ATTACHMENT 8:

Benefits and Cost Analysis

SANTA CLARA VALLEY WATER DISTRICT

Proposition 1E Round 2
Stormwater Flood Management Grant Program
Berryessa Creek Flood Protection Proposal

Attachment 8

Santa Clara Valley Water District
Berryessa Creek Flood Protection Project Grant Proposal

Benefits and Cost Analysis

In accordance with PSP requirements, **Attachment 8** consists of the following items:

- ✓ Documentation of the monetized and non-monetized benefits based on the physical benefit descriptions discussed in Attachment 7
- ✓ **Appendices** that include copies of the referenced technical documents that support the physical benefit claims.

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Selected Analysis Approach

The RWMG method was used to estimate Flood Reduction benefits (section D.1.) provided by the Berryessa Creek Flood Protection Project.. The DWR Method was used to estimate Non-Monetized Benefits (D.2.), Monetized Benefits (D.3), and the Project Benefits and Costs Summary (D.4).

Flood Damage Reduction Benefit Analysis (D1)

The RWMG method was used to estimate Flood Reduction benefits (section D.1.) provided by the Berryessa Creek Flood Protection Project.

The 2012 Berryessa Creek Evaluation Report ("GRR Study") included a detailed evaluation of existing flooding conditions in the project area, identification and assessment of potential alternatives to address these issues, and a detailed economic analysis. This report is provided as Appendix 8.1 to this attachment. All aspects of the economic analysis completed comply with DWR's requirements, except the following:

- A discount rate of 4 percent was used
- Values are presented in 2011 dollars

This economic analysis summarized below is taken from the Appendix C: Economics of the GRR Study provided in Appendix 8.1. Values from the Economic Appendix have been modified as follows:

- A discount rate of 6 percent has been used in lieu of the 4 percent discount rate used in the original study
- Values are presented in 2012 dollars

As described on page 1-1 of Appendix B: Engineering and Design of the GRR Study included in Appendix 8.1, floodplains for Berryessa Creek were developed for the 20, 10, 4, 2, 1, 0.5, and 0.2 percent chance exceedance flood events. The project study reach for Berryessa Creek extends from upstream of the Old Piedmont Road in the City of San Jose to just upstream of the Calaveras Boulevard in the City of Milpitas. The study area watershed was divided into two distinct subareas by the Interstate 680 (I-680) embankment located approximately midway through the study reach. The I-680 embankment forces breakout flow upstream of the I-680 embankment to either pond in low areas along the embankment or return to the creek channel. Therefore, the embankment was used to divide the study area into two separate floodplains, each modeled with a separate FLO-2D model. The first floodplain encompasses the study area from Old Piedmont Bridge to the I-680 embankment and is referred to as the Upper Model. The second floodplain encompasses the study area downstream of the I-680 embankment to Calaveras Boulevard (with the modeling extending to Penitencia Creek) and is referred to as the Lower Model. "Lower" Berryessa Creek refers to the portion of the authorized Federal project downstream from I-680, rather than to the SCVWD's Lower Berryessa Creek Project, which is located downstream from the Federal project.

The methodology used for modeling Berryessa Creek overflows was determined through discussions with the Sacramento District of the U.S. Army Corps (SPK) and the District. The original GRR methodology was built on the premise of using the available F3 pre-Feasibility Scoping Meeting without-project conditions (pre-FSM) report steady state HEC-RAS channel (HDR 2004b) and HEC-HMS watershed modeling (NHC,2003, 2006) coupled with FLO-2D for overbank modeling. The study methodology was extensively revised in 2010 to account for the effects of upstream attenuation on breakout flows. It was determined that the Upper FLO-2D model should be extended to encompasses the urban channelized portions of Sierra Creek, a major tributary to Berryessa Creek. The study methodology was revised to use FLO-2D to model both the channel and overbank flows in the Upper Model and use an unsteady HEC-RAS model coupled with FLO-2D for overbank flow in the Lower Model.

Based on the FLO-2D modeling modeling completed and summarized in Appendix B: Engineering and Design of the GRR Study (included in Appendix 8.1), a full economic analysis was developed in May 2012 (described in Appendix C: Economics of the GRR Study attached as Appendix 8.1). This economic

analysis was prepared in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The Planning Guidance Notebook (ER 1105-2-100, April 2000) served as the primary source for evaluation methods of flood damage reduction studies and was used as reference for this analysis. Additional guidance for risk-based analysis was obtained from EM 1110-2-1619, Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies (August 1996) and ER 1105-2-101, Planning - Risk Analysis for Flood Damage Reduction Studies (January 2006).

Economic Data Areas

The study area was divided into six economic impact areas for economic evaluation and project performance purposes. Delineations were made to address changes in hydrology, hydraulics and economic conditions throughout the creek. A map showing the six impact areas is shown in Figure 8-1. A comparison of the impact areas to the linear study reaches is provided in Figure 8-2.

- Area A lies farthest east and runs from Old Piedmont to the intersection of Cropley Avenue and Piedmont Road. The area consists of single family residences.
- Area B includes Cropley Avenue and runs along the right bank from Piedmont to Morrill Avenue. The area is primarily residential.
- Area C runs along the left bank just past Majestic Elementary and Berryessa Creek Park downstream just east of Morrill. The area is primarily residential.
- Area D runs from Morrill to the I-680 Freeway. This area in San Jose is primarily residential.
- Area E is the largest impact area in the study and begins just west of I-680. The area is bounded by Capitol Avenue, Abel Street and Berryessa Creek. This area includes the Midtown region of Milpitas and includes residential, commercial, public and industrial land uses.
- Area F runs along a short section of the left bank of Berryessa from Yosemite Drive to near Los Coches Street and east of WP railroad line. This impact area is highly industrial with many hi-tech firms in addition to some commercial and limited residential.

Inventory of Structures and Property in Study Area

This analysis included assessment of structures and property that would be impacted by flooding of Berryessa Creek. As discussed on page 2-4 of Appendix C of the GRR Study (Appendix 8.1), a structural inventory was previously completed based on data gathered from assessor's parcel data and on-site inspection of all the structures (100%) within the floodplain. Structures were determined to be within the economic study area by using Geographical Information Systems (GIS) to compare the 0.002 exceedance probability floodplain boundary with the spatially referenced assessor parcel numbers (APN). The inventory was developed in accordance with Section 308 of WRDA 1990. Information from the assessor's parcel database (such as land use, building square footage, address) was supplemented during field visitation for each parcel within the floodplain to collect additional required data such as, foundation height, specific business activity (non-residential), building condition, type of construction, number of units. Parcels with structures, were categorized by land use and grouped into the following structural damage categories:

- Single Family Residential – includes all parcels represented by a single unit such as detached single family homes, individually owned condominiums and townhouses.
- Multiple Family Residential – includes residential parcels with more than one unit such as apartment complexes, duplexes and quadplex units. Each parcel may have multiple structures.
- Commercial – includes retail, office buildings, restaurants
- Industrial – includes warehouses, light and heavy manufacturing facilities. Also includes many computer and bio-tech industries that are in the Milpitas area.
- Public – includes both public and semi-public uses such as post offices, fire stations, government buildings, schools and churches.

All parcels with structures were assigned to one of the listed categories. Some parcels have more than one physical structure and some structures, such as condominiums, are represented by multiple parcels.

Figure 8-1: Economic Impact Areas

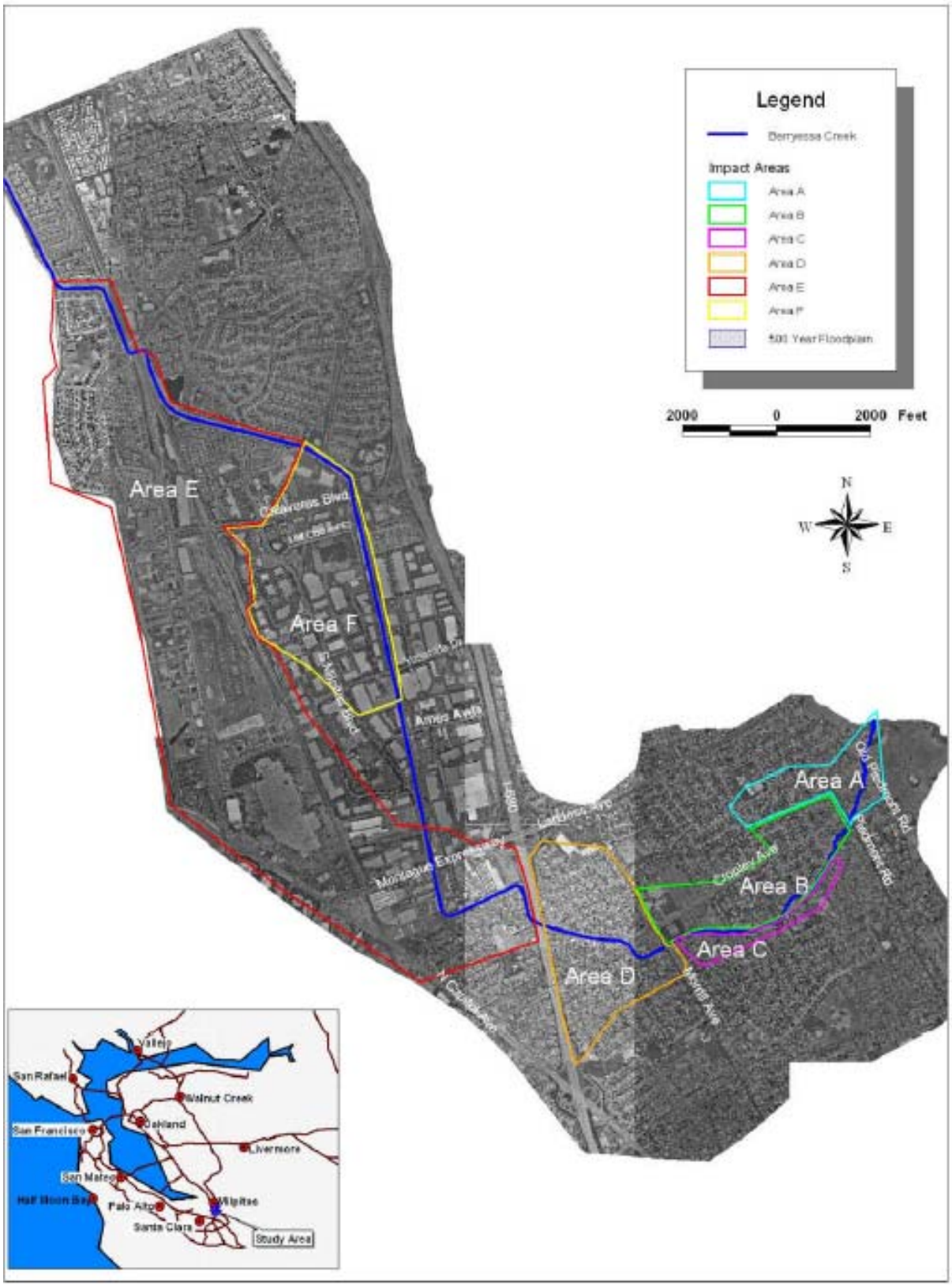

Figure 8-2: Study Reaches and Impact Area Locations

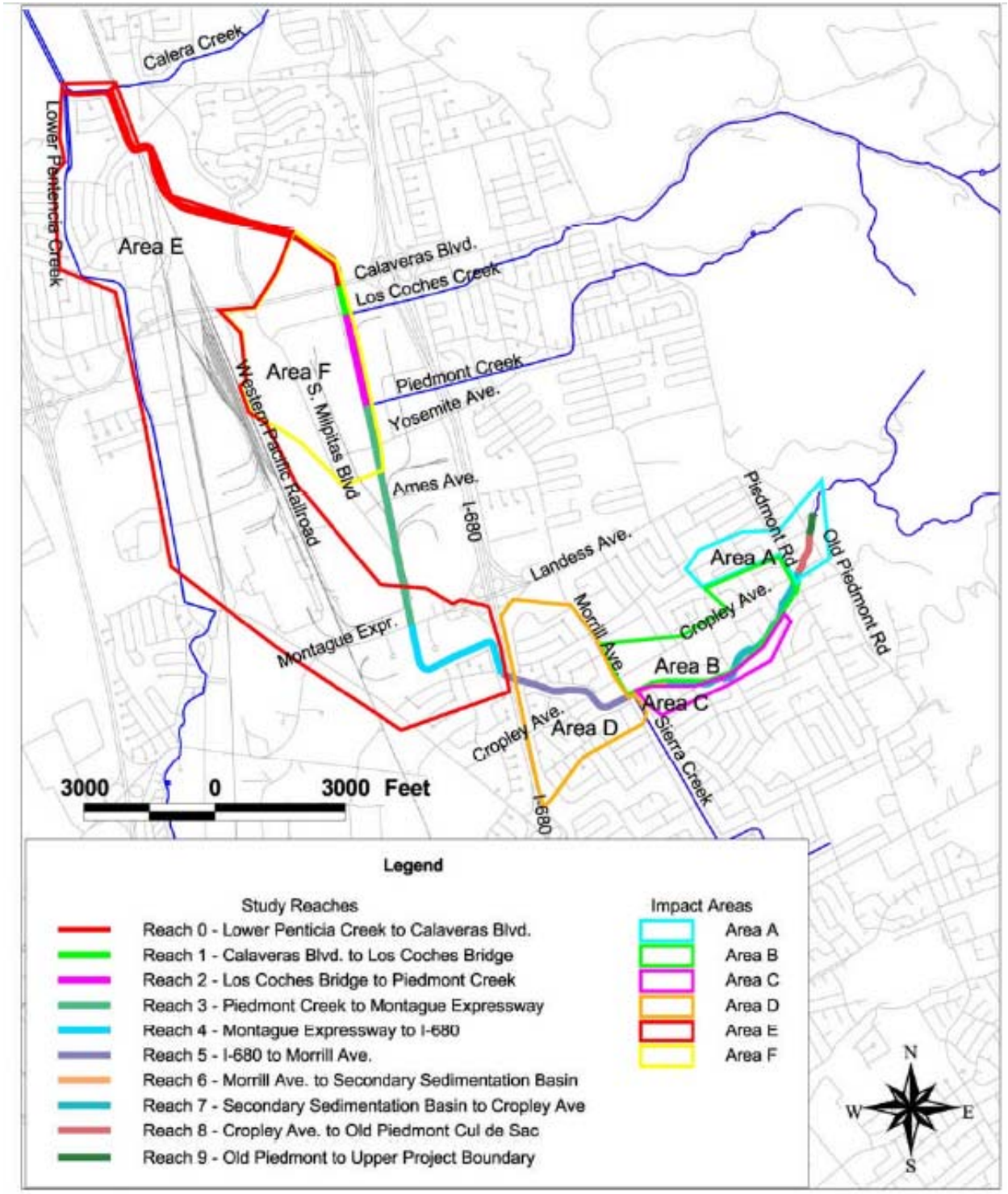

Table 8-1 displays the total number of parcels (number of units for multifamily residential) with structures by category.

Table 8-1. Number of Parcels in the 100- and 200-Year Floodplains

Economic Impact Area	Single Family Residential	Multiple Family Residential Units	Commercial	Industrial-General	Industrial-Tech	Public	Total
Number of Parcels with Structures within the 0.02 Exceedance Probability Floodplain by Land Use							
Area-A	64	0	0	0	0	0	64
Area-B	96	287	0	0	0	1	384
Area-C	14	0	0	0	0	0	14
Area-D	378	105	0	0	0	0	483
Area-E	723	1,110	95	22	17	15	1,982
Area-F	1	0	14	8	25	4	52
Total	1,276	1,502	109	30	42	20	2,979
Number of Parcels with Structures within the 0.01 Exceedance Probability Floodplain by Land Use							
Area-A	35	0	0	0	0	0	35
Area-B	77	257	0	0	0	1	335
Area-C	12	0	0	0	0	0	12
Area-D	231	26	0	0	0	0	257
Area-E	589	1,050	82	22	16	13	1,772
Area-F	1	0	14	8	25	4	52
Total	945	1,333	96	30	41	18	2,463

Value of Damageable Property - Structure Value

The value of property at risk was estimated based on depreciated replacement values (DRV). Structure value was determined based on the following function:

DRV = Square Footage * Cost per Square Foot * Depreciation Factor

Evaluations of Corps flood damage reduction projects require structures be valued using replacement costs minus depreciation. These values may differ from assessed values, sales or market values, reproduction costs or values determined by income capitalization. Depreciated replacement cost does not include land values and market prices (which include land value) or sale price for homes and commercial property would be higher than the value of the depreciated structure alone.

Building characteristics such as quality type, condition, number of stories were gathered for each parcel. Square footage representing the building area was taken from assessor's parcel data for each structure. Values for cost per square foot were determined based on land use, building type, construction class and quality. Values were taken from the Marshall and Swift (M&S) Valuation Service and were adjusted using the M&S local multipliers for San Jose to account for the higher construction costs found in the Milpitas/San Jose area. Factors such as the year the structure was built, overall condition of the building, improvements, required maintenance and comparative data from of other studies were used in determining the subjective measure of how much depreciation to assign each structure.

In the database, each structure was assigned a mean remaining value percentage (100% replacement minus estimated percent depreciated) to be used in determining depreciated replacement value. The

range of depreciation varied with each structure and land use with new structures assigned zero depreciation and a maximum of 60% for a few structures in poor condition. Uncertainty in remaining percent value was determined to be a triangular distribution with minimum and maximums set at plus or minus 10% not to exceed 100% total value.

Examples of a typical structure valuation by damage category using median values found in the study are shown in Table 8-2. These values are displayed to explain the methodology used but do not represent any particular structure or mean values within the study. They are based on the values presented in Table 2.2 of Appendix C of the GRR Study (Appendix 8.1), converted from 2011 to 2012 dollars (multiplied by 1.01).

Table 8-2. Example Structure Valuation by Damage Category (October 2011 Prices, escalated to 2012 Dollars)

Structure Category	Square Footage	Price Per Sqare Foot (locally adjusted)	Estimated Depreciation Percentage	Remaining Value Percentage	Depreciated Replacement Value of Typical Structure
	Using Median Values by Category				
Single Family Residential	1,480	$145.52	15%	85%	181,247
Multiple Family Residential Units	1,900	$97.37	30%	70%	128,219
Commercial	4,680	$146.19	15%	85%	575,759
Industrial	11,870	$148.96	15%	85%	1,488,051
Public	10,000	$184.35	10%	90%	1,642,674

Value of Damageable Property- Content Value

In addition to structures, building contents can also be at risk of flood damages. In the 2012 study, content values were estimated as a percentage of depreciated structure value based on land use. During the 1992 General Design Memorandum (GDM) on Berryessa Creek, detailed content surveys were made to determine content percentages specific to the Milpitas/San Jose area. For the 2012 study, additional content surveys were completed to confirm or adjust values used in the original study.

The survey requested identification of business activity, square footage or known value of the building, total value of content or ratio content to structure value if known. The survey also asked respondents to provide estimated loss of contents for various theoretical floods. As no known flood events have occurred in the study area resulting in non-residential damage, responses were limited to best guess estimates. Based on these survey results, the 1992 GDM content percentages are considered to be reasonable. Minor adjustments were made to the industrial category (sub-divided for content analysis only in this study as Industrial- General and Industrial-Tech) to represent the recent surveys. The industrial-tech content category includes computer component manufacture and distribution, and bio-technology commonly found in the San Jose/Milpitas area. Both content values and percent losses were greater for the industrial-tech than typical industrial activities, which is why industrial content losses were separated for this analysis. The sub-categories for commercial business only differ in the assigned content percentages (does not affect structure depth-damage functions). Content percentages by sub-category are given in Table 8-3.

