2%	1.9%
10	73.2%	2.7%	38.4%	2.1%
11	75.4%	3.0%	39.2%	2.3%
12	77.2%	3.3%	39.7%	2.6%
13	78.5%	3.7%	40.0%	2.9%
14	79.5%	4.1%	39.9%	3.2%
15	80.2%	4.5%	39.6%	3.5%
16	80.7%	4.9%	39.1%	3.8%

(1) Expressed as a percent of structural value.

Other Flood Damage

In addition to structural and crop damage, floods in the project area also cause significant transportation delays on Interstate 5[2], evacuation costs, and emergency response costs. The assumptions used in the derivation of these other flood-related costs are shown in Tables 7 – 9.

Table 7
Interstate 5 Transportation Delays and Costs

Event	Hours Closed (1)	Ave. Annual Vehicles/ Day (2)	Ave. Annual Vehicles/ Hour	Hours Delay/ Vehicle (3)	Cost/ Hour/ Vehicle (4)	Total Cost
5 yr	6	22,550	940	1	$10	$56,375
25 yr	12	22,550	940	1	$10	$112,750
50 yr	24	22,550	940	1	$10	$225,500
100 yr	36	22,550	940	1	$10	$338,250

(1) Glenn County Public Works
(2) CalTrans Traffic and Vehicle Data Systems Unit
(3) Based upon alternative trip from Red Bluff to Sacramento, through Chico, on Hwy 99
(4) USACE planning guidance

Table 8
Evacuation Costs

Floodplain Population	Population Evacuated (1)	Cost/Person (2)	Days/ Evacuated	Total Cost
147	110	$35	1	3,867
348	261	$35	1	9,125
536	402	$35	2	28,146
710	533	$35	3	55,930

(1) Assumed to be 75% of floodplain population
(2) Cost of temporary lodging (Hamilton City Flood Damage Reduction and Ecosystem Restoration Project Feasibility Study)

[2] Delays also occur on other roadways (such as Highway 162) and the Southern Pacific Railroad, however, costs associated with these delays have not been estimated for this study.

Table 9
Emergency Response Costs

Event	Total Cost (1)
5 yr	$0
25 yr	$100,000
50 yr	$125,000
100 yr	$125,000

(1) Glenn County Public Works

Frequency/Stage-Damage Curves

To calculate stage-damage curves with uncertainty, a program called @RISK by Palisade Corporation was used. @RISK is an add-on program for MS-EXCEL, which incorporates Monte Carlo Simulation. The model uses variables with probability distributions to account for uncertainty[3]. Computationally, @RISK outputs are frequency-damage curves that are then manually converted into stage-damage curves for entry into FDA. Table 10 summarizes total frequency-damage curves for all impact areas (existing conditions). Tables 11 through 17 show the aggregate frequency/stage-damage curves (and top of bank elevation) for all impact areas (existing conditions). Although not shown here, similar tables were developed for each of the alternative plans (described below) for each impact area.

HEC-FDA Model Development

The Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA, or FDA) program was used to estimate equivalent annual damages. The program uses risk analysis to integrate hydrologic, hydraulic, geotech, and economic relationships. The two primary outputs from HEC-FDA include expected annual damage estimates and project performance statistics. Expected annual flood damage is the average of all possible damage values, taking into account all expected flood events and associated hydrologic, hydraulic, geotech, and economic uncertainties. Project performance statistics provide information concerning the risk within an area of annual (or long-term) flooding and the ability to survive flood events of given magnitudes. Specifically these are defined as follows:

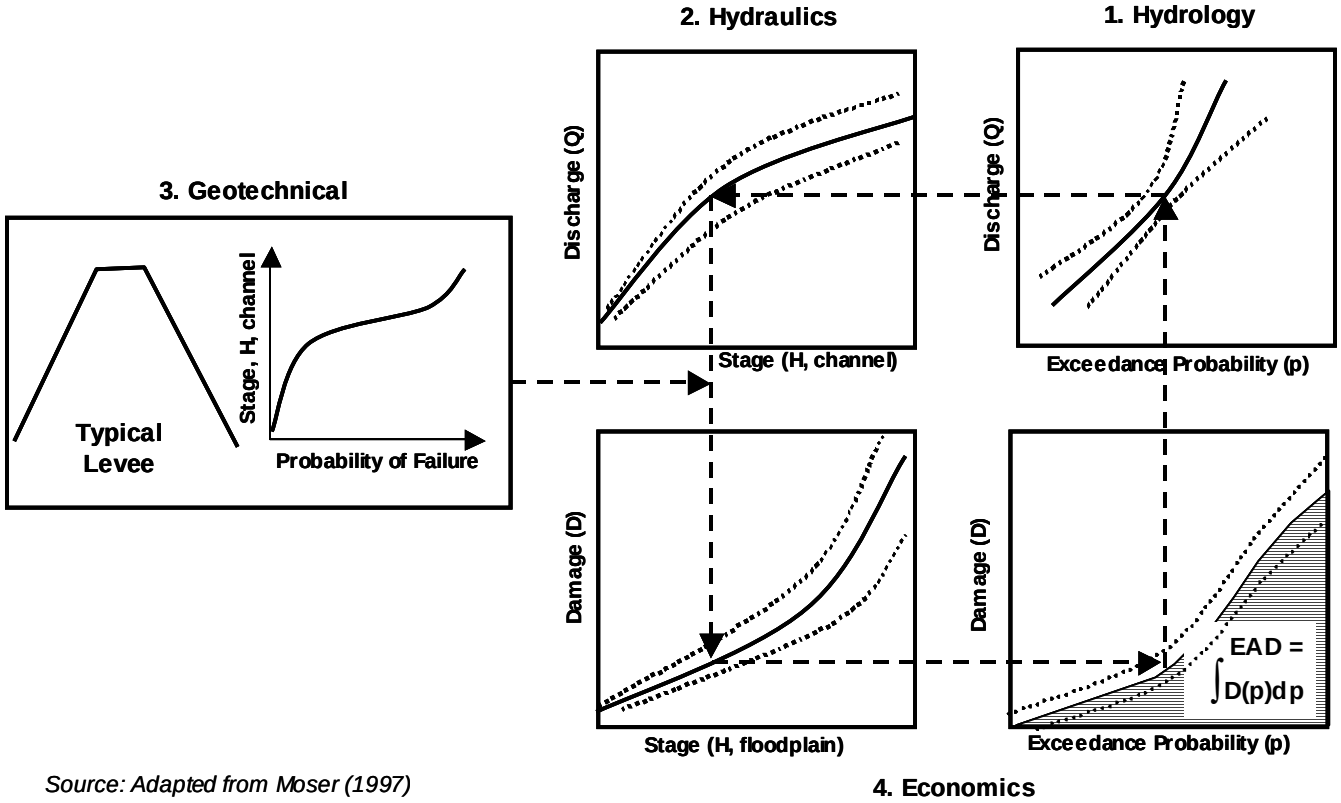
- Expected Annual Damage. Floods occur at different frequencies and magnitudes with varying damages. However, in a flood damage analysis, flood damage is typically expressed as an expected annual damage. In the U.S. Army Corps of Engineers' risk-based analysis, expected annual damage is defined as the average or mean of all possible

[3] Economic variables and their associated uncertainty include structure value (10 percent coefficient of variation), contents value (10 percent coefficient of variation), foundation height (0.6-foot standard error), and percent damage (5 percent coefficient of variation).

damage values determined by Monte Carlo sampling of discharge (or stage)-exceedance probability, stage discharge, and stage-damage relationships and their associated uncertainties. Expected annual damage is then calculated as the integral of the damage-probability function. Figure 3 illustrates the conceptual risk and uncertainty approach used by the U.S. Army Corps of Engineers in flood damage reduction analyses (assuming river systems with levees).

- Project Performance Statistics. These statistics describe the hydraulic performance of a plan incorporating geotechnical levee failure assumptions. These include *expected annual exceedance probability* (the annual probability of having a damaging flood event in a given year, such as a levee failure); *long-term risk* (the chance of having one or more damaging events over a period of time, similar to the question: what's the chance my house could be flooded during the life of my 30-year mortgage?); and *conditional nonexceedance probability* **(**the probability of containing specific flood events and avoiding damage).

Figure 3
Conceptual U.S. Army Corps of Engineers' Risk and Uncertainty Approach for Estimating Flood Damage



Source: Adapted from Moser (1997)

Table 10
Summary of Impact Area Frequency-Damage Curves
Without Project (Existing Conditions)

Exceedance Years	Frequency-Damage Curves (Thousands of Dollars; January 2004 Price Levels)							
	Impact Area 1	Impact Area 2	Impact Area 3	Impact Area 4	Impact Area 5	Impact Area 6	Impact Area 7	Total
5-yr	247.5	535.2	485.1	592.3	401.7	719.3	941.0	3,922.1
25-yr	1,172.8	636.5	835.1	1,126.3	633.1	1,032.7	2,976.8	8,413.2
50-yr	1,744.3	794.2	1,347.3	1,342.3	702.1	1,342.7	4,566.0	11,838.9
100-yr	1,821.5	802.4	1,421.6	1,514.5	728.3	1,351.9	7,474.0	15,114.3

Table 11
Impact Area 1 Frequency/Stage-Damage Curves
Without Project (Existing Conditions)

Exceedance Years	Total Flow (cfs)	Water Surface Elevation (ft)	Frequency/Stage-Damage Curves (Thousands of Dollars; January 2004 Price Levels)							
			Residential	Farmsteads	Commercial	Autos	Trans. Delays	Evacuation Costs	Crops	Total
5-yr	5,270	188.16	0.0	56.7	0.0	10.7	0.0	0.1	180.0	247.5
25-yr	10,200	191.80	162.3	399.5	0.0	28.8	0.0	0.7	581.6	1,172.8
50-yr	12,780	191.94	201.5	739.6	0.0	48.1	0.0	5.4	749.6	1,744.3
100-yr	14,740	192.20	224.2	785.4	0.0	54.4	0.0	8.0	749.6	1,821.5