Table 8-3. Example Structure Valuation by Damage Category (escalated to 2012 dollars)

Structure Sub-Category	Content Percent of Structure Value
Commercial-Food	130%
Commercial-Office	50%
Commercial-Retail	100%
Commercial-Restaurants	75%
Commercial-Department Stores	150%
Industrial-General	131%
Industrial-Tech	187%
Public	45%
Residential	50%

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Total value of damageable property is comprised of the structural and content values described for the parcels within the 0.002 exceedance probability floodplain. Table 8-4 shows the total structure and content values by category and economic impact area. This table reflects values presented in Table 2.4 of the Appendix C of the GRR Study (Appendix 8.1, page 2-8), escalated from 2011 to 2012 dollars (multiplied by 1.01). In total, the study area has just under $2.3 billion worth of estimated damageable property.

Table 8-4. Value of Damageable Property within the 200-Year Floodplain by Impact Area, Values in $Millions (escalated to 2012 dollars)

Structure Category	Area-A	Area-B	Area-C	Area-D	Area-E	Area-F	Total
SFR-Structure	11.817	17.776	2.424	63.933	124.533	0.404	220.887
SFR-Content	5.858	8.888	1.212	32.017	62.317	0.202	110.494
MFR-Structure	0	27.573	0	11.514	226.846	0	265.933
MFR-Content	0	13.736	0	5.757	113.423	0	132.916
Commercial-Structure	0	0	0	0	229.876	30.906	260.782
Commercial-Content	0	0	0	0	248.46	29.391	277.851
Industrial-General	0	0	0	0	0	0	0
Structure	0	0	0	0	74.841	31.209	106.05
Industrial-Tech	0	0	0	0	0	0	0
Structure	0	0	0	0	83.325	162.61	245.935
Industrial-General	0	0	0	0	0	0	0
Content	0	0	0	0	98.071	40.804	138.875
Industrial-Tech Content	0	0	0	0	155.843	304.111	459.954
Public-Structure	0	8.383	0	0	30.603	14.342	53.328
Public-Content	0	3.737	0	0	13.736	6.464	23.937
Total Value	17.675	80.093	3.636	113.221	1,461.87	620.443	2,296.94

Economic HEC-FDA Model and Application of Floodplain Data

As discussed beginning on page 2-9 of the Economic Appendix, the Hydrologic Engineering Center's HEC-FDA model (version 1.2.4, FRM-PCX certified model) was used to perform the economic damage and benefits analyses.

The HEC-FDA model was used to integrate the engineering data (hydrologic, hydraulic, and geotechnical), compute stage-damage curves using specially-formatted output data, and compute initial AEP and Expected Annual Damage (EAD) results under without-project and with-project conditions. For structure and content damages, depth of flooding relative to the structure's first floor is the primary factor in determining the magnitude of damage. The analysis utilizes HEC-FDA's internal processes for the determination of structural inundation. The HEC-FDA process combined a GIS database, provided by the District, containing spatially referenced polygons for each parcel in the study area with water surface elevations from Flo2D modeling.

A ground elevation was assigned to the centroid of each parcel using GIS for the study. Foundation heights, determined during field visitation, were added to the assigned ground elevation to establish first floor elevations. Water surface elevations (WSE) from the Flo2D model were provided in the form of grid cells for the 0.500, 0.200, 0.100, 0.040, 0.020, 0.010, 0.005, and 0.002 exceedance probability events. Parcels were then correlated with the grid cell in which the centroid laid. Flooding depths in general were rather shallow with very few structures facing depths greater than 3 feet and an average of one foot above ground elevation for the largest event.

Computation of Stage-Damage Curves within the HEC-FDA Model

For the suite of floodplains, WSE floodplain data was formatted so that the floodplains could be directly imported into the HEC-FDA model as a water surface profile. The formatted files contained every grid cell that contained a structure and the water surface elevations in each grid cell for each frequency event. The suite of floodplains along with the imported structure inventory was used in HEC-FDA to compute stage-damage curves.

Instead of using river station numbers, assignment of water surface elevations by frequency event were completed using grid cell numbers; the grid cell assignments represent actual floodplain water surface elevations by frequency event rather than in-channel water surface elevations. Once the formatted floodplain data were imported into HEC-FDA, a row was inserted at the top of the WSP which included the in-channel stages associated with the index point (for a particular impact area). This step allowed for the linkage between the 2-dimensional floodplain data and the in-channel stages. Importing formatted floodplain data and assigning water surface elevations to grid cells eliminated the need for creating interior exterior relationships, which is another way to link exterior (river) stages to interior (floodplain) stages within HEC-FDA.

Depth-Damage Relationships

Damages to structures and contents were determined based on depth of flooding relative to the structure's first floor elevation. To compute these damages, depth damage curves were developed. These curves assign loss as a percentage of value for each parcel. The deeper the relative depth, the greater the percentage of value damaged. The sources of the relationships were different depending on land use. For single family residential structures and contents, depth damage curves were taken from Economic Guidance Memorandum EGM 01-03, Generic Depth Damage Relationships. For the other (non-single family residential) structure categories, the damage curves were based on 1998 FEMA Flood Insurance Administration data with the exception of the industrial content curves. For industrial content, the depth damage curves used in the original Corps study were modified based on the current survey responses (see Section 2.4 of the Economic Appendix). The resultant depth damage curves are shown in Table 8-5 by category.

Table 8-5. Depth-Damage Curves

Damage Category	Depth of Flooding (Above First Floor in Feet)						
	-1	0	1	2	3	4	5
	Percent Damage of Structure Value						
Commercial 1-Story	0%	7%	16.3%	24.7%	27.7%	29.6%	30.9%
Commercial 2-Story	0%	5%	9.9%	13.4%	18%	20%	22%
Industrial Gen 1-Story	0%	7%	16%	25%	28%	30%	31%
Industrial Gen 2-Story	0%	5%	10%	13%	18%	20%	22%
Industrial Tech 1-Story	0%	7%	16%	25%	28%	30%	31%
Industrial Tech 2-Story	0%	5%	10%	13%	18%	20%	22%
Public 1-Story	0%	7%	16.3%	24.7%	27.7%	29.6%	30.9%
Public 2-Story	0%	5%	9.9%	13.4%	18%	20%	22%
Residential 1-Story SF	0%	13.4%	23.3%	32.1%	40.1%	47.1%	53.2%
Residential 2-story SF	0%	9.3%	15.2%	20.9%	26.3%	31.4%	36.2%
Residential 2-Story Apt	0%	9.3%	15.2%	20.9%	26.3%	31.4%	36.2%
	Percent Damage of Content Value						
Commercial 1-Story	0%	0%	22.8%	49.5%	64.7%	91.2%	100%
Commercial 2-Story	0%	0%	19.1%	31.4%	35.6%	45.1%	50%
Industrial Gen 1-Story	0%	0%	35.2%	64.2%	74.8%	91.8%	96.3%
Industrial Gen 2-Story	0%	0%	29.6%	40.8%	41.2%	45.9%	48.1%
Industrial Tech 1-Story	0%	0%	35.2%	64.2%	74.8%	91.8%	96.3%
Industrial Tech 2-Story	0%	0%	29.6%	40.8%	41.2%	45.9%	48.1%
Public 1-Story	0%	0%	22.8%	49.5%	64.7%	90.2%	100%
Public 2-Story	0%	0%	19.1%	31.4%	35.6%	45.1%	50%
Residential[1] 1-Story SF	0%	16.2%	26.6%	35.8%	44%	51.4%	57.6%
Residential[1] 2-story SF	0%	10%	17.4%	24.4%	31%	37%	42.6%
Residential 2-Story Apt	0%	5%	8.7%	12.2%	15.5%	18.5%	21.3%

1 The EGM 01-03 curves estimate content damages as a direct function of structure value. The percentages listed in this table assume content value at 50% of structure value and percentages have been modified accordingly.

Damage Estimation

Damages were estimated within HEC-FDA employing its full function of relating structure inventory data with water surface elevations by exceedance probability events. Structure values for insertion into HEC-FDA were determined as a function of Marshall Valuation Service values per square foot, square footage and estimated depreciation. To estimate the uncertainty in structure valuation, triangular distributions for each of these parameters were set in the model. For additional information on economic uncertainty parameters, refer to section 4.2 of Appendix C, page 4-1 to the GRR Study (Appendix 8.1).

Other Damage Categories

Losses to automobiles were determined as a function of the number of vehicles per residence, average value per automobile, estimated percentage of autos removed from area prior to inundation, and depth of flooding above the ground elevation. Depth-damage relationships for autos were taken EGM 09-04. Source of vehicle counts per housing unit were taken from the US Census 2000 (San Jose and Milpitas averages). Evacuation (autos moved out of the flooded area) was assumed to be a triangular distribution with the most likely value set at 50%. Assumption is that there are many factors that could determine

ability to evacuate and 50% has been used as an average on most Sacramento District studies. Depreciated replacement value of autos was based on average used car prices (taken from prior studies and updated using Bureau of Labor Statistics CPI-Used Vehicles) and was set at $12,250 in 2011 dollars, or $12,373 in 2012 dollars. This value within HEC-FDA was assumed to be normally distributed with a standard deviation of 30%.

Emergency costs were estimated for the relocation and emergency services provided for those displaced both during the peak flood event and during post-flood structural renovations. Duration of services was formulated for two groups: short-term- residents evacuated for the duration of the flood but able to stay in the home once the flood recedes, and long-term- occupants displaced from the home due to inundation requiring repair and decontamination prior to return. Losses per resident per day were taken from prior Sacramento District studies (Napa River, South Sacramento County Streams) with a mean of $12 per day in 2011 dollars, or $12.12 in 2012 dollars. Long-term dislocation was estimated based on a triangular distribution with the most likely value set at 45 days. Occupants per residential unit were taken from the US Census 2000 for the Milpitas area. Based on these estimates, a residence inundated above the first floor requiring repair would face an average $1,950 in total emergency costs in 2011 dollars, or $1,970 in 2012 dollars, which is reasonable for the magnitude of flooding in the study area and is less than the national FEMA average for temporary rental and public assistance.

Stage-Damage Functions

Base damages (calculations without uncertainty or reflecting levees and channel tops) were estimated by the HEC-FDA model for each category by impact area and by event based on varying depths within the floodplain relative to individual structures. Stage-damage functions for Impact Areas A through F are presented in Tables 8-6 through 8-11, escalated to 2012 dollars.

Table 8-6. Stage-Damage Functions Impact Area A, Damages in $1,000's (escalated to 2012 dollars)

	Exceedance Probability of Event Followed by Corresponding Stage (elevation in feet)				
	0.04	**0.02**	**0.01**	**0.005**	**0.002**
Damage Category	**216.88**	**219.26**	**220.15**	**221.39**	**222.31**
Single Family Residential	87.87	160.59	714.07	1,203	1,364
Multi-Family Residential Units	0	0	0	0	0
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Public	0	0	0	0	0
Automobile	12.12	19.19	76.76	131.3	145.44
Emergency	4.04	5.05	13.13	16.16	20.2
Total	104.03	184.83	803.96	1,350	1,529

Table 8-7. Stage-Damage Functions Impact Area B, Damages in $1,000's (escalated to 2012 dollars)

	Exceedance Probability of Event Followed by Corresponding Stage (elevation in feet)				
	0.04	**0.02**	**0.01**	**0.005**	**0.002**
Damage Category	**147.49**	**147.69**	**147.74**	**147.81**	**147.83**
Single Family Residential	0	942.33	2434.1	3,124	3,539
Multi-Family Residential Units	843.35	2577.52	4137.97	5264.12	5887.29
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Public	0	0	29.29	1013.03	1636.2
Automobile	81.81	449.45	979.7	1323.1	1595.8
Emergency	26.26	198.97	390.87	497.93	599.94
Total	951.42	4168.27	7971.93	11,222	13,258

Table 8-8. Stage-Damage Functions Impact Area C, Damages in $1,000's (escalated to 2012 dollars)

	Exceedance Probability of Event Followed by Corresponding Stage (elevation in feet)				
	0.04	**0.02**	**0.01**	**0.005**	**0.002**
Damage Category	**146.7**	**146.89**	**146.91**	**146.93**	**146.94**
Single Family Residential	10.1	28.28	198.97	246	328
Multi-Family Residential Units	0	0	0	0	0
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Public	0	0	0	0	0
Automobile	0	3.03	21.21	27.27	35.35
Emergency	0	0	3.03	7.07	8.08
Total	10.1	31.31	223.21	281	372

Table 8-9. Stage-Damage Functions Impact Area D, Damages in $1,000's (escalated to 2012 dollars)

	Exceedance Probability of Event Followed by Corresponding Stage (elevation in feet)				
	0.04	**0.02**	**0.01**	**0.005**	**0.002**
Damage Category	**147.49**	**147.69**	**147.74**	**147.81**	**147.83**
Single Family Residential	255.53	1029.19	4579.34	9,823	13,935
Multi-Family Residential Units	0	0	385.82	1653.37	2885.57
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Public	0	0	0	0	0
Automobile	18.18	81.81	633.27	1656.4	2573.48
Emergency	3.03	11.11	152.51	419.15	636.3
Total	276.74	1122.11	5750.94	13,552	20,030

Table 8-10. Stage-Damage Functions Impact Area E, Damages in $1,000's (escalated to 2012 dollars)

	Exceedance Probability of Event Followed by Corresponding Stage (elevation in feet)				
	0.04	**0.02**	**0.01**	**0.005**	**0.002**
Damage Category	**64.5**	**64.71**	**64.86**	**65.01**	**65.07**
Single Family Residential	2096.76	4747	12663.38	20,734	25,451
Multi-Family Residential Units	0	667.61	5057.07	6816.49	9947.49
Commercial	2609.84	5571.16	9718.22	14209.69	22411.9
Industrial	3574.39	8583.99	15928.71	22838.12	27090.22
Public	96.96	432.28	1084.74	2500.76	3923.85
Automobile	267.65	856.48	2498.74	4116.76	5065.15
Emergency	10.1	106.05	450.46	875.67	1112.01
Total	8655.7	20964.57	47401.32	72,092	95,002

Table 8-11. Stage-Damage Functions Impact Area F, Damages in $1,000's (escalated to 2012 dollars)

	Exceedance Probability of Event Followed by Corresponding Stage (elevation in feet)				
	0.04	**0.02**	**0.01**	**0.005**	**0.002**
Damage Category	**38.13**	**38.21**	**38.31**	**38.33**	**38.35**
Single Family Residential	0	0	0	40	40
Multi-Family Residential Units	0	0	0	0	0
Commercial	741.34	1438.24	2910.82	3543.08	3850.12
Industrial	47145.79	58447.69	71751.41	87376.11	94004.74
Public	490.86	512.07	1145.34	1381.68	1398.85
Automobile	0	0	0	0	0
Emergency	0	0	0	0	0
Total	48377.99	60398	75807.57	92,341	99,294

Expected Annual Damages – Without Project

HEC-FDAModel

Expected annual damages were estimated using the US Army Corps of Engineers risk-based Monte Carlo simulation program called HEC-FDA. The HEC-FDA program integrates hydrology, hydraulics, geo-technical 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. The Berryessa Creek model includes the following relationships for each economic impact area:

- Probability-Discharge (with uncertainty determined by period of record)
- Stage-Discharge (stage in the channel with estimated error in feet)
- Stage-Damage (computed internally within HEC-FDA)

These relationships for each economic impact area are shown in Attachment A of the Economic Appendix. The hydrologic and hydraulic data was provided by study team members and included in the HEC-FDA model.

Estimation of Expected Annual Damages

HEC-FDA integrates the probability-discharge, stage-discharge and stage-damage relationships to determine a probability-damage function. Expected annual damages (EAD) are calculated as the numerical integration of the area under the probability-damage curve.

The derived probability damage function from the HEC-FDA model for each impact area is provided in Table 8-12. These damage values differ from the calculated damages by event shown in the stage-damage curves due to uncertainties in each relationship.

Table 8-12. Without-Project Probability Damage Functions – HEC-FDA Model, in $1000s (escalated to 2012 dollars)

	Total Damages by Impact Area					
Exceedance Probability	**A**	**B**	**C**	**D**	**E**	**F**
0.2	0	0	0	0	0	0
0.1	0	223.21	11.11	117.16	0	0
0.05	0	11,537	511.06	13,610	4,567	0
0.04	0	15,196	665.59	18,953	16,001	0
0.02	172.71	22,515	976.67	29,639	142,961	103,684
0.015	336.33	24,345	1,053	32,311	230,527	159,334
0.01	845.37	26,175	1,131	34,982	318,093	214,984
0.004	1,461	28,370	1,224	38,188	423,173	281,764
0.002	2,926	29,102	1,255	39,257	458,199	304,024
0.001	4,376	29,468	1,271	39,791	475,712	315,154

EAD, under existing without project conditions, was estimated for each damage category for all six impact areas. Results are summarized in the Table 8-13 below.

Table 8-13. Expected Annual Damages – Existing Without-Project Conditions, in $1000s (escalated to 2012 dollars)

	EAD by Economic Impact Area						
Damage Category	**A**	**B**	**C**	**D**	**E**	**F**	**Total**
Single Family Residential	20.18	285.24	37.01	1017.59	997.04	3.28	2360.34
Multi-Family Residential	0.00	457.99	0.00	179.58	522.95	0.00	1160.52
Commercial	0.00	0.00	0.00	0.00	1383.81	377.35	1761.16
Industrial	0.00	0.00	0.00	0.00	1809.78	6131.90	7941.68
Public	0.00	134.37	0.00	0.00	167.71	119.37	421.45
Automobile	2.30	137.44	4.28	186.82	253.82	0.12	584.79
Emergency	0.46	50.27	1.10	47.47	43.38	0.00	142.68
Total EAD	22.95	1065.32	42.39	1431.45	5178.49	6632.02	14372.62

With- and Without Project Comparison

An incremental analysis examining project location and sizing was conducted with near final H&H and economics. The final changes in H&H and economics were considered and deemed non-material to the overall outcomes of the HEC-FDA model and were not updated for this report.

Benefits were determined by making changes to the HEC-FDA model that represent various with project improvements. Flood damage reduction benefits equal the difference between the without project damage conditions and the with project residual damages. With project residual damages were simulated for the alternatives using residual floodplain depths. The reduction in project floodplains in both extent and depth from the larger without project floodplains accounts for the decrease in damages of the given alternative. Residual depths for each damage area from the four alternative with project Flo2D runs were linked to the without project inventory through modified water surface elevation (WSE) profiles within the HEC-FDA model. With the new WSEs, stage-damages functions for the alternatives were computed within HEC-FDA and overall model runs were computed for the alternatives. For alternatives 2B and 4

residual floodplains at the mean 500-yr event, the upper limit of the current HEC-FDA modeling effort, do not appear with Flo2D. Thus, the HEC-FDA model was not run for alternatives 2B and 4 as no residual damages are present. In addition to the modifications to the floodplains, changes to the stage-discharge function and/or top of bank (top of levee failure point) were made in the HEC-FDA model to simulate project conditions for any alternative that increased channel capacity (lowering water surface at a given exceedance probability) or raised levee height (increasing non-damaging elevation.) Details of HEC-FDA with project inputs can be found in Attachment B of the Appendix C: Economics to the GRR Study (Appendix 8.1).

For the alternatives considered, HEC-FDA was run simulating with project conditions. The residual with project damages were subtracted from the without project damages to determine flood damage reduction benefits. Total discharge- flow in channel, and stage discharge were modified to simulate these project conditions in the HEC-FDA model. All benefit values in the remaining tables of this report included average annual equivalents instead of expected annual damages. These average annual equivalent damages include future growth described previously. The future growth adds very little to the total damages (less than 1% of the total) and will not impact the plan formulation process.

Table 7.1 of the Economic appendix presents damages as calculated by the HEC-FDA model for the proposed Project (alternative 2a) in terms of equivalent annual damage. Equivalent annual damage is defined as the damage value associated with the without- or with-Project condition over the analysis period (project life) considering changes in hydrology, hydraulics, and flood damage conditions over the life. As discussed in the Economic Appendix on page 6-3, future hydrologic changes were assumed to be negligible, and all increases in EAD under future conditions were attributable to future growth. Neglecting future growth, EAD under future conditions would be equal to EAD under existing conditions.