Notes:
cfs = cubic feet per second
ft = feet
Trans. = transportation
South Fork Willow Creek; top of bank = 191 ft

Table 12
Impact Area 2 Frequency/Stage-Damage Curves
Without Project (Existing Conditions)

Exceedance Years	Total Flow (cfs)	Water Surface Elevation (ft)	Frequency/Stage-Damage Curves (Thousands of Dollars; January 2004 Price Levels)						
			Residential	Farmsteads	Commercial	Autos	Evacuation Costs	Crops	Total
5-yr	3,010	180.50	0.0	100.3	0.0	2.1	0.1	432.6	535.2
25-yr	5,460	180.70	0.0	117.3	0.0	2.6	0.1	516.4	636.5
50-yr	6,880	180.85	0.0	131.7	0.0	2.7	0.3	659.6	794.2
100-yr	7,830	181.57	0.0	139.5	0.0	2.9	0.4	659.6	802.4

Note:
Wilson Creek; top of bank = 180 ft

Table 13
Impact Area 3 Frequency/Stage-Damage Curves
Without Project (Existing Conditions)

Exceedance Years	Total Flow (cfs)	Water Surface Elevation (ft)	Frequency/Stage-Damage Curves (Thousands of Dollars; January 2004 Price Levels)							
			Residential	Farmsteads	Commercial	Autos	Trans. Delays	Evacuation Costs	Crops	Total
5-yr	4,220	175.10	0.0	64.4	2.6	0.0	0.0	0.1	418.0	485.1
25-yr	7,790	177.10	0.0	168.9	27.2	2.6	0.0	0.5	635.9	835.1
50-yr	9,620	177.30	0.0	421.9	48.1	10.7	0.0	1.3	865.2	1,347.3
100-yr	10,990	177.60	0.0	469.1	64.5	20.0	0.0	2.9	865.2	1,421.6

Note:
Walker Creek/Pond Area A; top of bank = 176 ft

Table 14
Impact Area 4 Frequency/Stage-Damage Curves
Without Project (Existing Conditions)

Exceedance Years	Total Flow (cfs)	Water Surface Elevation (ft)	Frequency/Stage-Damage Curves (Thousands of Dollars; January 2004 Price Levels)							
			Residential	Farmsteads	Commercial	Autos	Trans. Delays	Evacuation Costs	Crops	Total
5-yr	11,100	146.20	48.2	123.7	0.0	4.3	56.4	0.5	359.2	592.3
25-yr	20,000	147.40	226.7	321.8	0.0	28.8	112.8	1.0	435.2	1,126.3
50-yr	24,600	148.20	318.9	321.8	0.0	32.1	225.5	2.1	441.9	1,342.3
100-yr	28,600	148.26	368.8	328.1	0.0	34.4	338.3	3.1	441.9	1,514.5

Note:
Pond Area B; top of bank = 146 ft

Table 15
Impact Area 5 Frequency/Stage-Damage Curves
Without Project (Existing Conditions)

Exceedance Years	Total Flow (cfs)	Water Surface Elevation (ft)	Frequency/Stage-Damage Curves (Thousands of Dollars; January 2004 Price Levels)							
			Residential	Farmsteads	Commercial	Autos	Trans. Delays	Evacuation Costs	Crops	Total
5-yr	11,300	139.80	292.0	24.3	0.0	21.4	0.0	0.8	63.1	401.7
25-yr	20,300	140.80	427.9	37.0	0.0	26.2	0.0	0.8	141.2	633.1
50-yr	25,500	141.80	488.7	42.5	0.0	26.7	0.0	1.6	142.5	702.1
100-yr	29,400	142.00	507.8	43.9	0.0	31.5	0.0	2.7	142.5	728.3

Note:
Pond Area C; top of bank = 138 ft

Table 16
Impact Area 6 Frequency/Stage-Damage Curves
Without Project (Existing Conditions)

Exceedance Years	Total Flow (cfs)	Water Surface Elevation (ft)	Frequency/Stage-Damage Curves (Thousands of Dollars; January 2004 Price Levels)							
			Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Crops	Total
5-yr	15,360	132.98	105.6	240.4	0.0	4.3	0.0	0.7	368.2	719.3
25-yr	26,440	134.16	137.9	459.5	0.0	7.8	0.0	1.3	426.2	1,032.7
50-yr	32,640	134.61	205.7	660.9	0.0	45.5	0.0	2.5	428.1	1,342.7
100-yr	38,550	135.01	210.1	660.9	0.0	48.7	0.0	4.0	428.1	1,351.9

Note:
South Fork Willow, Wilson, and Walker Creek commingle area; top of bank = 130 ft

Table 17
Impact Area 7 Frequency/Stage-Damage Curves
Without Project (Existing Conditions)