Expected annual damage was estimated based on the equivalent annual damage presented in the Economics Appendix as follows:

1. Expected annual damages without the Project, in 2012 dollars, were assumed to equal the without-Project existing condition (presented in Table 8-13). This is a conservative assumption, as it does not consider damages that would incur to future development.
2. The ratio of expected annual damages with Project to expected annual damages without Project was assumed to equal the ratio of equivalent annual damages with the Project to expected annual damages without the Project presented in the Economics appendix (Table 7-1, page 7-3; equivalent annual damage without Project [2011 dollars] is $2,536,730 + $11,823,260 = $14,360,460, equivalent annual damage with Project [2011 dollars] is $2,536,730 + $886,620 = $3,423,350; ratio of with-Project equivalent annual damage to without-Project equivalent annual damage = $3,423,350 / $14,360,460 = 0.238).
3. With-Project expected annual damages in 2012 dollars were therefore assumed to be 0.238 * without-Project expected annual damages in 2012 dollars (from Table 8-13, $14,372,620 * 0.238 = $3,420,684).

Table 8-14 shows the approximate expected annual damage in 2012 dollars for the proposed Project (alternative 2a) with- and without-Project, estimated as described above.

Table 8-14. Expected Annual Damage Benefit with- Project, in $1000s (2012 dollars)

Expected Annual Damages ($1000s)		
Without Project	**With Project**	**Expected Annual Benefit**
14,372.62	3420.68	10,951.94

Table 8-15 (PSP table 12) presents the expected annual benefit in 2012 dollars, using a 50-year project life and 6 percent discount factor.

Table 8-15. Present Value of Expected Annual Damage Benefits (6% Interest Rate, 50-Year Period of Analysis, 2012 dollars)

Table 12 – Present Value of Expected Annual Damage Benefits Project: Berryessa Creek Flood Protection Project			
(a)	Expected Annual Damage Without Project (1)		**$10,951,940.00**
(b)	Expected Annual Damage With Project (1)		**$4,712,420.00**
(c)	Expected Annual Benefit	(a) – (b)	**$6,239,520.00**
(d)	Present Value Coefficient (2)		**15.76**
(e)	**Present Value of Future Benefits Transfer to Table 17, column (d).**	**(c) x (d)**	**$98,334,835.20**

(1) This program assumes no land use changes in the floodplain. So, EAD will be constant over analysis period.
(2) 6% discount rate; 50-year analysis period (could vary depending upon lifecycle of project).

Annual Cost of Avoided Projects

Implementation of this project would not cause an alternate project or projects to be avoided.

Non-Monetized Benefits Analysis (D2)

This section describes other physical benefits provided by the Berryessa Creek Flood Protection Project that are not easily monetized. Table 8-16 provides a checklist of non-monetized benefits, and the sections that follow provide an expanded discussion of the applicable benefits to the Berryessa Creek Flood Protection Project.

Table 8-16. Annual Cost of Avoided Projects (2012 dollars)

Table 13 – Non-monetized Benefits Checklist		
No.	Question	"Yes", "No" or "Neg"
	Community/Social Benefits **Will the proposal**	
1	**Provide education or technology benefits?**	**Yes**
	Examples are not limited to, but may include: - Include educational features that should result in water supply, water quality, or flood damage reduction benefits? - Develop, test or document a new technology for water supply, water quality, or flood damage reduction management? - Provide some other education or technological benefit?	
2	**Provide social recreation or access benefits?**	Yes
	Examples are not limited to, but may include: - Provide new or improved outdoor recreation opportunities? - Provide more access to open space? - Provide some other recreation or public access benefit?	
3	**Help avoid, reduce or resolve various public water resources conflicts?**	**No**
	Examples are not limited to, but may include: - Provide more opportunities for public involvement in water management? - Help avoid or resolve an existing conflict as evidenced by recurring fines or litigation? - Help meet an existing state mandate (e.g., water quality, water conservation, flood control)?	
4	**Promote social health and safety?**	Yes
	Examples are not limited to, but may include: - Increase urban water supply reliability for fire-fighting and critical services following seismic events? - Reduce risk to life from dam failure or flooding? - Reduce exposure to water-related hazards?	
5	**Have other social benefits?**	No
	Examples are not limited to, but may include: - Redress or increase inequitable distribution of environmental burdens? - Have disproportionate beneficial or adverse effects on disadvantaged communities, Native Americans, or other distinct cultural groups?	

Table 13 – Non-monetized Benefits Checklist		
No.	Question	"Yes", "No" or "Neg"
	Environmental Stewardship Benefits: **Will the proposal**	
6	**Benefit wildlife or habitat in ways that were not quantified in Attachment 7?**	Yes
	Examples are not limited to, but may include: - Cause an increase in the amount or quality of terrestrial, aquatic, riparian or wetland habitat? - Contribute to an existing biological opinion or recovery plan for a listed special status species? - Preserve or restore designated critical habitat of a listed species? - Enhance wildlife protection or habitat?	
7	**Improve water quality in ways that were not quantified in Attachment 7?**	Yes
	Examples are not limited to, but may include: - Cause an improvement in water quality in an impaired water body or sensitive habitat? - Prevent water quality degradation? - Cause some other improvement in water quality?	
8	**Reduce net emissions in ways that were not quantified in Attachment 7?**	No
	Examples are not limited to, but may include: - Reduce net production of greenhouse gasses? - Reduce net emissions of other harmful chemicals into the air or water?	
9	**Provide other environmental stewardship benefits, other than those claimed in Sections D1, D3 or D4?**	No
	Sustainability Benefits: **Will the proposal**	
10	**Improve the overall, long-term management of California groundwater resources?**	No
	Examples are not limited to, but may include: - Reduce extraction of non-renewable groundwater? - Promote aquifer storage or recharge?	
11	**Reduce demand for net diversions for the regions from the Delta?**	No
12	**Provide a long-term solution in place of a short-term one?**	No
	Examples are not limited to, but may include: - Replace a temporary water supply with a more permanent supply? - Replace a temporary water quality solution with a more permanent solution? - Replace temporary flood control management with a more permanent solution? - Replace temporary habitat with a more permanent solution?	
13	**Reduce water consumption on a permanent basis?**	No
14	**Promote energy savings or replace fossil fuel based energy sources with**	No

Table 13 – Non-monetized Benefits Checklist		
No.	Question	"Yes", "No" or "Neg"
	renewable energy and resources?	
	Examples are not limited to, but may include: - Reduce net energy use on a permanent basis? - Increase renewable energy production? - Include new buildings or modify buildings to include certified LEED features? - Provide a net increase in recycling or reuse of materials? - Replace unsustainable land or water management practices with recognized sustainable practices?	
15	**Improve water supply reliability in ways not quantified in Attachment 7?**	No
	Examples are not limited to, but may include: - Provide a more flexible mix of water sources? - Reduce likelihood of catastrophic supply outages? - Reduce supply uncertainty? - Reduce supply variability?	
16	**Other (If the above listed categories do not apply, provide non-monetized benefit description)?**	Yes

The project will achieve the following non-monetizable benefits.

2. Social Recreation or Access Benefits

Implementation of this Project will provide new recreational amenities for City of Milpitas and the northern portions of the City of San Jose, including pedestrian bridges and multiple-use trails that will extend for up to 6 miles along the Berryessa Creek.

3. Promote Social Health and Safety

According to the National Oceanic and Atmospheric Administration (NOAA), flash and river floods claimed 113 lives nationwide in 2011, up from 103 in 2010. Flooding represents a major hazard that threatens the health and safety of those affected. As discussed in Attachment 7, this project will protect 1,664 parcels from the 100-year flood, decreasing the number of displaced households in that event from 4,572 to 415. This represents a significant improvement in public health and safety.

6. Benefit Wildlife or Habitat

Erosion and sedimentation along Berryessa Creek and its tributaries are a major issue when it comes to impeded stream flow and channel capacity, degraded water quality, fish passage and establishment of native habitat. Implementation of the Project will widen channels to reduce erosion on banks, and will create a proper bankfull channel to transport sediments.

Berryessa Creek habitat is currently comprised of mostly non-native vegetation. Implementation of this Project will reduce the sedimentation and erosion and associated bank failures that currently limit native plant colonization. In addition, the Project involves construction of depressed benches which will provide a substrate for the planting of native vegetation along the 6-mile stream corridor.

Implementation of this Project will also allow for enhanced fish passage for critical species such as Steelhead.

7. Improve Water Quality in Ways Not Quantified in Attachment 7

The banks of Berryessa Creek and its tributaries are currently subject to varying degrees of erosion and sedimentation, which degrades the overall water quality of the creeks. Implementation of this Project will result in reduced sedimentation and erosion and will therefore improve water quality.

16. Other: Reduced Maintenance Requirements

Inadequate access makes maintenance of Berryessa Creek and its tributaries more difficult, costly and time-consuming. Additionally, these creeks frequently require sediment removal from the channel bottoms to maintain flow capacity, but this process is currently burdened by a lack of suitable access for equipment.

Implementation of this Project will provide improved access and a continuous maintenance road that will facilitate maintenance of the Creek. A properly-sized bankfull channel with a depressed benches constructed in the proper elevation will reduce maintenance activities in the channel in the long-term. In addition, the project will reduce maintenance requirements such as sediment removal and erosion repair work caused by bank failures, and trash and graffiti removal caused by existing blight conditions.

Other Monetized Benefits (D3)

This section describes other benefits (not including the flood reduction benefits described above) that can be monetized for the Berryessa Creek Flood Protection Project. Other monetized benefits include enhanced recreation opportunities associated with development of 6 miles of new trails.

Description of Benefits

The Project will provide the following other monetized benefits.

Enhanced Recreation Opportunities

The proposed Project will construct a maintenance road to accommodate up to 6 miles of multi-use recreational trails, and improvement of the Berryessa Creek Project levees would allow for the extension of a local recreational trail system.

As discussed on pages 7-2 and 7-3 of the GRR Study (Appendix7.I), in less than one mile of the project improvements, over 60,000 people reside, according to tract data of the 2000 Census. Assuming only one in one thousand of these people use the trials per day (60 users per day), and applying the FY12 unit day value for general recreation with a zero point value of $3.72, the value of this benefit is approximately $81,500 / year, as shown in Table 8-17 below.

Summary of Other Monetized Benefits

In addition to the flood damage reduction benefits summarized in section D.1., the proposed Project will construct a maintenance road to accommodate up to 6 miles of multi-use recreational trails, and improvement of the Berryessa Creek Project levees would allow for the extension of a local recreational trail system. As shown in Table 8-17 below (PSP Table 14), the monetary value of this benefit is approximately $81,500 / year, or $4.1 million over the 50-year life of the Project.

Table 8-17. Annual Benefit

Table 14 – Annual Benefit (All benefits are in 2012 dollars) Project: Berryessa Creek Flood Protection Project									
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Year	Type of Benefit	Measure of Benefit (Units)	Without Project	With Project	Change Resulting from Project (e) – (d)	Unit $ Value (1)	Annual $ Value (1) (f) x (g)	Discount Factor (1)	Discounted Benefits (1) (h) x (i)
2012									
2013									
2014									
2015									
2016									
2017									
2018	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2019	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2020	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2021	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2022	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2023	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2024	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2025	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2026	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2027	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2028	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2029	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2030	Recreation	Recreation	0	21,900	21,900	3.72	$81,468	1.000	$81,468

Table 14 – Annual Benefit (All benefits are in 2012 dollars) Project: Berryessa Creek Flood Protection Project									
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Year	Type of Benefit	Measure of Benefit (Units)	Without Project	With Project	Change Resulting from Project (e) – (d)	Unit $ Value (1)	Annual $ Value (1) (f) x (g)	Discount Factor (1)	Discounted Benefits (1) (h) x (i)
		Days							
2031	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2032	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2033	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2034	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2035	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2036	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2037	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2038	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2039	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2040	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2041	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2042	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2043	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2044	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2045	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2046	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2047	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2048	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2049	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2050	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468

Table 14 – Annual Benefit (All benefits are in 2012 dollars) Project: Berryessa Creek Flood Protection Project									
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Year	Type of Benefit	Measure of Benefit (Units)	Without Project	With Project	Change Resulting from Project (e) – (d)	Unit $ Value (1)	Annual $ Value (1) (f) x (g)	Discount Factor (1)	Discounted Benefits (1) (h) x (i)
2051	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2052	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2053	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2054	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2055	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2056	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2057	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2058	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2059	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2060	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2061	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2062	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2063	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2064	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2065	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2066	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2067	Recreation	Recreation Days	0	21,900	21,900	3.72	$81,468	1.000	$81,468
2068									
Total Present Value of Discounted Benefits Based on Unit Value (Sum of the values in Column (j) for all Benefits shown in table)									**$4,073,400**
Comments:									

Project Benefit and Cost Summary (D4)

This section highlights the overall costs and benefits of the Berryessa Creek Flood Protection Project.

Project Costs

Initial and Annual Costs

As shown in Table 8-18 below, the discounted Project cost is estimated to be $71.5 million. This estimate includes all costs associated with construction, administration, operation and maintenance of the project and reflects all the costs required for the Project to achieve its stated benefits. Costs funded by local, State, federal agencies and non-profits are included. The initial costs presented in this table are equivalent to those presented in Attachment 4.

Operations and maintenance costs are estimated to be $159,000, as presented in Table 8-17. These costs include the following:

- Levees: Reduced maintenance costs due to elimination of one levee and more durable materials used for reconstructed levee; savings estimated from elimination of spraying, mowing and rodent control for one levee ($-22,000)
- Sediment Maintenance: Sediment removal from channel at pump station by maintenance crew with light equipment, approximately 5 working days per year ($24,000)
- Vegetation Maintenance: Estimated for potential riparian plantings. Limited maintenance by maintenance crew with light equipment, approximately 60 working days/year ($62,000)
- Floodwalls: Graffiti removal cost estimate based on two, two-person crews, 1 day/month. ($23,000)
- Maintenance Access Roads: No significant increase anticipated ($0)
- Pump Station: No significant increase anticipated ($0)
- Wet well, inlet and outlet: Sediment removal from wet well, inlet and outlet by maintenance crew with light equipment, approximately 5 working days per year ($24,000)
- Building: Basic maintenance of building finishes and fixtures estimated based on 2-persons skilled labor crew, 10 working days/year ($18,000)
- Equipment: Test and exercise pumps monthly by 2-person skilled crew, plus 10 working days/year to service equipment, plus maintenance parts and supplies ($30,000)

Table 8-17. Annual Costs of Project (2012 Dollars)

Table 16 – Annual Costs of Project (All costs are in 2012 Dollars) Project: Berryessa Creek Flood Protection Project										
	Initial Costs Grand Total Cost from Table 6	Adjusted Grant Total Cost[1]	Annual Costs [2]						Discounting Calculations	
			Admin	Ops.	Maint.	Repl.	Other	Total Costs	Disc. Factor	Disc. Costs
Year	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
2012	$350,814	$350,814						$350,814	1.000	**$350,814**
2013	$18,551,079	$18,551,079						$18,551,079	0.943	**$17,501,018**
2014	$18,551,079	$18,551,079						$18,551,079	0.890	**$16,510,395**
2015	$18,551,079	$18,551,079						$18,551,079	0.840	**$15,575,844**
2016	$11,660,269	$11,660,269						$11,660,269	0.792	**$9,236,025**
2017	$11,660,269	$11,660,269						$11,660,269	0.747	**$8,713,232**
2018	$1,080,889	$1,080,889			$159,000			$1,239,889	0.705	**$874,073**
2019	$730,075	$730,075			$159,000			$889,075	0.665	**$591,286**
2020	$730,075	$730,075			$159,000			$889,075	0.627	**$557,817**
2021					$159,000			$159,000	0.592	**$94,112**
2022					$159,000			$159,000	0.558	**$88,785**
2023					$159,000			$159,000	0.527	**$83,759**
2024					$159,000			$159,000	0.497	**$79,018**
2025					$159,000			$159,000	0.469	**$74,545**
2026					$159,000			$159,000	0.442	**$70,326**
2027					$159,000			$159,000	0.417	**$66,345**
2028					$159,000			$159,000	0.394	**$62,590**
2029					$159,000			$159,000	0.371	**$59,047**
2030					$159,000			$159,000	0.350	**$55,705**
2031					$159,000			$159,000	0.331	**$52,552**
2032					$159,000			$159,000	0.312	**$49,577**
2033					$159,000			$159,000	0.294	**$46,771**
2034					$159,000			$159,000	0.278	**$44,123**
2035					$159,000			$159,000	0.262	**$41,626**
2036					$159,000			$159,000	0.247	**$39,270**
2037					$159,000			$159,000	0.233	**$37,047**
2038					$159,000			$159,000	0.220	**$34,950**
2039					$159,000			$159,000	0.207	**$32,972**
2040					$159,000			$159,000	0.196	**$31,105**
2041					$159,000			$159,000	0.185	**$29,345**

Table 16 – Annual Costs of Project

(All costs are in 2012 Dollars)

Project: Berryesssa Creek Flood Protection Project

	Initial Costs Grand Total Cost from Table 6	Adjusted Grant Total Cost[1]	Annual Costs [2]						Discounting Calculations	
			Admin	Ops.	Maint.	Repl.	Other	Total Costs	Disc. Factor	Disc. Costs
Year	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**
2042					$159,000			$159,000	0.174	**$27,684**
2043					$159,000			$159,000	0.164	**$26,117**
2044					$159,000			$159,000	0.155	**$24,638**
2045					$159,000			$159,000	0.146	**$23,244**
2046					$159,000			$159,000	0.138	**$21,928**
2047					$159,000			$159,000	0.130	**$20,687**
2048					$159,000			$159,000	0.123	**$19,516**
2049					$159,000			$159,000	0.116	**$18,411**
2050					$159,000			$159,000	0.109	**$17,369**
2051					$159,000			$159,000	0.103	**$16,386**
2052					$159,000			$159,000	0.097	**$15,458**
2053					$159,000			$159,000	0.092	**$14,583**
2054					$159,000			$159,000	0.087	**$13,758**
2055					$159,000			$159,000	0.082	**$12,979**
2056					$159,000			$159,000	0.077	**$12,244**
2057					$159,000			$159,000	0.073	**$11,551**
2058					$159,000			$159,000	0.069	**$10,898**
2059					$159,000			$159,000	0.065	**$10,281**
2060					$159,000			$159,000	0.061	**$9,699**
2061					$159,000			$159,000	0.058	**$9,150**
2062					$159,000			$159,000	0.054	**$8,632**
2063					$159,000			$159,000	0.051	**$8,143**
2064					$159,000			$159,000	0.048	**$7,682**
2065					$159,000			$159,000	0.046	**$7,247**
2066					$159,000			$159,000	0.043	**$6,837**
2067					$159,000			$159,000	0.041	**$6,450**
Total Present Value of Discounted Costs (Sum of Column (j)) Transfer to Table 17, column (c), Proposal Benefits and Costs Summaries										**$71,465,642**

Comments:

Cost Guidelines and Assumptions

The above-mentioned costs were developed in accordance with PSP requirements:

- **Consistency:** The economic analysis is consistent with the grant requirements, uses the total project costs as provided in Attachment 4.
- **Period of Analysis.** The initial costs presented in Table 8-18 are consistent with the projected construction schedule for the Berryessa Creek Flood Protection Project (shown in Attachment 5), and reflect start of construction activities in 2013 and the completion of construction activities in 2017. The operational life of the Project is assumed to be 50 years, which is consistent with most flood protection projects.
- **Economic Cost.** The economic cost of the total Project as presented in Attachment 4 considers all reasonably foreseeable costs including opportunity costs.
- **Sunk Costs.** No sunk costs have been eliminated from the initial costs.
- **Opportunity Costs.** All opportunity costs are accounted for including previous construction costs incurred since October 2008.
- **Discount Rate.** In accordance with PSP requirements, a 6% discount rate was applied.
- **Dollar Value.** In accordance with PSP requirements, all costs are presented in 2012 dollars.

Project Benefit and Cost Summary

Table 8-18 (PSP Table 17) presents a summary of the Proposal Benefits and Costs. A more detailed discussion of these costs and benefits is provided in the preceding sections.