Exceedance Years	Total Flow (cfs)	Water Surface Elevation (ft)	Frequency/Stage-Damage Curves (Thousands of Dollars; January 2004 Price Levels)							
			Residential	Farmsteads	Commercial	Autos	Evacuation Costs	Response Costs	Crops	Total
5-yr	15,360	132.98	743.8	0.0	157.8	23.5	1.4	0.0	14.5	941.0
25-yr	26,440	134.16	2,483.7	0.0	213.3	128.2	4.7	100.0	47.0	2,976.8
50-yr	32,640	134.61	3,930.9	0.0	213.3	208.6	14.9	125.0	73.5	4,566.0
100-yr	38,550	135.01	6,640.4	0.0	219.0	357.9	34.8	125.0	97.0	7,474.0

Note:
South Fork Willow, Wilson, and Walker Creek commingle area; top of bank = 130 ft

Without Project – Equivalent Annual Damages

Equivalent annual damages were estimated in FDA using a 50-year period of analysis (2007 – 2056), existing development levels, January 2004 price levels, and a discount rate of 5 5/8 percent. *Equivalent annual damage* is the damage value associated with the without- or with-project condition over the analysis period. Expected annual damage is computed for each analysis year and discounted to present worth, which is then annualized to obtain the equivalent annual damage value. Table 18 shows without-project equivalent annual damage by impact area and damage category. Total without project (existing conditions) EAD for all impact areas is about $6.5 million.

Without Project – Existing Project Performance

Table 19 presents the without-project (existing conditions) project performance statistics for the seven impact areas. The three indicators of project performance estimated by the FDA model include expected annual exceedance probability, long-term risk, and conditional nonexceedance probability.

Expected annual exceedance probability (AEP) is a key element in defining the performance of a plan. It is the probability that a specific capacity or target stage will be exceeded in a given year.[4] For example, in Table 16, the expected annual exceedance probability is estimated to be 0.2100 for Impact Area 1, indicating that there is about a 21 percent chance of a damaging flood event along that particular river reach in any given year.

Long-term risk is the probability of a target stage being exceeded during a specified period. FDA estimates long-term risk for 10-, 25-, and 50-year periods. For example, for impact Area 1, the long-term risk for a 25-year period is estimated to be 0.9972, indicating that there is about a 100 percent chance that there will be one or more events that exceed a specified target stage during that time period.

Conditional nonexceedance probability is the probability that a specified event will be contained by a project. If levees are involved, this statistic includes both the chance of levee overtopping as well as the chance of failure at lower stages. For example, in Impact Area 1, the conditional nonexceedance probability is 0.5973 for a 10 percent (i.e., 1 in 10-year) event, indicating that there is a 60 percent chance that the target stage will <u>not</u> be exceeded for that particular flood event. Thus, while the expected annual exceedance and long-term risk probabilities measure the susceptibility of areas to flooding, conditional nonexceedance probability measures their ability to survive specified flood events. FDA generates conditional nonexceedance probabilities for the 10, 4, 2, 1, 0.4, and 0.2 percent events.

As can be seen in Table 19, all of the impact areas are currently at risk for frequent flooding.

[4] Target stage is the maximum stage possible before any significant flood damage is incurred. For this study, target stage is the top of bank elevation for each stream.

Table 18
Equivalent Annual Damage by Impact Area
Without Project (Existing Conditions)

Impact Areas	Damage Categories (Thousands of Dollars, January 2004 Price Levels)								
	Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Response Costs	Crops	Total
Impact Area 1	41.1	134.9	0.0	9.4	0.0	0.9	0.0	142.4	328.7
Impact Area 2	0.0	79.9	0.0	1.7	0.0	0.2	0.0	373.7	455.5
Impact Area 3	0.0	180.4	21.6	4.6	0.0	0.7	0.0	575.4	782.8
Impact Area 4	182.7	230.6	0.0	18.8	147.1	1.3	0.0	404.0	984.5
Impact Area 5	287.6	25.5	0.0	18.4	0.0	1.0	0.0	79.0	411.4
Impact Area 6	135.6	379.9	0.0	15.4	0.0	1.5	0.0	390.3	922.7
Impact Area 7	2,187.1	0.0	178.4	107.1	0.0	8.1	47.1	37.1	2,565.0
Total	2,834.2	1,031.2	200.0	175.4	147.1	13.7	47.1	2,002.0	6,450.7

Table 19
Project Performance Statistics
Without Project (Existing Conditions)

Impact Area	Annual Exceedance Probability	Long-Term Risk			Conditional Nonexceedance					
		10 Years	25 Years	50 Years	10% (10 Year)	4% (25 Year)	2% (50 Year)	1% (100 Year)	0.4% (250 Year)	0.2% (500 Year)
Impact Area 1	0.2100	0.9049	0.9972	1.0000	0.5973	0.4474	0.4091	0.3960	0.3874	0.3837
Impact Area 2	0.6130	0.9999	1.0000	1.0000	0.3706	0.3393	0.3145	0.3117	0.3088	0.3070
Impact Area 3	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Impact Area 4	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Impact Area 5	0.7050	1.0000	1.0000	1.0000	0.2389	0.1692	0.1257	0.1022	0.0795	0.0675
Impact Area 6	0.9800	1.0000	1.0000	1.0000	0.0116	0.0056	0.0036	0.0026	0.0023	0.0021
Impact Area 7	0.9800	1.0000	1.0000	1.0000	0.0126	0.0066	0.0045	0.0035	0.0029	0.0028

Alternative Plan Analysis

For the Colusa Basin Study Area, seven alternative flood damage reduction and ecosystem restoration management plans were identified and are summarized below. More detailed information concerning these plans can be found in the Colusa Basin Drainage District Integrated Watershed Management Plan Final Alternatives Report (Section 6).