Table 8-18. Proposal Benefits and Costs Summary

Table 17 – Proposal Benefits and Costs Summary

Proposal: Berryessa Creek Flood Protection Project

Agency: Santa Clara Valley Water District

Project	Project Proponent	Total Present Value Project Costs (1)	Total Present Value Project Benefits			From Section D2 – Briefly describe the main Non-monetized benefits
			From Section D2 – Flood Damage Reduction (2)	From Section D3 – Monetized (3)	Total	
(a)	(b)	(c)	(d)	(e)	(f) = (d) + (e)	(g)
Berryessa Creek Flood Protection Project	Santa Clara Valley Water District	$71,465,642	$98,334,835	$4,073,400	$102,408,235	The project will: Provide for improved fish passage and habitat enhancement, improve water quality, reduce maintenance requirements, and im prove public health and safety
Total		$71,465,642	$98,334,835	$4,073,400	$102,408,235	

(1) From Table 16 or RWMG method

(2) From Table 12 or RWMG method

APPENDIX 8-1: Draft General Re-Evaluation Report and Environmental Impact Statement / Environmental Impact Report

(Appendix C: Economics provided in hard copy; full report including Appendix C provided on Attached CD as Att8_SWF_BenCost_2of2)

Berryessa Creek Project

Santa Clara County, California

Appendix C

Economics

TETRA TECH

MAY 2012

BERRYESSA CREEK PROJECT
APPENDIX C, ECONOMICS

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CHAPTER 1: INTRODUCTION

1.1 Purpose and Scope

The purpose of this report is to present the results of the economic analysis performed for the General Reevaluation study of the Berryessa Creek Project. The report documents the reevaluation of benefits and costs of the authorized project in comparison with potential changes in design, benefits, and costs for a modified project and alternative plans. This information is necessary to determine the extent of Federal interest in a modified or new plan for flood damage reduction along Berryessa Creek. The report presents findings related to flood risk, potential flood damages and potential flood damage reduction benefits.

1.2 Study Area

The study area is located in Santa Clara County California. Berryessa creek runs through the cities of Milpitas and San Jose, an urbanized alluvial plain that includes a diverse mix of residential, commercial, industrial, and public land uses. The population of Milpitas and San Jose are 67,476 and 958,789 respectively (source: California Department of Finance, E-1 May 2011.) The area is part of California's Silicon Valley, with many computer, bio-tech and hi-tech firms located in the area.

1.3 History of Flooding

Recent flood events from Berryessa Creek include March 1982, January 1983 and February 1998. It was reported that the 1998 event caused minor damages to homes and automobiles but dollar losses were not documented. No non-residential structure losses were reported from these events. Specific frequency was not identified for floods within the study area but each noted event was believed to be smaller than the 0.10 exceedance probability event.

1.4 Consistency with Regulations and Policies

This economic analysis is in accordance with standards, procedures, and guidance of the U.S. Army Corps of Engineers. The Planning Guidance Notebook (ER 1105-2-100, April 2000) serves as the primary source for evaluation methods of flood damage reduction studies and was used as reference for this analysis. Additional guidance for risk-based analysis was obtained from EM 1110-2-1619, *Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies (August 1996)* and ER 1105-2-101, *Planning - Risk Analysis for Flood Damage Reduction Studies (January 2006)*.

1.5 Price Levels, Period of Analysis, and Discount Rate

Unless otherwise noted, all values in this document are presented in October 2011 prices, and amortization calculations are based on the Fiscal Year 2012 federal discount rate of 4 percent

as published in Corps of Engineers Economic Guidance Memorandum 12-01. Economic evaluation was performed over a 50-year period of analysis.

CHAPTER 2: FLOODPLAIN AREA AND INVENTORY

2.1 Economic Data Area

The study area was divided into six economic impact areas for economic evaluation and project performance purposes. Delineations were made to address changes in hydrology, hydraulics and economic conditions throughout the creek. A map showing the six impact areas is shown in Figure 2.1. A comparison of the impact areas to the linear study reaches is provided in Figure 2.2.

- Area A lies farthest east and runs from Old Piedmont to the intersection of Cropley Avenue and Piedmont Road. The area consists of single family residences.

- Area B includes Cropley Avenue and runs along the right bank from Piedmont to Morrill Avenue. The area is primarily residential.

- Area C runs along the left bank just past Majestic Elementary and Berryessa Creek Park downstream just east of Morrill. The area is primarily residential.

- Area D runs from Morrill to the I-680 Freeway. This area in San Jose is primarily residential.

- Area E is the largest impact area in the study and begins just west of I-680. The area is bounded by Capitol Avenue, Abel Street and Berryessa Creek. This area includes the Midtown region of Milpitas and includes residential, commercial, public and industrial land uses.

- Area F runs along a short section of the left bank of Berryessa from Yosemite Drive to near Los Coches Street and east of WP railroad line. This impact area is highly industrial with many hi-tech firms in addition to some commercial and limited residential.

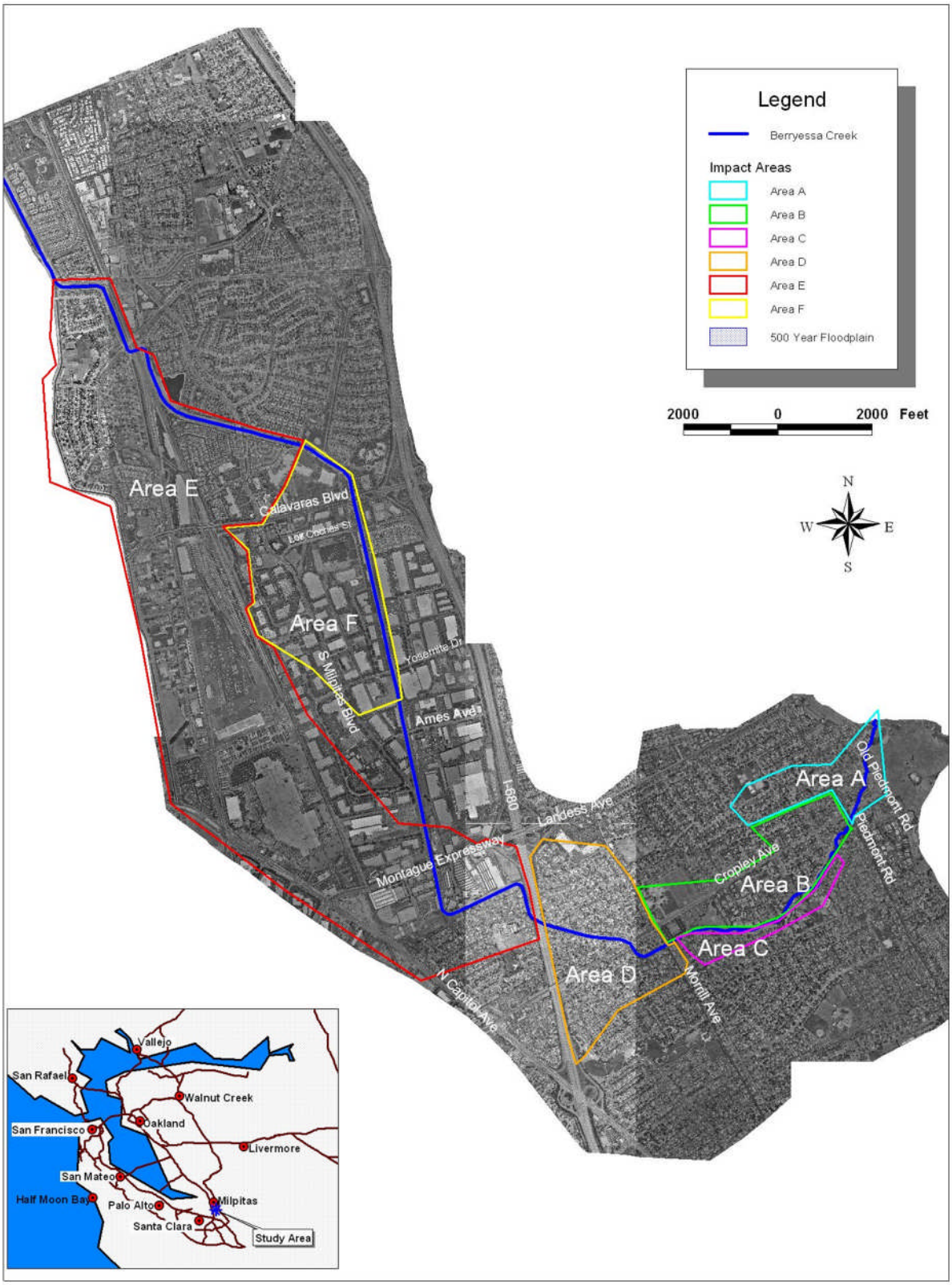

Figure 2.1 Economic Impact Areas

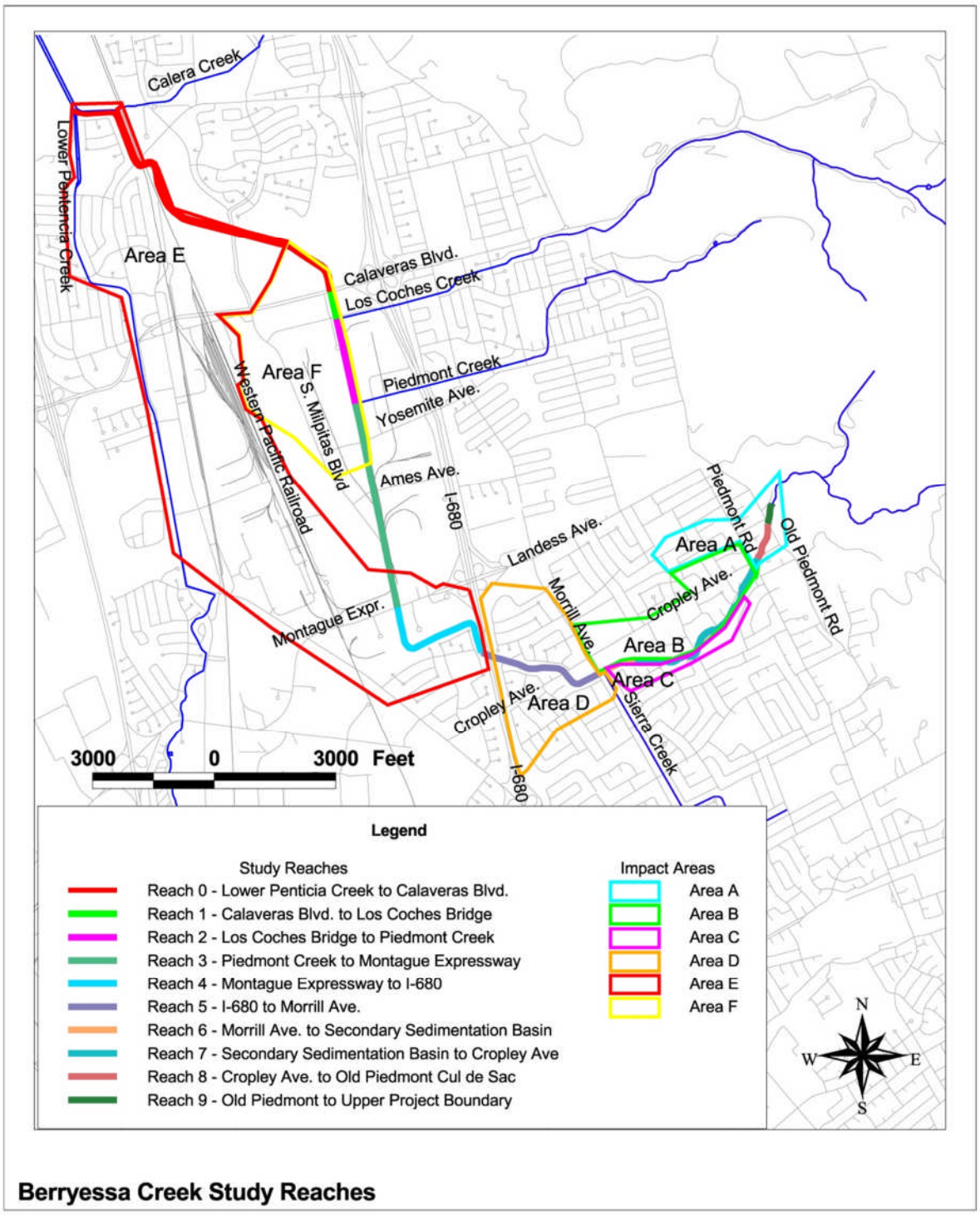

Figure 2.2 Study Reach and Impact Area Locations

2.2 Inventory of Structures and Property in Study Area

A structural inventory was previously completed based on data gathered from assessor's parcel data and on-site inspection of all the structures (100%) within the floodplain. Structures were determined to be within the economic study area by using Geographical Information Systems (GIS) to compare the 0.002 exceedance probability floodplain boundary with the spatially referenced assessor parcel numbers (APN). The inventory was developed in accordance with Section 308 of WRDA 1990. Information from the assessor's parcel database (such as land use, building square footage, address) was supplemented during field visitation for each parcel within the floodplain to collect additional required data such as, foundation height, specific business activity (non-residential), building condition, type of construction, number of units. Parcels with structures, were categorized by land use and grouped into the following structural damage categories:

1) **Single Family Residential** – includes all parcels represented by a single unit such as detached single family homes, individually owned condominiums and townhouses.
2) **Multiple Family Residential** – includes residential parcels with more than one unit such as apartment complexes, duplexes and quadplex units. Each parcel may have multiple structures.
3) **Commercial** – includes retail, office buildings, restaurants
4) **Industrial** – includes warehouses, light and heavy manufacturing facilities. Also includes many computer and bio-tech industries that are in the Milpitas area.
5) **Public** – includes both public and semi-public uses such as post offices, fire stations, government buildings, schools and churches.

All parcels with structures were assigned to one of the listed categories. Some parcels have more than one physical structure and some structures, such as condominiums, are represented by multiple parcels. Table 2.1 displays the total number of parcels (number of units for multifamily residential) with structures by category.

Table 2.1 Structural Inventory

Number of Parcels With Structures within the 0.002 Exceedance Probability Floodplain By Land Use							
Economic Impact Area	**Single Family Residential**	**Multiple Family Residential Units**	**Commercial**	**Industrial**		**Public**	**Total**
				General	**Tech**		
Area-A	64	0	0	0	0	0	64
Area-B	96	287	0	0	0	1	384
Area-C	14	0	0	0	0	0	14
Area-D	378	105	0	0	0	0	483
Area-E	723	1,110	95	22	17	15	1,982
Area-F	1	0	14	8	25	4	52
Total	**1,276**	**1,502**	**109**	**30**	**42**	**20**	**2,979**
Number of Parcels With Structures within the 0.010 Exceedance Probability Floodplain By Land Use							
Area-A	35	0	0	0	0	0	35
Area-B	77	257	0	0	0	1	335
Area-C	12	0	0	0	0	0	12
Area-D	231	26	0	0	0	0	257
Area-E	589	1,050	82	22	16	13	1,772
Area-F	1	0	14	8	25	4	52
Total	**945**	**1,333**	**96**	**30**	**41**	**18**	**2,463**

In total there are 1,000 more units at risk than shown in the 1987 Feasibility report. The biggest difference is multi-family residences that have increased in the area.

2.3 Value of Damageable Property - Structure Value

The value of property at risk was estimated based on depreciated replacement values (DRV). Structure value was determined based on the following function:

DRV = Square Footage * Cost per Square Foot * Depreciation Factor

Evaluations of Corps flood damage reduction projects require structures be valued using replacement costs minus depreciation. These values may differ from assessed values, sales or market values, reproduction costs or values determined by income capitalization. Depreciated replacement cost does not include land values and market prices (which include land value) or sale price for homes and commercial property would be higher than the value of the depreciated structure alone.

Building characteristics such as quality type, condition, number of stories were gathered for each parcel. Square footage representing the building area was taken from assessor's parcel data for each structure. Values for cost per square foot were determined based on land use, building type, construction class and quality.

Values were taken from the Marshall and Swift (M&S) Valuation Service and were adjusted using the M&S local multipliers for San Jose to account for the higher construction costs found in the Milpitas/San Jose area. Factors such as the year the structure was built, overall condition of the building, improvements, required maintenance and comparative data from of other studies were used in determining the subjective measure of how much depreciation to assign each structure.

In the database, each structure was assigned a mean remaining value percentage (100% replacement minus estimated percent depreciated) to be used in determining depreciated replacement value. The range of depreciation varied with each structure and land use with new structures assigned zero depreciation and a maximum of 60% for a few structures in poor condition.

Uncertainty in remaining percent value was determined to be a triangular distribution with minimum and maximums set at plus or minus 10% not to exceed 100% total value. Examples of a typical structure valuation by damage category using median values found in this study are shown in Table 2.2. These values are displayed to explain the methodology used but do not represent any particular structure or mean values within the study.

Table 2.2 Valuation Example

Depreciated Replacement Value, October 2011 Prices Using Typical Structures by Category					
Structure Category	**Square Footage**	**Price Per Square Foot (locally adjusted)**	**Estimated Depreciation Percentage**	**Remaining Value Percentage**	**Depreciated Replacement Value of Typical Structure**
	Using Median Values By Category				
Single Family Residential	1,480	$144.08	15%	85%	181,247
Multiple Family Residential Units	1,900	$96.41	30%	70%	128,219
Commercial	4,680	$144.74	15%	85%	575,759
Industrial	11,870	$147.49	15%	85%	1,488,051
Public	10,000	$182.52	10%	90%	1,642,674

2.4 Value of Damageable Property- Content Value

In addition to structures, building contents can also be at risk of flood damages. For this study, content values were estimated as a percentage of depreciated structure value based on land use. During the 1992 General Design Memorandum (GDM) on Berryessa Creek, detailed content surveys were made to determine content percentages specific to the Milpitas/San Jose area. For this general reevaluation study, additional content surveys were completed to confirm or adjust values used in the original study.

The survey requested identification of business activity, square footage or known value of the building, total value of content or ratio content to structure value if known. The survey also asked respondents to provide estimated loss of contents for various theoretical floods. As no known flood events have occurred in the study area resulting in non-residential damage, responses were limited to best guess estimates. Based on these survey results, the 1992 GDM content percentages are considered to be reasonable. Minor adjustments were made to the industrial category (sub-divided for content analysis only in this study as Industrial-General and Industrial-Tech) to represent the recent surveys. The industrial-tech content category includes computer component manufacture and distribution, and bio-technology commonly found in the San Jose/Milpitas area. Both content values and percent losses were greater for the industrial-tech than typical industrial activities, which is why industrial content losses were separated for this analysis. The sub-categories for commercial business only differ in the assigned content percentages (does not affect structure depth-damage functions). Content percentages by sub-category are given in Table 2.3.

Table 2.3 Content to Structure Ratios

Structure Sub-Category	Content Percent of Structure Value
Commercial-Food	130 %
Commercial-Office	50 %
Commercial-Retail	100 %
Commercial-Restaurants	75 %
Commercial- Department Stores	150 %
Industrial-General	131 %
Industrial- Tech	187 %
Public	45 %
Residential	50 %

Total value of damageable property is comprised of the structural and content values described for the parcels within the 0.002 exceedance probability floodplain. Table 2.4 shows the total structure and content values by category and economic impact area. In total, the study area has just under $2.3 billion worth of estimated damageable property. Total value of over $1 billion for structures within the floodplain is over eight times the value found in the 1987 Feasibility study. Factors leading to these increases include: additional structures, general increases in valuation from 1986 to 2011, improvements in existing structures and increased labor and construction costs in the area.

Table 2.4 Value of Damageable Property

Within the 0.002 Exceedance Probability Floodplain Values in $ Millions, October 2011 Prices							
Structure Category	**Area-A**	**Area-B**	**Area-C**	**Area-D**	**Area-E**	**Area-F**	**Total**
SFR-Structure	11.7	17.6	2.4	63.3	123.3	0.4	218.7
SFR-Content	5.8	8.8	1.2	31.7	61.7	0.2	109.4
MFR-Structure	0.0	27.3	0.0	11.4	224.6	0.0	263.3
MFR-Content	0.0	13.6	0.0	5.7	112.3	0.0	131.6
Commercial-Structure	0.0	0.0	0.0	0.0	227.6	30.6	258.2
Commercial-Content	0.0	0.0	0.0	0.0	246.0	29.1	275.1
Industrial-General Structure	0.0	0.0	0.0	0.0	74.1	30.9	105.0
Industrial-Tech Structure	0.0	0.0	0.0	0.0	82.5	161.0	243.5
Industrial- General Content	0.0	0.0	0.0	0.0	97.1	40.4	137.5
Industrial-Tech Content	0.0	0.0	0.0	0.0	154.3	301.1	455.4
Public- Structure	0.0	8.3	0.0	0.0	30.3	14.2	52.8
Public- Content	0.0	3.7	0.0	0.0	13.6	6.4	23.7
Total Value	**17.5**	**79.3**	**3.6**	**112.1**	**1,447.4**	**614.3**	**2,274.2**

CHAPTER 3: METHODOLOGIES, DEPTH-DAMAGE RELATIONSHIPS AND FLOODING CHARACTERISTICS

3.1 Economic HEC-FDA Model and Application of Floodplain Data

The Hydrologic Engineering Center's HEC-FDA model (version 1.2.4, FRM-PCX certified model) was used to perform the economic damage and benefits analyses. More detailed descriptions about the capabilities of HEC-FDA model and how it was used are provided in the following paragraphs.

The HEC-FDA model was used to integrate the engineering data (hydrologic, hydraulic, and geotechnical), compute stage-damage curves using specially-formatted output data, and compute initial AEP and EAD results under without-project and with-project conditions.

For structure and content damages, depth of flooding relative to the structure's first floor is the primary factor in determining the magnitude of damage. Unlike previous economic analyses for the study area, the current analysis utilizes HEC-FDA's internal processes for the determination of structural inundation. The HEC-FDA process combined a GIS database, provided by Santa Clara Valley Water District, containing spatially referenced polygons for each parcel in the study area with water surface elevations from Flo2D modeling.

A ground elevation was assigned to the centroid of each parcel using GIS for the study. Foundation heights, determined during field visitation, were added to the assigned ground elevation to establish first floor elevations. Water surface elevations (WSE) from the Flo2D model were provided in the form of grid cells for the 0.500, 0.200, 0.100, 0.040, 0.020, 0.010, 0.005, and 0.002 exceedance probability events. Parcels were then correlated with the grid cell in which the centroid laid. Flooding depths in general were rather shallow with very few structures facing depths greater than 3 feet and an average of one foot above ground elevation for the largest event

3.2 Computation of Stage-Damage Curves within the HEC-FDA Model

For the suite of floodplains, WSE floodplain data was formatted so that the floodplains could be directly imported into the HEC-FDA model as a water surface profile. The formatted files contained every grid cell that contained a structure and the water surface elevations in each grid cell for each frequency event. The suite of floodplains along with the imported structure inventory was used in HEC-FDA to compute stage-damage curves.

Instead of using river station numbers, assignment of water surface elevations by frequency event were completed using grid cell numbers; the grid cell assignments represent actual floodplain water surface elevations by frequency event rather than in-channel water surface elevations. Once the formatted floodplain data were imported into HEC-FDA, a row was inserted at the top of the WSP which included the in-channel stages associated with the index point (for a particular impact area). This step allowed for the linkage between the 2-

dimensional floodplain data and the in-channel stages. Importing formatted floodplain data and assigning water surface elevations to grid cells eliminated the need for creating interior-exterior relationships, which is another way to link exterior (river) stages to interior (floodplain) stages within HEC-FDA.

3.3 Depth-Damage Relationships

Damages to structures and contents were determined based on depth of flooding relative to the structure's first floor elevation. To compute these damages, depth damage curves were developed. These curves assign loss as a percentage of value for each parcel. The deeper the relative depth, the greater the percentage of value damaged. The sources of the relationships were different depending on land use. For single family residential structures and contents, depth damage curves were taken from Economic Guidance Memorandum EGM 01-03, *Generic Depth Damage Relationships*. For the other (non-single family residential) structure categories, the damage curves were based on 1998 FEMA Flood Insurance Administration data with the exception of the industrial content curves. For industrial content, the depth damage curves used in the original Corps study were modified based on the current survey responses (see Section 2.4). The resultant depth damage curves are shown in Table 3.1 by category.

Table 3.1 Depth Damage Curves

Damage Category	Depth of Flooding – Above First Floor in Feet						
	-1	0	1	2	3	4	5
Percent Damage of Structure Value							
Commercial 1-Story	0 %	7.0 %	16.3 %	24.7 %	27.7 %	29.6 %	30.9 %
Commercial 2-Story	0 %	5.0 %	9.9 %	13.4 %	18.0 %	20.0 %	22.0 %
Industrial Gen 1-Story	0 %	7.0 %	16.0 %	25.0 %	28.0 %	30.0 %	31.0 %
Industrial Gen 2-Story	0 %	5.0 %	10.0 %	13.0 %	18.0 %	20.0 %	22.0 %
Industrial Tech 1-Story	0 %	7.0 %	16.0 %	25.0 %	28.0 %	30.0 %	31.0 %
Industrial Tech 2-Story	0 %	5.0 %	10.0 %	13.0 %	18.0 %	20.0 %	22.0 %
Public 1-Story	0 %	7.0 %	16.3 %	24.7 %	27.7 %	29.6 %	30.9 %
Public 2-Story	0 %	5.0 %	9.9 %	13.4 %	18.0 %	20.0 %	22.0 %
Residential 1-Story SF	0 %	13.4 %	23.3 %	32.1 %	40.1 %	47.1 %	53.2 %
Residential 2-story SF	0 %	9.3 %	15.2 %	20.9 %	26.3 %	31.4 %	36.2 %
Residential 2-Story Apt	0 %	9.3 %	15.2 %	20.9 %	26.3 %	31.4 %	36.2 %
Percent Damage of Content Value							
Commercial 1-Story	0 %	0 %	22.8 %	49.5 %	64.7 %	91.2 %	100.0 %
Commercial 2-Story	0 %	0 %	19.1 %	31.4 %	35.6 %	45.1 %	50.0 %
Industrial Gen 1-Story	0 %	0 %	35.2 %	64.2 %	74.8 %	91.8 %	96.3 %
Industrial Gen 2-Story	0 %	0 %	29.6 %	40.8 %	41.2 %	45.9 %	48.1 %
Industrial Tech 1-Story	0 %	0 %	35.2 %	64.2 %	74.8 %	91.8 %	96.3 %
Industrial Tech 2-Story	0 %	0 %	29.6 %	40.8 %	41.2 %	45.9 %	48.1 %
Public 1-Story	0 %	0 %	22.8 %	49.5 %	64.7 %	90.2 %	100.0 %
Public 2-Story	0 %	0 %	19.1 %	31.4 %	35.6 %	45.1 %	50.0 %
Residential[1] 1-Story SF	0 %	16.2 %	26.6 %	35.8 %	44.0 %	51.4 %	57.6 %
Residential[1] 2-story SF	0 %	10.0 %	17.4 %	24.4 %	31.0 %	37.0 %	42.6 %
Residential 2-Story Apt	0 %	5.0 %	8.7 %	12.2 %	15.5 %	18.5 %	21.3 %

[1] The EGM 01-03 curves estimate content damages as a direct function of structure value. The percentages listed in this table assume content value at 50% of structure value and percentages have been modified accordingly.

CHAPTER 4: DAMAGES BY EVENT

4.1 Damage Estimation

As previously referenced, damages were estimated within HEC-FDA employing its full function of relating structure inventory data with water surface elevations by exceedance probability events. Structure values for insertion into HEC-FDA, as mentioned in Section 2.3, were determined as a function of Marshall Valuation Service values per square foot, square footage and estimated depreciation. To estimate the uncertainty in structure valuation, triangular distributions for each of these parameters were set in the model.

4.2 Economic Uncertainty Parameters

Many of the factors that determine flood damages can be represented by a range of values instead of a single number. Errors in measurement, variation in classification and judgment can lead to differences in values. For this study, in accordance with EM 1110-2-1619, uncertainties in the following parameters were considered in the HEC-FDA damage estimation:

- Structure Value
- Content Ratio
- First Floor Elevation
- Depth-Damage Percentage

For all structure occupancy types within HEC-FDA errors with the following were normally distributed with means of:

- Structure Value = 12 %
- Content to Structure Value = 12 %
- First Floor Stage = 0.1 feet

Uncertainty in first floor elevation was based on topography used in both the hydraulics and structural analysis. The standard deviation of first floor elevation was estimated at 0.1 feet in accordance with EM 1110-2-1619.

For single family residential depth-damage functions, uncertainties were based on the standard deviations provided in EGM 01-03 (varies by depth, with a maximum of 5%). Uncertainties for depth-damage percentages for commercial, industrial and public structures were triangular error functions based on prior Sacramento District studies.

4.3 Other Damage Categories

In addition to damages directly related to structures and their contents, losses were estimated for other categories such as damages to automobiles and emergency costs. While economic uncertainties for these damage categories are not specifically identified or required in EM 1110-2-1619, uncertainty parameters for these categories were included in this study.

Losses to automobiles were determined as a function of the number of vehicles per residence, average value per automobile, estimated percentage of autos removed from area prior to inundation, and depth of flooding above the ground elevation. Depth-damage relationships for autos were taken EGM 09-04. Source of vehicle counts per housing unit were taken from the US Census 2000 (San Jose and Milpitas averages). Evacuation (autos moved out of the flooded area) was assumed to be a triangular distribution with the most likely value set at 50%. Assumption is that there are many factors that could determine ability to evacuate and 50% has been used as an average on most Sacramento District studies. Depreciated replacement value of autos was based on average used car prices (taken from prior studies and updated using Bureau of Labor Statistics CPI-Used Vehicles) and was set at $12,250. This value within HEC-FDA was assumed to be normally distributed with a standard deviation of 30%.

Emergency costs were estimated for the relocation and emergency services provided for those displaced both during the peak flood event and during post-flood structural renovations. Duration of services was formulated for two groups: short-term- residents evacuated for the duration of the flood but able to stay in the home once the flood recedes, and long-term- occupants displaced from the home due to inundation requiring repair and decontamination prior to return. Losses per resident per day were taken from prior Sacramento District studies (Napa River, South Sacramento County Streams) with a mean of $12 per day. Long-term dislocation was estimated based on a triangular distribution with the most likely value set at 45 days. Occupants per residential unit were taken from the US Census 2000 for the Milpitas area. Based on these estimates, a residence inundated above the first floor requiring repair would face an average $1,950 in total emergency costs which is reasonable for the magnitude of flooding in the study area and is less than the national FEMA average for temporary rental and public assistance.

4.4 Stage-Damage Functions

Base damages (calculations without uncertainty or reflecting levees and channel tops) were estimated by the HEC-FDA model for each category by impact area and by event based on varying depths within the floodplain relative to individual structures. These damages are contained in the output file *FDA_StrucDetail.out* for each impact area displayed in the following tables.

Table 4.1 Stage-Damage Functions Impact Area A

Damages in $1,000's, October 2011 Prices					
Damage Category	**Exceedance Probability of Event Followed By Corresponding Stage (elevation in feet)**				
	0.040	**0.020**	**0.010**	**0.005**	**0.002**
	216.88	**219.26**	**220.15**	**221.39**	**222.31**
Single Family Residential	87	159	707	1,191	1,350
Multi-Family Residential	0	0	0	0	0
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Public	0	0	0	0	0
Automobile	12	19	76	130	144
Emergency	4	5	13	16	20
Total	**103**	**183**	**796**	**1,337**	**1,514**

Table 4.2 Stage-Damage Functions Impact Area B

Damages in $1,000's, October 2011 Prices					
Damage Category	**Exceedance Probability of Event Followed By Corresponding Stage (elevation in feet)**				
	0.040	**0.020**	**0.010**	**0.005**	**0.002**
	147.49	**147.69**	**147.74**	**147.81**	**147.83**
Single Family Residential	0	933	2,410	3,093	3,504
Multi-Family Residential	835	2,552	4,097	5,212	5,829
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Public	0	0	29	1,003	1,620
Automobile	81	445	970	1,310	1,580
Emergency	26	197	387	493	594
Total	**942**	**4,127**	**7,893**	**11,111**	**13,127**

Table 4.3 Stage-Damage Functions Impact Area C

Damages in $1,000's, October 2011 Prices					
Damage Category	**Exceedance Probability of Event Followed By Corresponding Stage (elevation in feet)**				
	0.040	**0.020**	**0.010**	**0.005**	**0.002**
	146.70	**146.89**	**146.91**	**146.93**	**146.94**
Single Family Residential	10	28	197	244	325
Multi-Family Residential	0	0	0	0	0
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Public	0	0	0	0	0
Automobile	0	3	21	27	35
Emergency	0	0	3	7	8
Total	**10**	**31**	**221**	**278**	**368**

Table 4.4 Stage-Damage Functions Impact Area D

Damages in $1,000's, October 2011 Prices					
Damage Category	**Exceedance Probability of Event Followed By Corresponding Stage (elevation in feet)**				
	0.040	**0.020**	**0.010**	**0.005**	**0.002**
	147.49	**147.69**	**147.74**	**147.81**	**147.83**
Single Family Residential	253	1,019	4,534	9,726	13,797
Multi-Family Residential	0	0	382	1,637	2,857
Commercial	0	0	0	0	0
Industrial	0	0	0	0	0
Public	0	0	0	0	0
Automobile	18	81	627	1,640	2,548
Emergency	3	11	151	415	630
Total	**274**	**1,111**	**5,694**	**13,418**	**19,832**

Table 4.5 Stage-Damage Functions Impact Area E

Damages in $1,000's, October 2011 Prices					
Damage Category	**Exceedance Probability of Event Followed By Corresponding Stage (elevation in feet)**				
	0.040	**0.020**	**0.010**	**0.005**	**0.002**
	64.50	**64.71**	**64.86**	**65.01**	**65.07**
Single Family Residential	2,076	4,700	12,538	20,529	25,199
Multi-Family Residential	0	661	5,007	6,749	9,849
Commercial	2,584	5,516	9,622	14,069	22,190
Industrial	3,539	8,499	15,771	22,612	26,822
Public	96	428	1,074	2,476	3,885
Automobile	265	848	2,474	4,076	5,015
Emergency	10	105	446	867	1,101
Total	**8,570**	**20,757**	**46,932**	**71,378**	**94,061**

Table 4.6 Stage-Damage Functions Impact Area F

Damages in $1,000's, October 2011 Prices					
Damage Category	**Exceedance Probability of Event Followed By Corresponding Stage (elevation in feet)**				
	0.040	**0.020**	**0.010**	**0.005**	**0.002**
	38.13	**38.21**	**38.31**	**38.33**	**38.35**
Single Family Residential	0	0	0	40	40
Multi-Family Residential	0	0	0	0	0
Commercial	734	1,424	2,882	3,508	3,812
Industrial	46,679	57,869	71,041	86,511	93,074
Public	486	507	1,134	1,368	1,385
Automobile	0	0	0	0	0
Emergency	0	0	0	0	0
Total	**47,899**	**59,800**	**75,057**	**91,427**	**98,311**

CHAPTER 5: FUTURE ECONOMIC DEVELOPMENT

5.1 Midtown Redevelopment

The city of Milpitas currently has a redevelopment plan for Midtown area, with some of the land lying within economic impact area E of this study. Primarily along the South Main and Abel Street corridors, the plan calls for renovation of many of the existing buildings and new high density residential and commercial construction on existing vacant acres near light rail and proposed BART stations. This area is the only portion of the study floodplain identified for future growth. Development is projected to be complete by 2020.

5.2 Vacant Acres and Proposed Land Use

Land use plans for the Midtown area were taken from the Milpitas Midtown Specific Plan (MMSP) (April 2002) and were compared with vacant parcels within the impact area. The MMSP identifies location specific use and density. Nearly fifty acres were identified for residential ranging from medium to very high density multi-family. Most of the commercial redevelopment involved existing structures but parcels were identified with just over seven vacant acres for new commercial. Based on these acreages and densities found in the MMSP, about 1,900 of the Midtown's proposed 4,800 residential units could be in the floodplain and around 83,000 square feet of new commercial buildings. Values per square foot were taken from M&S by structure type and structure values were determined based on the estimated square footage (without any depreciation). With over 2,000,000 square feet of additional multi-family units, future residential structures were estimated at over $200 million. Future commercial structures were valued just over $10 million. Total additional value to the future inventory of damageable property was estimated to be over $320 million including both residential and commercial structure and content.

5.3 Inundation Damages – 100-year Event

In accordance with Corps guidance (reference ER-1105-2-100 paragraph E-19j), no structural damages were estimated for future development from the 100-year event. The analysis assumes that all construction would have ground elevations raised one foot above the 100-yr water surface elevation and typical construction would occur over this elevation for commercial and residential structures in compliance with this guidance.

CHAPTER 6: EXPECTED ANNUAL DAMAGES – WITHOUT-PROJECT CONDITIONS

6.1 HEC-FDA Model

Expected annual damages were estimated using the US Army Corps of Engineers risk-based Monte Carlo simulation program called HEC-FDA. The HEC-FDA program integrates hydrology, hydraulics, geo-technical 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. The Berryessa Creek model includes the following relationships for each economic impact area:

- Probability-Discharge (with uncertainty determined by period of record)
- Stage-Discharge (stage in the channel with estimated error in feet)
- Stage-Damage (computed internally within HEC-FDA)

These relationships for each economic impact area are shown in Attachment A of this economic appendix. The hydrologic and hydraulic data was provided by study team members and included in the HEC-FDA model.

6.2 Estimation of Expected Annual Damages

HEC-FDA integrates the probability-discharge, stage-discharge and stage-damage relationships to determine a probability-damage function. Expected annual damages (EAD) are calculated as the numerical integration of the area under the probability-damage curve. The dotted lines in the Figure 6.1 below represent the uncertainty band around each relationship with EAD represented as the area under a range of simulated damage-probability curves.

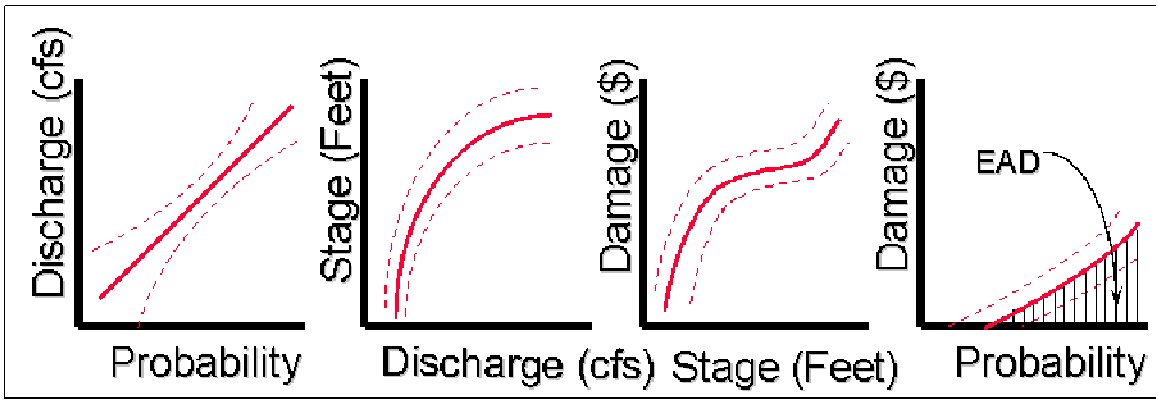

Figure 6.1 Uncertainty in Discharge, Stage and Damage in Determination of Expected Annual Damages

The derived probability damage function from the HEC-FDA model for each impact area is provided in Table 6.1. These damage values differ from the calculated damages by event shown in the stage-damage curves due to uncertainties in each relationship.