- No Action Alternative: With the No Action plan, which is synonymous with the "Without-Project Condition," it is assumed that no project would be implemented. The No Action Alternative provides a base against which all other alternatives are measured and ensures that any action taken is more in the public interest than doing nothing.

- Nonstructural Plan: This plan consists of all of the potential measures that can be implemented through management changes and/or programs, including the following:
  - Rangeland management (Upper Watershed)
  - Woodland management (Upper Watershed)

- Detention Basins Plan: this plan incorporates only the potential detention basin measures, including the following:
  - South Fork Willow Creek detention basin (Upper Watershed)
  - Wilson Creek detention and infiltration basin (Upper Watershed)

- Structural Plan: This plan incorporates the following potential measures that require a physical modification to the watershed. These measures include the following:
  - South Fork Willow Creek detention basin (Upper Watershed)
  - Wilson Creek detention and infiltration basin (Upper Watershed)
  - Rice field spreading basins (Valley Floor)
  - Stream restoration (Upper Watershed and Valley Floor)

- Combined Plan: this plan incorporates all of the measures in the structural and nonstructural plans, as follows:
  - Rangeland management (Upper Watershed)
  - Woodland management (Upper Watershed)
  - South Fork Willow Creek detention basin (Upper Watershed)
  - Wilson Creek detention and infiltration basin (Upper Watershed)
  - Rice field spreading basins (Valley Floor)
  - Stream restoration (Upper Watershed and Valley Floor)

In addition to these plans, the following two plans were analyzed separately from the above plans:

- Ring Levee Plan: this plan includes a ring or other type of levee to protect the northeast portion of the City of Willows.

- Floodplain Management Plan: this plan includes raising residential structures to 1 foot above the 100-year water surface elevation. It was assumed that only two-thirds of the residential structures at risk would be elevated.

With Project—Equivalent Annual Damage

Table 20 summarizes the total equivalent annual damage estimates for the with-project conditions for all alternatives in all seven impact areas. Of all the plans evaluated, the ring levee plan results in the greatest reduction in EAD (about $2.5 million). Tables 21 – 27 summarize with project equivalent annual damage estimates for all impact areas.

With Project – Project Performance

Tables 28 – 34 summarize with project performance statistics for all impact areas.

Table 20
Equivalent Annual Damage
With Project
(Thousands of Dollars, January 2004 Price Levels)

Alternative Plans	Total Without Project	Total With Project	Damage Reduced
Without Project	6,451	6,451	0
Nonstructural Plan	6,451	6,257	194
FPM Plan (Structure Raises)	6,451	4,875	1,576
Detention Basins Plan	6,451	4,713	1,738
Structural Plan	6,451	4,590	1,861
Combined Plan	6,451	4,437	2,014
Ring Levee Plan	6,451	3,988	2,463

Table 21
Equivalent Annual Damage: Impact Area 1
With Project
(Thousands of Dollars, January 2004 Price Levels)

Plans	Damage Categories								
	Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Response Costs	Crops	Total
Without Project	41.1	134.9	0.0	9.4	0.0	0.9	0.0	142.4	328.7
Nonstructural	36.5	120.4	0.0	8.6	0.0	0.8	0.0	126.4	292.7
Floodplain Management	22.4	63.2	0.0	9.4	0.0	0.9	0.0	0.0	95.8
Detention Basins	5.4	15.4	0.0	1.1	0.0	0.0	0.2	21.9	44.0
Structural	8.4	15.5	0.0	1.3	0.0	0.1	0.0	21.9	47.2
Combined	4.3	12.2	0.0	0.9	0.0	0.1	0.0	17.9	35.3
Ring Levee	41.1	134.9	0.0	9.4	0.0	0.9	0.0	142.4	328.7

Note:
50-year analysis period (2007- 2056); 5 5/8% discount rate.

Table 22
Equivalent Annual Damage: Impact Area 2
With Project
(Thousands of Dollars, January 2004 Price Levels)

Plans	Damage Categories								
	Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Response Costs	Crops	Total
Without Project	0.0	79.9	0.0	1.7	0.0	0.2	0.0	373.7	455.5
Nonstructural	0.0	75.8	0.0	1.6	0.0	0.2	0.0	364.6	442.3
Floodplain Management	0.0	74.4	0.0	1.7	0.0	0.2	0.0	373.9	450.1
Detention Basins	0.0	66.1	0.0	1.4	0.0	0.2	0.0	325.1	392.7
Structural	0.0	56.0	0.0	1.3	0.0	0.1	0.0	300.7	358.1
Combined	0.0	55.4	0.0	1.2	0.0	0.1	0.0	287.0	343.8
Ring Levee	0.0	79.9	0.0	1.7	0.0	0.2	0.0	373.7	455.5

Note:
50-year analysis period (2007- 2056); 5 5/8% discount rate.