Table 6.1 Without-Project Probability Damage Functions – HEC-FDA Model

October 2011 Prices, in $ 1,000's						
Exceedance Probability	Total Damages by Economic Impact Area					
	A	B	C	D	E	F
0.200	0	0	0	0	0	0
0.100	0	221	11	116	0	0
0.050	0	11,423	506	13,475	4,522	0
0.040	0	15,046	659	18,765	15,843	0
0.020	171	22,292	967	29,346	141,546	102,657
0.015	333	24,104	1,043	31,991	228,245	157,756
0.010	837	25,916	1,120	34,636	314,944	212,855
0.004	1,447	28,089	1,212	37,810	418,983	278,974
0.002	2,897	28,814	1,243	38,868	453,662	301,014
0.001	4,333	29,176	1,258	39,397	471,002	312,034

EAD, under existing without project conditions, was estimated for each damage category for all six impact areas. Results are summarized in the Table 6.2 below.

Table 6.2 Expected Annual Damages Existing Without-Project Conditions

October 2011 Prices, Values in $ 1,000's							
Damage Category	**EAD by Economic Impact Area**						
	A	**B**	**C**	**D**	**E**	**F**	**Total**
Single Family Residential	19.98	282.42	36.64	1,007.51	987.17	3.25	2,336.97
Multi-Family Residential	0.00	453.46	0.00	177.80	517.77	0.00	1,149.03
Commercial	0.00	0.00	0.00	0.00	1,370.11	373.61	1,743.72
Industrial	0.00	0.00	0.00	0.00	1,791.86	6,071.19	7,863.05
Public	0.00	133.04	0.00	0.00	166.05	118.19	417.28
Automobile	2.28	136.08	4.24	184.97	251.31	0.12	579.00
Emergency	0.46	49.77	1.09	47.00	42.95	0.00	141.27
Total EAD	22.72	1,054.77	41.97	1,417.28	5,127.22	6,566.36	14,230.32

6.3 EAD Future Conditions

Future development was estimated out to the year 2020, representing full build-out for the Milpitas Midtown area (see Chapter 5). Future developments for this area were entered into the HEC-FDA model and EAD values were calculated for the future without project economic condition. Future hydrology was evaluated in hydrology and hydraulic studies, which concluded that the change in flow would be insignificant. Therefore, all increases in EAD under future conditions were attributable to future growth. Existing and future EAD estimates for the area of development are displayed in Table 6.3. The average annual equivalent represents the present value of future damages amortized over the 50 year period of economic analysis at the fiscal year 2012 federal discount rate of 4.0%. The increased (future at full build out) damages need to be brought back to the study year of 2011 in present value terms. Total EAD future (2020) listed in Table 6.3 is amortized over the period of analysis to arrive at average annual equivalent damages. The closer the growth is in timeline to the base year the less discounting occurs. More time between base year and most likely future the greater the discounting.

Table 6.3 Average Annual Equivalent Damages Future-Without Project Conditions

Values in $ 1,000's, October 2011 Prices 50-Year Period of Analysis				
Damage Category	**Expected Annual Damages**			**Average Annual Equivalent @ 4.0%**
	Existing	**Future Midtown (2020)**	**Total EAD Future (2020)**	
Single Family Residential	987.17	0.00	987.17	987.17
Multi-Family Residential	517.77	156.82	674.59	642.86
Commercial	1,370.11	5.71	1,375.82	1,374.67
Industrial	1,791.86	0.00	1,791.86	1,791.86
Public	166.05	0.00	166.05	166.05
Automobile	251.31	0.00	251.31	251.31
Emergency	42.95	0.00	42.95	42.95
Total EAD	5,127.22	162.53	5,289.75	5,256.87

6.4 Project Performance- Without Project Conditions

In addition to damages estimates, HEC-FDA reports flood risk in terms of project performance. Three statistical measures are provided, in accordance with ER 1105-2-101, to describe performance risk in probabilistic terms. These include annual exceedance probability, long-term risk, and conditional non-exceedance probability by events.

- Annual exceedance probability measures the chance of having a damaging flood in any given year.
- Long-term risk provides the probability of having one or more damaging floods over a period of time.
- Conditional non-exceedance probability indicates the chance of not having a damaging flood given a specific magnitude event.

Project performance for each impact area is displayed in Table 6.4 below.

Table 6.4 Project Performance – Without-Project Conditions

Economic Impact Area	Annual Exceedance Probability	Long-Term Risk			Conditional Non-Exceedance Probability by Events			
		10 Year Period	30 Year Period	50 Year Period	10 %	2 %	1 %	0.2 %
A	0.0336	29%	57%	82%	99%	31%	9%	1%
B	0.1964	89%	100%	100%	42%	20%	19%	18%
C	0.2461	94%	100%	100%	35%	18%	17%	17%
D	0.1967	89%	100%	100%	42%	20%	19%	18%
E	0.0696	51%	84%	97%	68%	27%	22%	18%
F	0.0292	26%	52%	77%	88%	83%	82%	79%

CHAPTER 7: WITH-PROJECT CONDITIONS – FLOOD DAMAGE REDUCTION BENEFITS

7.1 Project Benefits – The Role of Economics in the Plan Formulation Process

This section will describe how benefits of flood damage reduction of various potential alternatives were estimated. In this section, benefits and project performance outputs will be limited to flood damage reduction components. Non-monetary outputs such as environmental measures, which may vary for the final array of alternatives, are not included but may factor in the plan formulation decision process.

On Berryessa Creek, flood damage reduction measures have been considered and screened during several phases of the study. A description of all management measures and the screening process can be found in the Main Report. In this section of the economic appendix, flood damage reduction benefits have been explicitly calculated for the measures that might be feasible and have been carried forward in the plan formulation. Those measures that have been screened out are not included in this appendix.

An incremental analysis examining project location and sizing was conducted with near final H&H and economics. The final changes in H&H and economics were considered and deemed non-material to the overall outcomes of the HEC-FDA model and were not updated for this report given study constraints (budget and time). Although not updated, the previous incremental results are presented in Attachment C.

7.2 With Project Conditions - Model Simulations

Benefits were determined by making changes to the HEC-FDA model that represent various with project improvements. Flood damage reduction benefits equal the difference between the without project damage conditions and the with project residual damages.

With project residual damages were simulated for the alternatives using residual floodplain depths. The reduction in project floodplains in both extent and depth from the larger without project floodplains accounts for the decrease in damages of the given alternative. Residual depths for each damage area from the four alternative with project Flo2D runs were linked to the without project inventory through modified water surface elevation (WSE) profiles within the HEC-FDA model. With the new WSEs, stage-damages functions for the alternatives were computed within HEC-FDA and overall model runs were computed for the alternatives. For alternatives 2B and 4 residual floodplains at the mean 500-yr event, the upper limit of the current HEC-FDA modeling effort, do not appear with Flo2D. Thus, the HEC-FDA model was not run for alternatives 2B and 4 as no residual damages are present.

In addition to the modifications to the floodplains, changes to the stage-discharge function and/or top of bank (top of levee failure point) were made in the HEC-FDA model to simulate project conditions for any alternative that increased channel capacity (lowering water surface at a given exceedance probability) or raised levee height (increasing non-damaging

elevation.) Details of HEC-FDA with project inputs can be found in Attachment B of this appendix.

7.3 Average Annual Equivalent Damages –With Project Conditions

For the alternatives considered, HEC-FDA was run simulating with project conditions. The residual with project damages were subtracted from the without project damages to determine flood damage reduction benefits. Total discharge- flow in channel, and stage-discharge were modified to simulate these project conditions in the HEC-FDA model. All benefit values in the remaining tables of this report included average annual equivalents instead of expected annual damages. These average annual equivalent damages include future growth described in section 6.3. The future growth adds very little to the total damages (less than 1% of the total) and will not impact the plan formulation process.

7.4 Alternatives Evaluated – Flood Damage Reduction Benefits

Four alternatives, including the previous authorized plan, were analyzed for their flood damage reduction potential. These plans are:

1) Alternative 2A - Incised Trapezoidal Channel
2) Alternative 2B - Incised Trapezoidal Channel - Certification Level
3) Alternative 4 - Walled Trapezoidal Channel - Certification Level
4) Alternative 5 - The 1988 Authorized Plan

Damages as calculated by the HEC-FDA model for these alternatives are displayed in Table 7.1. Annual benefits in the table, represent the difference between the without and with project equivalent annual damage.

Table 7.1 Annual Benefits by Alternative

Values in $1,000's, October 2011 Prices, 4% Interest Rate, 50-Year Period of Analysis			
Alternative	**Equivalent Annual Damages**		**Annual Benefits**
	Without Project	**With Project**	
Upstream of I-680 - Damage Areas A, B, C, & D			
Without	2,536.73	2,536.73	0
1) Alt. 5	2,536.73	454.00	2,082.73
2) Alt. 2A	2,536.73	2,536.73	0
3) Alt. 2B	2,536.73	2,536.73	0
4) Alt. 4	2,536.73	2,536.73	0
Downstream of I-680 - Damage Areas E & F			
Without	11,823.26	11,823.26	0
1) Alt. 5	11,823.26	318.50	11,504.76
2) Alt. 2A	11,823.26	886.62	10,936.64
3) Alt. 2B	11,823.26	0.00	11,823.26
4) Alt. 4	11,823.26	0.00	11,823.26

7.5 Probability Distribution – Damages Reduced

In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded.

Table 7.2 shows the benefits derived by each alternative in the upstream area at probabilities of 75%, 50% and 25% that benefits will exceed the indicated value. Table 7.3 shows this distribution for the downstream area. The damage reduced column represents the mean benefits for each alternative and the 75%, 50% and 25% represent the probability that the flood damage reduction benefits exceed the number in that column for that alternative. For example, Alternative 5 upstream has an average (mean) benefit of $2,083,000 but only a 50% chance that benefits will be greater than $385,000 and 75% confidence that benefits will be equal or greater than $309,000 and a 25% chance benefits will exceed $2,556,000. This range is the probability distribution of damages reduced and represents the uncertainty in the benefit estimates and incorporates all the uncertainties in hydrology, hydraulics, and economics in the HEC-FDA model. The uncertainty in damages reduced should be considered when selecting an optimal plan during the plan formulation process. Judgment should be used to determine if an alternative meets a reasonable level of confidence regarding positive net benefits and identifying if changes in net benefits from alternative to alternative are significant.

Table 7.2 Equivalent Annual Damages Reduced Upstream

Values in $1,000's, October 2011 Prices Upstream of I-680 (Areas A, B, C, D)						
Alternative	**Equivalent Annual Damage**			**Probability Damage Reduced Exceeds Indicated Values**		
	Without Project	**With Project**	**Damage Reduced**	**75%**	**50%**	**25%**
Without	2,537	2,537	0	0	0	0
1) Alt. 5	2,537	454	2,083	309	385	2,556
2) Alt. 2A	2,537	2,537	0	0	0	0
3) Alt. 2B	2,537	2,537	0	0	0	0
4) Alt. 4	2,537	2,537	0	0	0	0

Table 7.3 Equivalent Annual Damage Reduced Downstream

Values in $1,000's, October 2011 Prices Downstream of I-680 (Areas E, F)						
Alternative	**Equivalent Annual Damage**			**Probability Damage Reduced Exceeds Indicated Values**		
	Without Project	**With Project**	**Damage Reduced**	**75%**	**50%**	**25%**
Without	11,823	11,823	0	0	0	0
1) Alt. 5	11,823	318	11,505	3,042	3,716	8,359
2) Alt. 2A	11,823	887	10,936	2,731	3,337	8,068
3) Alt. 2B	11,823	0	11,823	11,823	11,823	11,823
4) Alt. 4	11,823	0	11,823	11,823	11,823	11,823

7.6 Project Performance – With Project Conditions

Comparisons of project performance under both with and without project conditions by economic impact area are shown in Table 7.4 to Table 7.9. The annual exceedance probability measures the chance of having a damaging flood in any given year.

The long-term risk numbers measure the chance of having one or more damaging flood over a giver period of time. As shown in Table 7.5, Alternative 2B reduces the chance of getting damaged (in impact area E) over the next 30 years from 84% under the without project condition to 0% with the project.

The conditional non-exceedance probability (CNP) measures the probability of not being damaged if a given event were to occur. As with the other measures, project conditions reduce the risk and larger projects have a greater reduction in risk than small projects. The CNP for the 1% event is often targeted to determine if a project meets Corps criteria for levee certification. It is important to note the relationship between AEP and CNP in determining project accomplishment. For example, in impact Area E (see Table 7.8) Alternative 2A only provides a 73% chance of non-damage from a 1% event. To be 90% confident that the 1% event can pass without causing damage in impact Area E, a larger project must be constructed. This often causes confusion in how to identify the performance of a project in a single traditional term such as “100-year level of protection,” and as per the guidance ER 1105-2-101, the Corps has dropped all reference to describing level of protection.

Again, it is important to note, that all of these statistics (AEP, long-term risk, and CNP) were calculated in HEC-FDA with uncertainties in hydrology, hydraulics and economics.

Table 7.4 Project Performance Impact Area A

With and Without Project Conditions								
Alternative	**Annual Exceedance Probability**	**Long-Term Risk %**			**Conditional Non-Exceedance Probability by Events %**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10 %**	**2 %**	**1 %**	**0.2%**
Without	0.0336	29	57	82	99	31	9	1
1) Alt. 5	0.0052	5	12	23	100	98	83	37
2) Alt. 2A	0.0336	29	57	82	99	31	9	1
3) Alt. 2B	0.0336	29	57	82	99	31	9	1
4) Alt. 4	0.0336	29	57	82	99	31	9	1

Table 7.5 Project Performance Impact Area B

With and Without Project Conditions								
Alternative	**Annual Exceedance Probability**	**Long-Term Risk %**			**Conditional Non-Exceedance Probability by Events %**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10 %**	**2 %**	**1 %**	**0.2%**
Without	0.1964	89	100	100	42	20	19	18
1) Alt. 5	0.2115	91	100	100	37	12	7	5
2) Alt. 2A	0.1964	89	100	100	42	20	19	18
3) Alt. 2B	0.1964	89	100	100	42	20	19	18
4) Alt. 4	0.1964	89	100	100	42	20	19	18

Table 7.6 Project Performance Impact Area C

With and Without Project Conditions								
Incremental Alternative	**Annual Exceedance Probability**	**Long-Term Risk %**			**Conditional Non-Exceedance Probability by Events %**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10 %**	**2 %**	**1 %**	**0.2%**
Without	0.2461	94	100	100	35	18	17	17
1) Alt. 5	0.3418	98	100	100	32	13	9	7
2) Alt. 2A	0.2461	94	100	100	35	18	17	17
3) Alt. 2B	0.2461	94	100	100	35	18	17	17
4) Alt. 4	0.2461	94	100	100	35	18	17	17

Table 7.7 Project Performance Impact Area D

With and Without Project Conditions								
Incremental Alternative	Annual Exceedance Probability	Long-Term Risk %			Conditional Non-Exceedance Probability by Events %			
		10 Year Period	30 Year Period	50 Year Period	10 %	2 %	1 %	0.2%
Without	0.1967	89	100	100	42	20	19	18
1) Alt. 5	0.2111	91	100	100	37	12	7	5
2) Alt. 2A	0.1967	89	100	100	42	20	19	18
3) Alt. 2B	0.1967	89	100	100	42	20	19	18
4) Alt. 4	0.1967	89	100	100	42	20	19	18

Table 7.8 Project Performance Impact Area E

With and Without Project Conditions								
Incremental Alternative	Annual Exceedance Probability	Long-Term Risk %			Conditional Non-Exceedance Probability by Events %			
		10 Year Period	30 Year Period	50 Year Period	10 %	2 %	1 %	0.2%
Without	0.0696	51	84	97	68	27	22	18
1) Alt. 5	0.0062	6	14	27	100	94	70	53
2) Alt. 2A	0.0071	7	16	30	100	83	73	61
3) Alt. 2B	0.0000	0	0	0	100	100	100	100
4) Alt. 4	0.0000	0	0	0	100	100	100	100

Table 7.9 Project Performance Impact Area F

With and Without Project Conditions								
Incremental Alternative	Annual Exceedance Probability	Long-Term Risk %			Conditional Non-Exceedance Probability by Events %			
		10 Year Period	30 Year Period	50 Year Period	10 %	2 %	1 %	0.2%
Without	0.0292	26	52	77	88	83	82	79
1) Alt. 5	0.0000	0.02	0.06	0.11	100	100	100	100
2) Alt. 2A	0.0089	9	20	36	99	86	77	64
3) Alt. 2B	0.0000	0	0	0	100	100	100	100
4) Alt. 4	0.0000	0	0	0	100	100	100	100

7.7 Other Benefits

7.7.1 Savings in Flood Insurance Administration Costs

In addition to flood damages reduced, savings in the administration costs for the National Flood Insurance Program (NFIP) can be considered in the determination of NED benefits. Any alternative that removes the FEMA requirement for flood insurance can claim this benefit by reducing the number of policies required thus marginally reducing the federal administration cost of the national program. Economic Guidance Memorandum 06-04 lists the current operating cost per policy at $192 and this value was used in the benefit calculation (number of policies reduced times $192). Based on the most recent FEMA data, Milpitas has 2,493 policies in force and based on the total estimated number of structures inundated from various sources to include Berryessa and Penitencia Creeks within Milpitas, the participation rate for the area in the NFIP would be around 40%. Using this participation rate, potential benefits from savings in NFIP administration costs may be around $171,000 ($46,000 upstream of I-680 and $125,000 downstream) for any alternative that would remove all the existing structures in the Berryessa Study from the 100-year FEMA floodplain.

7.7.2 Advance Bridge Replacement Benefits

For many projects, relocations will result in the replacement of existing bridge facilities. Often the expected life of the replacement bridge will be greater than that of the existing structure, thereby extending the life of the bridge service being provided. Since the total cost of the new bridge is included in the first cost of the project, a credit for this extension is needed on the benefit side. A credit is also needed if any reduction in O&M costs will occur during the remaining life of the existing facility.

Calculation of replacement benefit is a function of interest rate, projected replacement bridge life, remaining bridge life and cost of replacement. In total, 4 bridges need to be replaced downstream of I-680. Following the procedures of IWR Report 88-R-2, “National Economic Development Procedures Manual – Urban Flood Damage,” advance bridge replacement benefits for these bridges are shown in Table 7.10. In general, all of the bridges were constructed in the early 1970’s and replacement will extend their lives beyond the study’s period of analysis. The life extension within the period of analysis is estimated at 24 years. Benefits from an O&M change are not expected to occur with the bridge replacements.

Table 7.10 Advance Bridge Replacement Benefits

In Oct 2011 Prices, Using 4% 50-year Period of Analysis				
Downstream of I-680				
	Alt 2A Cost	Alts 2B & 4 Cost	Alt 2A Benefit	Alts 2B & 4 Benefit
Montague Expressway	-	$3,201,550	-	$38,152
UPRR Trestle	$1,072,200	$1,077,200	$12,777	$12,837
Los Coches Street	-	$2,187,625	-	$26,069
Calaveras Road	-	$4,854,750	-	$57,853
Alternative 5				
	Alt 5 Cost		Alt 5 Benefit	
Old Piedmont Bridge	$708,589		$8,444	
Montague Expressway	$1,040,751		$12,402	
UPRR Trestle	$1,190,522		$14,187	

7.7.3 Recreation Benefits

Improvements for flood damage reduction may provide the opportunity for increased recreation uses in the study area. Improvements to the levees would allow for completion of locally proposed recreational trails. At this time, no recreation benefits have been computed as the recreation components have not yet been selected and recreation has not been identified as a federal project purpose for Berryessa. Based on preliminary investigations, recreation measures could be added as a local project improvement to any of the flood damage reduction alternatives without altering the formulation for flood damage reduction.

7.7.4 Environmental Benefits

Some of the alternatives provide incidental outputs in addition to flood damage reduction. These benefits are non-monetary and were not part of the economic analysis. Details of the Environmental Quality (EQ) account outputs of the various alternatives can be found in the Main Report.