Table 23
Equivalent Annual Damage: Impact Area 3
With Project
(Thousands of Dollars, January 2004 Price Levels)

Plans	Damage Categories								
	Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Response Costs	Crops	Total
Without Project	0.0	180.4	21.6	4.6	0.0	0.7	0.0	575.4	782.8
Nonstructural	0.0	180.4	21.6	4.6	0.0	0.7	0.0	575.4	782.8
Floodplain Management	0.0	180.4	21.5	4.6	0.0	0.7	0.0	575.4	782.8
Detention Basins	0.0	180.4	21.6	4.6	0.0	0.7	0.0	575.4	782.8
Structural	0.0	180.4	21.6	4.6	0.0	0.7	0.0	575.4	782.8
Combined	0.0	180.4	21.6	4.6	0.0	0.7	0.0	575.4	782.8
Ring Levee	0.0	180.4	21.6	4.6	0.0	0.7	0.0	575.4	782.8

Note:
50-year analysis period (2007- 2056); 5 5/8% discount rate.

Table 24
Equivalent Annual Damage: Impact Area 4
With Project
(Thousands of Dollars, January 2004 Price Levels)

Plans	Damage Categories								
	Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Response Costs	Crops	Total
Without Project	182.7	230.6	0.0	18.8	147.1	1.3	0.0	404.0	984.5
Nonstructural	178.8	198.7	0.0	17.4	137.1	1.3	0.0	376.2	909.5
Floodplain Management	0.0	179.9	21.5	4.6	0.0	0.6	0.0	575.4	782.1
Detention Basins	173.8	153.0	0.0	12.9	116.9	1.0	0.0	339.9	797.4
Structural	117.9	159.0	0.0	12.2	109.7	1.1	0.0	319.6	719.6
Combined	119.2	158.9	0.0	13.2	100.6	1.0	0.0	322.1	714.9
Ring Levee	182.7	230.6	0.0	18.8	147.1	1.3	0.0	404.0	984.5

Note:
50-year analysis period (2007- 2056); 5 5/8% discount rate.

Table 25
Equivalent Annual Damage: Impact Area 5
With Project
(Thousands of Dollars, January 2004 Price Levels)

Plans	Damage Categories								
	Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Response Costs	Crops	Total
Without Project	287.6	25.5	0.0	18.4	0.0	1.0	0.0	79.0	411.4
Nonstructural	278.4	23.4	0.0	17.7	0.0	1.0	0.0	74.7	395.0
Floodplain Management	133.4	2.0	0.0	18.6	0.0	1.0	0.0	79.8	234.8
Detention Basins	257.3	19.4	0.0	16.5	0.0	0.9	0.0	68.9	362.9
Structural	215.5	19.0	0.0	13.6	0.0	0.8	0.0	66.3	315.3
Combined	207.1	17.5	0.0	13.2	0.0	0.8	0.0	62.5	301.0
Ring Levee	287.6	25.5	0.0	18.4	0.0	1.0	0.0	79.0	411.4

Note:
50-year analysis period (2007- 2056); 5 5/8% discount rate.

Table 26
Equivalent Annual Damage: Impact Area 6
With Project
(Thousands of Dollars, January 2004 Price Levels)

Plans	Damage Categories								
	Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Response Costs	Crops	Total
Without Project	135.6	379.9	0.0	15.4	0.0	1.5	0.0	390.3	922.7
Nonstructural	134.6	387.6	0.0	15.0	0.0	1.5	0.0	367.9	906.6
Floodplain Management	21.9	159.2	0.0	15.5	0.0	1.5	0.0	390.3	588.4
Detention Basins	136.3	344.8	0.0	14.1	0.0	1.4	0.0	368.0	864.5
Structural	128.2	336.7	0.0	15.3	0.0	1.5	0.0	358.9	840.5
Combined	123.4	322.1	0.0	14.8	0.0	1.2	0.0	302.1	763.7
Ring Levee	135.6	379.9	0.0	15.4	0.0	1.5	0.0	390.3	922.7

Note:
50-year analysis period (2007- 2056); 5 5/8% discount rate.

Table 27
Equivalent Annual Damage: Impact Area 7
With Project
(Thousands of Dollars, January 2004 Price Levels)

Plans	Damage Categories								
	Residential	Farmsteads	Commercial	Autos	Highway Delays	Evacuation Costs	Response Costs	Crops	Total
Without Project	2,187.1	0.0	178.4	107.1	0.0	8.1	47.1	37.1	2,565.0
Nonstructural	2,160.6	0.0	174.4	105.7	0.0	8.0	44.4	34.8	2,527.8
Floodplain Management	57.7	0.0	1.9	3.1	0.0	0.3	1.1	0.8	64.9
Detention Basins	1,175.4	0.0	170.7	54.1	0.0	4.1	39.9	24.4	1,468.6
Structural	1,242.5	0.0	160.3	55.4	0.0	3.8	38.2	25.9	1,526.1
Combined	1,215.5	0.0	159.8	54.5	0.0	3.7	36.2	25.8	1,495.4
Ring Levee	57.7	0.0	1.9	3.1	0.0	0.3	1.1	0.8	64.9

Note:
50-year analysis period (2007- 2056); 5 5/8% discount rate.

Table 28
Project Performance Statistics: Impact Area 1
With Project

Plan	Annual Exceedance Probability	Long-Term Risk			Conditional Nonexceedance					
		10 Years	25 Years	50 Years	10% (10 Year)	4% (25 Year)	2% (50 Year)	1% (100 Year)	0.4% (250 Year)	0.2% (500 Year)
Without Project	0.2100	0.9049	0.9972	1.0000	0.5973	0.4474	0.4091	0.3960	0.3874	0.3837
Nonstructural	0.1820	0.8658	0.9934	1.0000	0.6404	0.4627	0.4168	0.4012	0.3905	0.3859
Floodplain Management	0.2100	0.9049	0.9972	1.0000	0.5973	0.4474	0.4091	0.3960	0.3874	0.3837
Detention Basins	0.0380	0.3240	0.6243	0.8589	0.9058	0.7017	0.5738	0.5178	0.4704	0.4482
Structural	0.0380	0.3212	0.6204	0.8559	0.9071	0.7028	0.5747	0.5184	0.4708	0.4486
Combined	0.0310	0.2701	0.5448	0.7928	0.9312	0.7306	0.5958	0.5342	0.4827	0.4580
Ring Levee	0.2100	0.9049	0.9972	1.0000	0.5973	0.4474	0.4091	0.3960	0.3874	0.3837

Table 29
Project Performance Statistics: Impact Area 2
With Project

Plan	Annual Exceedance Probability	Long-Term Risk			Conditional Nonexceedance					
		10 Years	25 Years	50 Years	10% (10 Year)	4% (25 Year)	2% (50 Year)	1% (100 Year)	0.4% (250 Year)	0.2% (500 Year)
Without Project	0.6130	0.9999	1.0000	1.0000	0.3706	0.3393	0.3145	0.3117	0.3088	0.3070
Nonstructural	0.6000	0.9999	1.0000	1.0000	0.3756	0.3442	0.3185	0.3078	0.3000	0.2970
Floodplain Management	0.6130	0.9999	1.0000	1.0000	0.3706	0.3393	0.3145	0.3117	0.3088	0.3070
Detention Basins	0.5939	0.9999	1.0000	1.0000	0.3924	0.3621	0.3394	0.3356	0.3317	0.3290
Structural	0.5890	0.9999	1.0000	1.0000	0.4131	0.4020	0.4007	0.3738	0.3421	0.3166
Combined	0.5830	0.9998	1.0000	1.0000	0.4143	0.4012	0.4006	0.3830	0.3649	0.3498
Ring Levee	0.6130	0.9999	1.0000	1.0000	0.3706	0.3393	0.3145	0.3117	0.3088	0.3070

Table 30
Project Performance Statistics: Impact Area 3
With Project

Plan	Annual Exceedance Probability	Long-Term Risk			Conditional Nonexceedance					
		10 Years	25 Years	50 Years	10% (10 Year)	4% (25 Year)	2% (50 Year)	1% (100 Year)	.4% (250 Year)	.2% (500 Year)
Without Project	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nonstructural	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Floodplain Management	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Detention Basins	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Structural	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Combined	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ring Levee	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 31
Project Performance Statistics: Impact Area 4
With Project

Plan	Annual Exceedance Probability	Long-Term Risk			Conditional Nonexceedance					
		10 Years	25 Years	50 Years	10% (10 Year)	4% (25 Year)	2% (50 Year)	1% (100 Year)	0.4% (250 Year)	0.2% (500 Year)
Without Project	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nonstructural	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Floodplain Management	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Detention Basins	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Structural	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Combined	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Ring Levee	0.9990	0.9999	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 32
Project Performance Statistics: Impact Area 5
With Project

Plan	Annual Exceedance Probability	Long-Term Risk			Conditional Nonexceedance					
		10 Years	25 Years	50 Years	10% (10 Year)	4% (25 Year)	2% (50 Year)	1% (100 Year)	0.4% (250 Year)	0.2% (500 Year)
Without Project	0.7050	1.0000	1.0000	1.0000	0.2389	0.1692	0.1257	0.1022	0.0795	0.0675
Nonstructural	0.6810	1.0000	1.0000	1.0000	0.2583	0.1864	0.1467	0.1164	0.0870	0.0716
Floodplain Management	0.7050	1.0000	1.0000	1.0000	0.2389	0.1692	0.1257	0.1022	0.0795	0.0675
Detention Basins	0.6400	1.0000	1.0000	1.0000	0.2915	0.2164	0.1769	0.1697	0.1606	0.1550
Structural	0.6260	0.9999	1.0000	1.0000	0.3146	0.2448	0.2092	0.1841	0.1571	0.1393
Combined	0.6060	0.9999	1.0000	1.0000	0.3314	0.2522	0.2166	0.1922	0.1660	0.1488
Ring Levee	0.7050	1.0000	1.0000	1.0000	0.2389	0.1692	0.1257	0.1022	0.0795	0.0675