7.7.5 Additional Flood Related Risks

In addition to the monetary losses to categories listed above, flooding from Berryessa Creek could have other damage impacts and place many public services at risk , and if reduced would provide additional non-monetary benefit. Emergency costs (about 1% of total damages) evaluated in this appendix were limited to evacuation, relocation and temporary assistance based on examples of similar flood risks found on other flood damage studies in Northern California. Administrative costs and increased public services such as police and fire were not included in these emergency cost estimates primarily due to lack of available data regarding any comparable historical flooding within the Bay Area. Nationwide, where

depth of flooding and duration of event were much greater, some studies have estimated total emergency costs (including temporary relocation, evacuation, public administration, additional emergency healthcare and increased labor) as high as 15% of the total without-project damages. While the emergency costs listed for Berryessa do not capture the total potential loss, these non-quantified losses are an incrementally-small portion of the overall losses and would not change the feasibility or formulation of any of the alternatives.

Potential traffic delays and temporary interruption in public services were also not quantified. Highway I-680 runs through the study area but would not be closed from flooding along Berryessa Creek. Minor roads within the floodplain may be closed for short durations due to flooding but alternate routes would not add significant time loss or additional resource consumption to the NED account and would not change the feasibility or formulation of any of the alternatives.

The area could suffer from significant business losses which could be included as Regional Economic Development (RED) damages in the analysis. But because most of these income losses could not be included in the NED analysis and therefore would not change the determination of the NED plan, RED benefits were not explicitly quantified for this document. Discussion of EQ, RED and Other Social Effects (OSE) accounts can be found in the Main Report.

Other non-monetary risks could also occur from a flood event but are not included in the NED evaluation. General reductions in risks to health, safety and public welfare are typically associated with flood conditions and are further reasons why flood protection serves the federal interest and the public good. Within the Berryessa Creek floodplain there are several elementary schools, two fire stations, a hospital, several medical clinics, police station and Milpitas City Hall that could lose vital public services due to flooding at least one-foot above the first floor.

CHAPTER 8: BENEFIT COST ANALYSIS – NED PLAN IDENTIFICATION

ER 1105-2-100 requires the identification of the plan that maximizes net annual benefits as the NED plan. Economic feasibility and project efficiency are determined through benefit cost analysis. For a project or increment to be feasible, benefits must exceed costs and the most efficient alternative is the one that maximizes net benefits (annual benefits minus annual costs.) The NED plan serves as the basis for federal participation. Deviations from the NED plan, as with a case of a locally preferred alternative, are measured from the NED plan for federal cost sharing allocations.

8.1 Annual Costs

With benefits calculations complete, annual costs need to be derived to complete the benefit cost analysis. Project costs were developed for the four alternatives. The project features unique to each alternative are summarized below:

- *Alternative 1 (No Action)*. Without-project condition, assuming routine maintenance.

- *Alternative 2 (Incised Trapezoidal Channel)*. Earthen trapezoidal section with varying bottom width and 2:1 side slopes. Access road intermittently along one or both banks, within channel at approximate level of 0.04 exceedance probability event, or both. Cellular bank stabilization with rip rap toe protection throughout. Levees with 2:1 to 3:1 side slopes and 12’ top width or floodwalls as required.

- *Alternative 4 (Walled Trapezoidal Channel)*. 10’ bottom width earthen low-flow channel with 3:1 side slopes, 3’ deep. Two vegetated floodplain benches bounded by vertical concrete floodwalls, 32’ bench width on the left bank, and 10’ width on the right bank. Access road location varies. Wall extensions as required to contain flows.

- *Alternative 5 (Authorized Plan)*. Sediment basin upstream of Old Piedmont, earthen levees in the Greenbelt, concrete trapezoidal channel downstream of I-680.

Appendix B Part IV, Design and Cost Alternatives reports the total construction costs for each alternative as shown in Table 8.1.

Table 8.1 Summary of Construction Cost by Alternative

Item	Alt - 2A	Alt - 2B	Alt - 4	Alt - 5
Total Construction Cost	$9,215,695	$25,969,253	$45,656,081	$25,889,676
Contingency	$2,764,708	$7,790,776	$13,696,824	$7,766,903
Design Phase/PED	$1,382,354	$3,895,388	$6,848,412	$3,883,451
Construction Mgt-Inspection & Admin/SI/SA	$737,256	$2,077,540	$3,652,487	$2,071,174
LERRD Acquisition Costs	$9,825,000	$10,800,000	$15,000,000	$46,200,000
LERRD Investigations cost	$200,000	$200,000	$200,000	$200,000
Total First Cost	$24,125,013	$50,732,956	$85,053,805	$86,011,205
Interest During Construction (IDC)	$984,301	$2,069,905	$3,470,195	$3,509,257
Total Project Economic Cost	$25,109,313	$52,802,861	$88,524,000	$89,520,462
Annualized Project Economic Cost	$1,168,844	$2,457,984	$4,120,810	$4,167,195
Annual OMRR&R	$63,071	$78,610	$89,195	$128,141
Total Annual Economic Cost	$1,231,914	$2,536,594	$4,210,005	$4,295,337

Interest during construction (IDC) for these alternatives is based on a 2 year midlife full expenditure approach.

8.2 Net Annual Benefits

Economic efficiency is measured based on the maximization of project net benefits. Net benefits are determined as the difference between the annual benefits and the annual costs of an alternative. Table 8.2 shows equivalent damage reductions and Table 8.3 shows net benefits and the benefit-cost ratio for each alternative.

Table 8.2 Equivalent Annual Damage Reduced

Values in $1000s, October 2011 Prices						
	Equivalent Annual Damage			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damage Reduced	75%	50%	25%
Alt 1: No Action	14,360	14,360	0	-	-	-
Alt 2A/downstream	11,824	887	10,937	2,731	3,337	8,068
Alt 2B/downstream	11,824	0	11,824	n/a	n/a	n/a
Alt 4/downstream	11,824	0	11,824	n/a	n/a	n/a
Alt 5: Authorized Plan	14,360	773	13,587	3,351	4,100	10,915

Table 8.3 Annual Benefits and Costs by Alternative

Values are in October 2011 Prices in $1000s Based on a 50-year Period of Analysis (Discounted using 4 % interest rate)				
Item	**Alt 2A**	**Alt 2B**	**Alt 4**	**Alt 5**
Total Cost	25,109	52,803	88,524	89,520
Annual Benefits Flood Damage Reduction[1]	10,937	11,824	11,824	13,587
Savings in NFIP Administration Costs	0	125	125	171
Advanced Bridge Replacement	13	135	135	35
Total Annual Benefits	10,950	12,084	12,084	13,793
Annual Costs	1,232	2,537	4,210	4,295
Net Benefits	9,718	9,547	7,874	9,498
B/C Ratio	8.89	4.76	2.87	3.21
Alternative 2A under OMB's 7% rate				
Annual Benefits	10,944			
Annual Costs	1,938			
Net Annual Benefits	9,006			
B/C Ratio	5.65			

The alternative that maximizes net annual benefits is Alternative 2A and as such is the NED plan. Alternative 2A is a Moderate Protection plan that includes channel modifications in addition to modifications and/or complete replacements at bridge and culvert crossings with the top of bank or top of levee/floodwall elevations set at the water surface level of the 0.01 exceedance probability event (100-year). The modifications or retrofits include shoring and transition structures, headwall extensions with transition structure, and bridge replacement (UPRR Trestle). Modifications within channel reaches include channel widening, bank stabilization, and levee/floodwall construction.

[1] Including future development flood damage reduction benefits.

Reach A								
Incremental Alternative	**Annual Exceedance Probability**	**Long-Term Risk**			**Conditional Non-Exceedance Probability by Events**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10%**	**2%**	**1%**	**0.20%**
Without	0.0336	0.2896	0.5746	0.8190	0.9896	0.3067	0.0917	0.0102
Alt - 5	0.0052	0.0505	0.1215	0.2283	1.0000	0.9760	0.8270	0.3662
Reach B								
Incremental Alternative	**Annual Exceedance Probability**	**Long-Term Risk**			**Conditional Non-Exceedance Probability by Events**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10%**	**2%**	**1%**	**0.20%**
Without	0.1964	0.8878	0.9958	1.0000	0.4237	0.2043	0.1938	0.1842
Alt - 5	0.2115	0.9071	0.9974	1.0000	0.3720	0.1200	0.0693	0.0518
Reach C								
Incremental Alternative	**Annual Exceedance Probability**	**Long-Term Risk**			**Conditional Non-Exceedance Probability by Events**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10%**	**2%**	**1%**	**0.20%**
Without	0.2461	0.9407	0.9991	1.0000	0.3453	0.1813	0.1745	0.1682
Alt - 5	0.3418	0.9847	1.0000	1.0000	0.3232	0.1274	0.0875	0.0727
Reach D								
Incremental Alternative	**Annual Exceedance Probability**	**Long-Term Risk**			**Conditional Non-Exceedance Probability by Events**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10%**	**2%**	**1%**	**0.20%**
Without	0.1967	0.8881	0.9958	1.0000	0.4232	0.2045	0.1941	0.1845
Alt - 5	0.2111	0.9067	0.9973	1.0000	0.3716	0.1199	0.0692	0.0517
Reach E								
Incremental Alternative	**Annual Exceedance Probability**	**Long-Term Risk**			**Conditional Non-Exceedance Probability by Events**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10%**	**2%**	**1%**	**0.20%**
Without	0.0696	0.5138	0.8352	0.9728	0.6790	0.2716	0.2217	0.1781
Alt - 2A	0.0071	0.0692	0.1642	0.3015	0.9989	0.8343	0.7333	0.6058
Alt - 2B	Protection beyond the upper limit of HEC-FDA							
Alt - 4	Protection beyond the upper limit of HEC-FDA							
Alt - 5	0.0062	0.0601	0.1436	0.2666	1.0000	0.9974	0.6993	0.5309
Reach F								
Incremental Alternative	**Annual Exceedance Probability**	**Long-Term Risk**			**Conditional Non-Exceedance Probability by Events**			
		10 Year Period	**30 Year Period**	**50 Year Period**	**10%**	**2%**	**1%**	**0.20%**
Without	0.0292	0.2567	0.5236	0.7730	0.8821	0.8304	0.8198	0.7852
Alt - 2A	0.0089	0.0856	0.2005	0.3608	0.9899	0.8627	0.7749	0.6377
Alt - 2B	Protection beyond the upper limit of HEC-FDA							
Alt - 4	Protection beyond the upper limit of HEC-FDA							
Alt - 5	0.0000	0.0002	0.0006	0.0011	1.0000	0.9997	0.9989	0.9978

ATTACHMENT A: H&H RELATIONSHIPS WITHOUT-PROJECT USED IN THE HEC-FDA MODEL

Along with the economic stage-damage functions, hydrologic and hydraulic functions are part of the flood damage analysis model. The probability-discharge, stage-discharge and interior-exterior stage relationships were provided and developed by the H&H members of the Berryessa study team. These relationships in Attachment A represent without project conditions.

A.1 Probability Curves

For Areas A-F, probability- discharge curves were developed for the HEC-FDA model. The discharge values in these relationships represent total flows both in channel and in the floodplain. Tables A1-A to A1-F display the probability functions for each damage area in the study.

Table A1-A: Probability-Discharge Area A

Exceedance Probability	Total Discharge (cfs)	Confidence Limits (standard error) Discharge cfs @ standard deviation(SD)			
		-2 SD	- 1 SD	+ 1 SD	+ 2 SD
0.999	50	35	42	60	71
0.500	240	188	212	271	307
0.200	420	304	357	494	580
0.100	560	371	456	688	846
0.040	830	515	654	1054	1338
0.020	1090	642	837	1420	1850
0.010	1430	798	1068	1915	2564
0.004	1904	1000	1380	2628	3627
0.002	2142	1096	1532	2995	4186
0.001	2392	1194	1690	3385	4790

Table A1-B: Probability-Discharge Area B

Exceedance Probability	Total Discharge (cfs)	Confidence Limits (standard error) Discharge cfs @ standard deviation(SD)			
		-2 SD	- 1 SD	+ 1 SD	+ 2 SD
0.999	50	35	42	60	72
0.500	252	196	222	285	323
0.200	444	318	376	525	620
0.100	603	399	491	741	911
0.040	886	551	698	1124	1426
0.020	1118	666	863	1449	1878
0.010	1180	695	906	1537	2003
0.004	1238	722	946	1620	2121
0.002	1252	729	955	1641	2150
0.001	1266	735	965	1660	2178

Table A1-C: Probability-Discharge Area C

Exceedance Probability	Total Discharge (cfs)	Confidence Limits (standard error) Discharge Cfs @ standard deviation(SD)			
		-2 SD	- 1 SD	+ 1 SD	+ 2 SD
0.999	50	35	42	60	72
0.500	252	196	222	285	323
0.200	444	318	376	525	620
0.100	603	399	491	741	911
0.040	886	551	698	1124	1426
0.020	1118	666	863	1449	1878
0.010	1180	695	906	1537	2003
0.004	1238	722	946	1620	2121
0.002	1252	729	955	1641	2150
0.001	1266	735	965	1660	2178

Table A1-D: Probability-Discharge Area D

Exceedance Probability	Total Discharge (cfs)	Confidence Limits (standard error) Discharge Cfs @ standard deviation(SD)			
		-2 SD	- 1 SD	+ 1 SD	+ 2 SD
0.999	50	35	42	60	72
0.500	252	196	222	285	323
0.200	444	318	376	525	620
0.100	603	399	491	741	911
0.040	886	551	698	1124	1426
0.020	1118	666	863	1449	1878
0.010	1180	695	906	1537	2003
0.004	1238	722	946	1620	2121
0.002	1252	729	955	1641	2150
0.001	1266	735	965	1660	2178

Table A1-E: Probability-Discharge Area E

Exceedance Probability	Total Discharge (cfs)	Confidence Limits (standard error) Discharge Cfs @ standard deviation(SD)			
		-2 SD	- 1 SD	+ 1 SD	+ 2 SD
0.999	200	164	181	221	243
0.500	488	420	453	526	566
0.200	698	533	610	798	913
0.100	953	691	812	1119	1314
0.040	1145	799	956	1370	1640
0.020	1398	931	1141	1712	2098
0.010	1544	1004	1245	1915	2375
0.004	1650	1055	1320	2063	2580
0.002	1771	1112	1403	2234	2818
0.001	1892	1168	1487	2407	3063

Table A1-F: Probability-Discharge Area F

Exceedance Probability	Total Discharge (cfs)	Confidence Limits (standard error) Discharge Cfs @ standard deviation(SD)			
		-2 SD	- 1 SD	+ 1 SD	+ 2 SD
0.999	100	63	80	126	158
0.500	678	550	611	752	834
0.200	924	705	807	1057	1210
0.100	1300	962	1118	1512	1758
0.040	1521	1105	1296	1783	2091
0.020	1550	1124	1320	1819	2136
0.010	1612	1164	1369	1896	2232
0.004	1741	1246	1473	2058	2434
0.002	1924	1359	1617	2289	2723
0.001	2113	1475	1765	2529	3027

A.2 Rating Curves- Stage vs. Discharge

The following Tables A3-A to A3-E show the stage-discharge functions with uncertainty used in the HEC-FDA model. Stage represents elevation in channel and discharge is flow in channel. Curves were developed for Areas A-F.

Table A3-A: Stage-Discharge Area A

Discharge in Channel (cfs)	Stage in Channel (Feet)	Standard Deviation Of Error
10	207.90	0.000
240	213.70	0.426
420	214.28	0.469
560	215.12	0.530
830	216.88	0.660
1090	219.26	0.835
1430	220.15	0.900
1820	221.39	0.900
2142	222.31	0.900

Table A3-B: Stage-Discharge Area B

Discharge (cfs)	Stage in Channel (Feet)	Standard Deviation Of Error
10	141.40	0.000
252	146.06	0.662
444	146.79	0.765
603	147.06	0.803
886	147.49	0.865
1118	147.69	0.896
1180	147.74	0.900
1233	147.81	0.900
1252	147.83	0.900

Table A3-C: Stage-Discharge Area C

Discharge (cfs)	Stage in Channel (Feet)	Standard Deviation Of Error
10	140.75	0.000
252	145.40	0.679
444	146.09	0.780
603	146.34	0.817
886	146.70	0.869
1118	146.89	0.897
1180	146.91	0.900
1233	146.93	0.900
1252	146.94	0.900

Table A3-D: Stage-Discharge Area D

Discharge (cfs)	Stage in Channel (Feet)	Standard Deviation Of Error
10	141.40	0.000
252	146.06	0.662
444	146.79	0.765
603	147.06	0.803
886	147.49	0.865
1118	147.69	0.896
1180	147.74	0.900
1233	147.81	0.900
1252	147.83	0.900

Table A3-E: Stage-Discharge Area E

Discharge (cfs)	Stage in Channel (Feet)	Standard Deviation Of Error
10	57.01	0.000
487.7	61.63	0.529
697.8	62.59	0.639
953.3	63.58	0.753
1144.7	64.50	0.858
1397.8	64.71	0.882
1544.2	64.86	0.900
1611.1	65.01	0.900
1770.5	65.07	0.900

Table A3-F: Stage-Discharge Area F

Discharge (cfs)	Stage in Channel (Feet)	Standard Deviation Of Error
10	31.10	0.000
677.5	36.80	0.712
923.5	37.76	0.831
1300.4	37.86	0.844
1520.5	38.13	0.878
1549.7	38.21	0.888
1611.5	38.31	0.900
1683.4	38.33	0.900
1923.9	38.35	0.900

ATTACHMENT B: HEC-FDA MODEL WITH-PROJECT MODIFIED RELATIONSHIPS

Project conditions were simulated in the model by making changes to the base relationships. For all alternatives, the stage-damage functions were modified to reflect depth of flooding under various project conditions. The exceedance probability – damage function from HEC-FDA for each alternative are shown in Tables B1-A to B1-F.

Table B1-A: Damage Area A - Mean Damages in $1,000's

Frequency	Without Project	Alt. 5	Alt. 2A	Alt. 2B	Alt. 4
.20	0	0	0	0	0
.10	0	0	0	0	0
.04	0	0	0	0	0
.02	171	0	171	171	171
.01	837	0	837	837	837
.004	1,447	0	1,447	1,447	1,447
.002	2,897	931	2,897	2,897	2,897

Table B1-B: Damage Area B - Mean Damages in $1,000's

Frequency	Without Project	Alt. 5	Alt. 2A	Alt. 2B	Alt. 4
.20	0	0	0	0	0
.10	221	0	221	221	221
.04	15,046	15	15,046	15,046	15,046
.02	22,292	4,296	22,292	22,292	22,292
.01	25,916	11,658	25,916	25,916	25,916
.004	28,089	15,545	28,089	28,089	28,089
.002	28,814	16,841	28,814	28,814	28,814

Table B1-C: Damage Area C - Mean Damages in $1,000's

Frequency	Without Project	Alt. 5	Alt. 2A	Alt. 2B	Alt. 4
.20	0	0	0	0	0
.10	11	0	11	11	11
.04	659	35	659	659	659
.02	967	403	967	967	967
.01	1,120	588	1,120	1,120	1,120
.004	1,212	699	1,212	1,212	1,212
.002	1,243	755	1,243	1,243	1,243

Table B1-D: Damage Area D - Mean Damages in $1,000's

Frequency	Without Project	Alt. 5	Alt. 2A	Alt. 2B	Alt. 4
.20	0	0	0	0	0
.10	116	0	116	116	116
.04	18,765	712	18,765	18,765	18,765
.02	29,346	4,625	29,346	29,346	29,346
.01	34,636	11,810	34,636	34,636	34,636
.004	37,810	15,990	37,810	37,810	37,810
.002	38,868	17,384	38,868	38,868	38,868

Table B1-E: Damage Area E - Mean Damages in $1,000's

Frequency	Without Project	Alt. 5	Alt. 2A	Alt. 2B	Alt. 4
.20	0	0	0	0	0
.10	0	0	0	0	0
.04	15,843	0	0	0	0
.02	141,546	0	0	0	0
.01	314,944	0	0	0	0
.004	418,983	26,761	22,016	0	0
.002	453,662	99,304	40,833	0	0

Table B1-F: Damage Area F - Mean Damages in $1,000's

Frequency	Without Project	Alt. 5	Alt. 2A	Alt. 2B	Alt. 4
.20	0	0	0	0	0
.10	0	0	0	0	0
.04	0	0	0	0	0
.02	102,657	0	0	0	0
.01	212,855	0	0	0	0
.004	278,974	0	127,319	0	0
.002	301,014	0	176,285	0	0

For some alternatives, top of bank/levee, stage-discharge, and inflow vs. outflow were modified to reflect channel and bank improvements. These modifications were incorporated into the HEC-FDA where applicable. Tables B2-A to F show the changes in flow and stage for each alternative. Table B3 lists the top of levee/failure damage elevation for each area and alternative.