Table 33
Project Performance Statistics: Impact Area 6
With Project

Plan	Annual Exceedance Probability	Long-Term Risk			Conditional Nonexceedance					
		10 Years	25 Years	50 Years	10% (10 Year)	4% (25 Year)	2% (50 Year)	1% (100 Year)	0.4% (250 Year)	0.2% (500 Year)
Without Project	0.9800	1.0000	1.0000	1.0000	0.0116	0.0056	0.0036	0.0026	0.0023	0.0021
Nonstructural	0.9780	1.0000	1.0000	1.0000	0.0127	0.0062	0.0040	0.0027	0.0023	0.0022
Floodplain Management	0.9800	1.0000	1.0000	1.0000	0.0116	0.0056	0.0036	0.0026	0.0023	0.0021
Detention Basins	0.9760	1.0000	1.0000	1.0000	0.0149	0.0081	0.0059	0.0055	0.0044	0.0042
Structural	0.9730	1.0000	1.0000	1.0000	0.0175	0.0105	0.0074	0.0051	0.0031	0.0027
Combined	0.9720	1.0000	1.0000	1.0000	0.0185	0.0109	0.0079	0.0054	0.0031	0.0026
Ring Levee	0.9800	1.0000	1.0000	1.0000	0.0116	0.0056	0.0036	0.0026	0.0023	0.0021

Table 34
Project Performance Statistics: Impact Area #7
With Project

Plan	Annual Exceedance Probability	Long-Term Risk			Conditional Nonexceedance					
		10 Years	25 Years	50 Years	10% (10 Year)	4% (25 Year)	2% (50 Year)	1% (100 Year)	0.4% (250 Year)	0.2% (500 Year)
Without Project	0.9800	1.0000	1.0000	1.0000	0.0126	0.0066	0.0045	0.0035	0.0029	0.0028
Nonstructural	0.9780	1.0000	1.0000	1.0000	0.0134	0.0070	0.0048	0.0036	0.0029	0.0028
Floodplain Management	0.9800	1.0000	1.0000	1.0000	0.0126	0.0066	0.0045	0.0035	0.0029	0.0028
Detention Basins	0.9750	1.0000	1.0000	1.0000	0.0163	0.0087	0.0060	0.0057	0.0050	0.0048
Structural	0.9730	1.0000	1.0000	1.0000	0.0185	0.0109	0.0078	0.0055	0.0039	0.0030
Combined	0.9710	1.0000	1.0000	1.0000	0.0195	0.0113	0.0083	0.0059	0.0042	0.0033
Ring Levee	0.0090	0.0840	0.1969	0.3551	0.9860	0.9566	0.9233	**0.9042 (1)**	0.8918	0.8872

(1) Meets FEMA certification requirements for successfully passing a 100-year event.

Conclusions

The study area includes the city of Willows (2000 population of 6,220) and the surrounding rural area in western Glenn County. Surrounding land use is agricultural, primarily in field crops such as rice, sunflower, alfalfa, wheat, and corn. The principal sources of flooding in the study area are the creeks that flow east from the coastal foothills towards the valley floor. From the north to the south, these include Walker Creek, Wilson Creek, and South Fork Willow Creek. Flooding from these creeks occurs frequently and is relatively shallow. Northeast of Willows the creeks nearly converge just prior to crossing underneath I-5, Highway 99W, and the Southern Pacific rail line. Although the creek channels do not merge, flood waters from them merge and form ponds just to the west of I-5 and Highway 99W. Although some of the creeks have unofficial "spot levees" in a few locations, there is no consistent levee plan. Without project (existing conditions) equivalent annual damage is estimated to be about $6.5 million and all of the impact areas are currently at risk for frequent flooding.

Seven plans were analyzed that combined various structural and nonstructural flood management measures: no-action plan, nonstructural plan (range and woodland management measures), detention basins-only plan, structural plan (detention basins plus rice field spreading basins and stream restoration), combined plan (includes measures from the structural and nonstructural plans), ring levee plan (for northeast Willows) and floodplain management plan (structure raises). Of all of these plans, the one that produced the greatest damage reduced (about $2.5 million) was the ring levee plan. The reason the ring levee is out-performing the plans which contain the detention basins is that the levee "removes" a large number of structures from the 100-year (and more frequent) floodplains, whereas the detention basins only reduce the depth and slightly reduce the extent of the floodplains, but do not completely remove a large number of structures from frequent flood impacts. However, the ring levee plan may also result in negative hydraulic impacts across and downstream. If these hydraulic impacts were to occur, then mitigation costs would have to be included for this plan.

The economic justification of projects is based upon *net* benefits or benefit/cost ratios, both of which compare project benefits with project costs for all project purposes. Net benefits and benefit/cost ratios for all of the alternative plans are presented in a separate memorandum titled "Benefit-Cost Analysis for Colusa Basin Drainage District Integrated Watershed Management Plan Feasibility Study."