Table B2-A: Total Discharge - Stage in Channel Area A

Without Project		Alt. 5		Alt. 2A		Alts. 2B & 4	
Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)
240	213.7	243	211.19	240	213.7	240	213.7
420	214.28	420	212.66	420	214.28	420	214.28
560	215.12	564	213.80	560	215.12	560	215.12
830	216.88	830	215.24	830	216.88	830	216.88
1,090	219.26	1,096	216.70	1,090	219.26	1,090	219.26
1,430	220.15	1,427	218.51	1,430	220.15	1,430	220.15
1,820	221.39	1,820	219.38	1,820	221.39	1,820	221.39
2,130	222.31	2,130	223.14	2,130	222.31	2,130	222.31

Table B2-B: Total Discharge - Stage in Channel Areas B & D

Without Project		Alt. 5		Alt. 2A		Alts. 2B & 4	
Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)
252	146.06	261	146.09	252	146.06	252	146.06
444	146.79	452	146.88	444	146.79	444	146.79
603	147.06	595	147.17	603	147.06	603	147.06
886	147.49	870	147.61	886	147.49	886	147.49
1118	147.69	1160	147.96	1118	147.69	1118	147.69
1180	147.74	1521	148.33	1180	147.74	1180	147.74
1233	147.81	1755	148.55	1233	147.81	1233	147.81
1252	147.83	1787	148.57	1252	147.83	1252	147.83

Table B2-C: Total Discharge - Stage in Channel Area C

Without Project		Alt. 5		Alt. 2A		Alts. 2B & 4	
Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)
252	145.40	261	146.09	252	145.40	252	145.40
444	146.09	452	146.10	444	146.09	444	146.09
603	146.34	595	146.36	603	146.34	603	146.34
886	146.70	870	146.78	886	146.70	886	146.70
1118	146.89	1160	147.02	1118	146.89	1118	146.89
1180	146.91	1521	147.27	1180	146.91	1180	146.91
1233	146.93	1755	147.42	1233	146.93	1233	146.93
1252	146.94	1787	147.44	1252	146.94	1252	146.94

Table B2-D: Total Discharge - Stage in Channel Area E

Without Project		Alt. 5		Alt. 2A		Alt. 2B		Alt. 4	
Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)
487.7	61.63	481.2	57.67	487.7	58.20	487.80	58.97	489.50	58.42
697.8	62.59	676.6	59.28	697.8	59.23	698.60	59.86	699.70	58.94
953.3	63.58	848.6	60.06	953.3	60.11	953.40	60.46	953.40	59.47
1144.7	64.50	1207.9	62.06	1144.7	61.07	1144.70	60.86	1144.70	59.98
1397.8	64.71	1525.6	63.12	1397.8	61.59	1399.50	61.39	1400.80	60.36
1544.2	64.86	1987.7	64.62	1544.2	64.15	1544.20	61.70	1544.20	61.00
1611.1	65.01	2310.7	65.32	1611.1	65.28	1611.20	62.49	1611.30	61.97
1770.5	65.07	2358.6	65.50	1770.5	65.48	1770.70	62.95	1770.70	62.55

Table B2-E: Total Discharge - Stage in Channel Area F

Without Project		Alt. 5		Alt. 2A		Alt. 2B		Alt. 4	
Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)	Total Discharge (inflow)	Stage in Channel (Feet)
677.5	36.80	685.4	34.14	676.7	35.01	676.40	34.84	674.00	36.52
923.5	37.76	1016.5	34.94	1020.0	35.94	1019.90	35.84	1016.10	37.37
1300.4	37.86	1192.6	35.32	1306.8	36.59	1312.00	36.53	1307.40	37.97
1520.5	38.13	1685.8	36.29	1690.6	37.53	1696.60	37.45	1686.20	38.91
1549.7	38.21	1963.6	36.78	1895.8	37.86	1902.30	37.83	1886.60	39.36
1611.5	38.31	2340.8	37.35	2189.7	38.20	2206.10	38.19	2194.60	39.83
1683.4	38.33	2623.3	37.75	2586.9	38.56	2658.80	38.65	2638.10	40.43
1923.9	38.35	2826.1	37.99	2861.1	38.73	2975.50	38.93	2946.70	40.80

Table B3: Top of Levee Elevations

Damage Failure Points by Alternatives and Areas

Damage Area	Without Project	Alt. 5	Alt. 2A	Alt. 2B	Alt. 4
A	217.90	220.50	217.90	217.90	217.90
B	146.90	146.90	146.90	146.90	146.90
C	146.00	146.00	146.00	146.00	146.00
D	146.90	146.90	146.90	146.90	146.90
E	64.07	65.15	65.27	65.50	66.01
F	39.00	40.42	38.88	41.35	43.80

ATTACHMENT C: INCREMENTAL ANALYSIS (PRELIMINARY F4A REPORT JUNE 2006)

C.1 Incremental Alternatives (Preliminary)

Benefits were calculated on incremental basis. The first was to determine feasibility of separable geographic areas: downstream of I-680 and upstream of I-680. The second was to determine optimal project sizing.

The goal of this incremental benefit analysis is to answer two simple questions: WHERE and HOW BIG? Is there a federal interest to construct a continuous project providing flood damage reduction to all impact areas? And what is the optimal size of project for these areas? For this analysis, benefits were evaluated for basic trapezoidal earthen channel improvements with varying capacity to reflect different sizing. Additional improvements such as levees and bridge improvements were added to some reaches or creek sections of the channel when needed to allow for full target conveyance (a more complete description of improvements required to meet conveyance can be found in Appendix B: Engineering Part IV Design and Cost of Alternatives.)

C.2 Project Conditions- Model Simulations

Benefits were determined by making changes to the economic model that represent various with project improvements. Flood damage reduction benefits equal the difference between the without project damage conditions and the with project residual damages.

With project residual damages were simulated for the incremental alternatives using residual floodplain depths. The reduction in project floodplains in both extent and depth from the larger without project floodplains accounts for the decrease in damages of the given alternative. Residual depths from five different sized with project Flo2D (see Appendix B Part I and II) runs for each damage area were linked to the without project inventory and the @RISK model was rerun to determine mean and standard deviation for the residual damage. From the @RISK output, with project stage-damage curves were generated for entry in the HEC-FDA model.

In addition to the modifications to the floodplains, changes to the stage-discharge function and/or top of bank (top of levee failure point) were made in the HEC-FDA model to simulate project conditions for any alternative or incremental measure that increased channel capacity (lowering water surface at a given exceedance probability) or raised levee height (increasing non-damaging elevation.) Details of HEC-FDA with project inputs can be found in Attachment B of this appendix.

C.3 Average Annual Equivalent Damages –With Project Conditions

For the preliminary alternatives considered, HEC-FDA was run simulating with project conditions. The residual with project damages were subtracted from the without project damages to determine flood damage reduction benefits. Total discharge- flow in channel, stage-discharge, and interior-exterior stage relationships were modified to simulate these project conditions in the HEC-FDA model. All benefit values in the remaining tables of this report included average annual equivalents instead of expected annual damages. These average annual equivalent damages include future growth described in section 6.3. The future growth adds very little to the total damages (less than 1% of the total) and will not impact the plan formulation process.

C.4 Alternatives Evaluated – Incremental Benefit Analysis

Incremental benefit evaluation to determine the optimal NED plan was formulated based on reasonable separable project features and sizing. The damage areas upstream of I-680 and downstream of I-680 are hydraulically independent and were separated into two groups:

Upstream – Areas A, B, C, & D
Downstream – Areas E & F

See Figure 1 for location of each impact area. Features were identified and categorized based on potential flood reduction and magnitude of cost. Exceedance probability of breakout by location, constriction, component costs and project performance goals were all used to select reasonable increments for benefit evaluation. Details of the project components and selection can be found in the main report. After preliminary iterations, with project residual damages were modeled for the following increments:

1) Project designed to pass flows (without uncertainty) equivalent to a minimum of 0.03 exceedance probability.
2) Project designed to pass flows (without uncertainty) equivalent to a minimum of 0.02 exceedance probability.
3) Project designed to pass flows (without uncertainty) equivalent to a minimum of 0.01 exceedance probability.
4) Additional components to the 0.01 project design to meet project performance criteria of 90% Conditional Non-Exceedance Probability of the 0.01 exceedance probability event.
5) Additional components to the 0.01 project design to meet project performance criteria of 95% Conditional Non-Exceedance Probability of the 0.01 exceedance probability event.

In total, ten project increments were run (five sizes each for the two separable areas) in HEC-FDA with the residual damages and benefits displayed in Table 17. Annual benefits in the table, represent the difference between the without and with project equivalent annual damages for each alternative row. The incremental benefits show the difference between

benefits from one incremental alternative to the next larger increment. It should be noted that alternatives beyond the 0.01 exceedance probability provide diminishing returns. The greatest benefit increments are realized as the more frequent floods are reduced. The channel improvements not only eliminate damages from the more frequent events but also reduce the magnitude of damage for the larger residual events.

Table 17
Annual Benefits by Increment
Values in $1,000's, October 2005 Prices,
5 3/8 % Interest Rate, 50 Year Period of Analysis

Increment/ Alternative	Equivalent Annual Damages		Annual Benefits	Incremental Benefits
	Without Project	With Project		
Upstream of I-680 – Damage Areas A, B, C, D				
Without	581	581	0	0
1) Pass 0.03 exceedance probability	581	326	255	255
2) Pass 0.02 exceedance probability	581	280	301	46
3) Pass 0.01 exceedance probability	581	65	516	215
4) Meet 90% CNP	581	14	567	51
5) Meet 95% CNP	581	10	571	4
Downstream of I-680 – Damage Areas E, F				
Without	9,863	9,863	0	0
1) Pass 0.03 exceedance probability	9,863	5,643	4,220	4220
2) Pass 0.02 exceedance probability	9,863	3,981	5,882	1662
3) Pass 0.01 exceedance probability	9,863	530	9,333	3451
4) Meet 90% CNP	9,863	160	9,703	370
5) Meet 95% CNP	9,863	60	9,803	100

C.5 Probability Distribution – Damages Reduced

In accordance with ER 1105-2-101, flood damages reduced were determined as mean values and by probability exceeded. Table 18 shows benefits for each upstream increment for the 75%, 50% and 25% probability that benefit exceeds indicated value. Table 19 shows this probability distribution for the downstream increments. The damage reduced column represents the mean benefits for each increment and the 75%, 50% and 25% represent the probability that the flood damage reduction benefits exceed the number in that column for that increment. For example, the upstream increment designed to pass the 0.01 exceedance probability event has a average (mean) benefit of $516,000 but only a 50% chance that benefits will be greater than $435,000 and 75% confidence that benefits will be equal or greater than $258,000 and a 25% chance benefits will exceed $681,000. This range is the probability distribution of damages reduced and represents the uncertainty in the benefit estimates and incorporates all the uncertainties in hydrology, hydraulics, and economics in the HEC-FDA model. The uncertainty in damages reduced should be considered when selecting an optimal plan during the plan formulation process. Judgment should be used to determine if an alternative meets a reasonable level of confidence regarding positive net benefits and identifying if changes in net benefits from alternative to alternative are significant.

Table 18
Equivalent Annual Damage Reduced
Values in $ 1,000's, October 2005 Prices
Upstream of I-680 (Areas A, B, C, D)

Increment	Equivalent Annual Damage			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damage Reduced	75%	50%	25%
Without	581	581	0	0	0	0
1) Pass 0.03 exceedance probability	581	326	255	173	250	320
2) Pass 0.02 exceedance probability	581	280	301	199	291	378
3) Pass 0.01 exceedance probability	581	65	516	258	435	681
4) Meet 90% CNP	581	14	567	268	465	752
5) Meet 95% CNP	581	10	571	268	468	760

Table 19
Equivalent Annual Damage Reduced
Values in $ 1,000's, October 2005 Prices
Downstream of I-680 (Areas E, F)

Increment	Equivalent Annual Damage			Probability Damage Reduced Exceeds Indicated Values		
	Without Project	With Project	Damage Reduced	75%	50%	25%
Without	9,863	9,863	0	0	0	0
1) Pass 0.03 exceedance probability	9,863	5,643	4,220	2,760	3,771	5,254
2) Pass 0.02 exceedance probability	9,863	3,981	5,882	3,707	5,262	7,570
3) Pass 0.01 exceedance probability	9,863	530	9,333	5,170	7,924	12,185
4) Meet 90% CNP	9,863	160	9,703	5,292	8,185	12,715
5) Meet 95% CNP	9,863	60	9,803	5,316	8,262	12,862

C.6 Project Performance – With Project Conditions

The following Tables 20-25 show a comparison of project performance under both with and without project conditions by economic impact area (see Section 6.4 for overview of terms). The annual exceedance probability measures the chance of having a damaging flood in any given year. As larger increments are analyzed, the annual exceedance probability (AEP) drops (for example-impact area A goes from a 1 in 25 chance without project to a 1 in 500 chance for the largest project) representing a decrease in flood risk.

The long-term risk numbers measure the chance of having one or more damaging flood over a giver period of time. As shown in Table 21, building a project that will pass the 0.01 exceedance probability event reduces the chance of getting damaged (in impact area B) over the next 25 years from 94% under the without project condition to only 23 % with the project.

The conditional non-exceedance probability (CNP) measures the probability of not being damaged if a given event were to occur. As with the other measures, project conditions reduce the risk and larger projects have a greater reduction in risk than small projects. The CNP for the 1% event is often targeted to determine if a project meets Corps criteria for levee certification. It is important to note the relationship between AEP and CNP in determining project accomplishment. For example, in impact area d (see Table 23) the project that has an AEP of 0.01 (1%) only provides a 52% chance of non-damage from a 1% event. To be 95%

confident that the 1% event can pass without causing damage in impact area D, a much larger project with AEP of 0.002 (0.2%) must be constructed. This often causes confusion in how to identify the performance of a project in a single traditional term such as "100-year level of protection," and as per the guidance ER 1105-2-101, the Corps has dropped all reference to describing level of protection.

Again, it is important to note, that all of these statistics (AEP, long-term risk, and CNP) were calculated in HEC-FDA with uncertainties in hydrology, hydraulics and economics.

Table 20
Project Performance With and Without Project Conditions
Impact Area A

Incremental Alternative	Annual Exceedance Probability	Long-Term Risk			Conditional Non-Exceedance Probability by Events			
		10 Year Period	25 Year Period	50 Year Period	10 %	2 %	1 %	0.2%
Without	0.040	33%	64%	87%	97%	23%	6%	1%
1) Pass 0.03 exceedance probability	0.040	33%	64%	87%	97%	23%	6%	1%
2) Pass 0.02 exceedance probability	0.024	21%	45%	70%	100%	51%	20%	2%
3) Pass 0.01 exceedance probability	0.011	11%	24%	43%	100%	86%	56%	15%
4) Meet 90% CNP	0.004	4%	9%	17%	100%	99%	90%	58%
5) Meet 95% CNP	0.002	2%	6%	11%	100%	100%	95%	79%

Table 21
Project Performance With and Without Project Conditions
Impact Area B

Incremental Alternative	Annual Exceedance Probability	Long-Term Risk			Conditional Non-Exceedance Probability by Events			
		10 Year Period	25 Year Period	50 Year Period	10 %	2 %	1 %	0.2%
Without	0.108	68%	94%	99%	51%	1%	0%	0%
1) Pass 0.03 exceedance probability	0.035	30%	59%	83%	98%	30%	9%	1%
2) Pass 0.02 exceedance probability	0.026	23%	48%	73%	99%	46%	17%	2%
3) Pass 0.01 exceedance probability	0.010	10%	23%	40%	100%	84%	52%	12%
4) Meet 90% CNP	0.004	4%	10%	18%	100%	99%	90%	49%
5) Meet 95% CNP	0.002	2%	6%	12%	100%	100%	95%	66%

Table 22
Project Performance With and Without Project Conditions
Impact Area C

Incremental Alternative	Annual Exceedance Probability	Long-Term Risk			Conditional Non-Exceedance Probability by Events			
		10 Year Period	25 Year Period	50 Year Period	10 %	2 %	1 %	0.2%
Without	0.047	38%	70%	91%	95%	14%	3%	0%
1) Pass 0.03 exceedance probability	0.035	30%	59%	83%	99%	26%	7%	1%
2) Pass 0.02 exceedance probability	0.020	18%	40%	64%	100%	58%	28%	8%
3) Pass 0.01 exceedance probability	0.013	12%	28%	47%	100%	79%	49%	15%
4) Meet 90% CNP	0.004	4%	9%	16%	100%	99%	90%	55%
5) Meet 95% CNP	0.002	2%	5%	9%	100%	100%	95%	73%

Table 23
Project Performance With and Without Project Conditions
Impact Area D

Incremental Alternative	Annual Exceedance Probability	Long-Term Risk			Conditional Non-Exceedance Probability by Events			
		10 Year Period	25 Year Period	50 Year Period	10 %	2 %	1 %	0.2%
Without	0.107	68%	94%	99%	51%	1%	0%	0%
1) Pass 0.03 exceedance probability	0.034	30%	58%	83%	98%	30%	9%	1%
2) Pass 0.02 exceedance probability	0.026	23%	48%	73%	99%	46%	17%	2%
3) Pass 0.01 exceedance probability	0.010	10%	22%	40%	100%	84%	52%	12%
4) Meet 90% CNP	0.004	4%	10%	18%	100%	99%	90%	49%
5) Meet 95% CNP	0.001	1%	3%	6%	100%	100%	95%	66%

Table 24
Project Performance With and Without Project Conditions
Impact Area E

Incremental Alternative	Annual Exceedance Probability	Long-Term Risk			Conditional Non-Exceedance Probability by Events			
		10 Year Period	25 Year Period	50 Year Period	10 %	2 %	1 %	0.2%
Without	0.117	71%	96%	99%	52%	1%	0%	0%
a) Pass 0.03 exceedance probability	0.034	30%	58%	83%	99%	27%	3%	0%
b) Pass 0.02 exceedance probability	0.022	20%	43%	68%	100%	57%	14%	1%
c) Pass 0.01 exceedance probability	0.010	9%	22%	39%	100%	95%	53%	6%
d) Meet 90% CNP	0.004	4%	9%	17%	100%	100%	90%	30%
e) Meet 95% CNP	0.002	2%	5%	10%	100%	100%	95%	42%

Table 25
Project Performance With and Without Conditions
Impact Area F

Incremental Alternative	Annual Exceedance Probability	Long-Term Risk			Conditional Non-Exceedance Probability by Events			
		10 Year Period	25 Year Period	50 Year Period	10 %	2 %	1 %	0.2 %
Without	0.133	76%	97%	99%	43%	0%	0%	0%
a) Pass 0.03 exceedance probability	0.034	29%	58%	82%	98%	40%	17%	2%
b) Pass 0.02 exceedance probability	0.030	26%	53%	78%	99%	46%	21%	3%
c) Pass 0.01 exceedance probability	0.008	8%	18%	33%	100%	90%	56%	12%
d) Meet 90% CNP	0.002	2%	5%	10%	100%	99%	90%	43%
e) Meet 95% CNP	0.001	1%	3%	5%	100%	100%	95%	68%

ATTACHMENT D: VERIFICATION OF INCREASING NET BENEFITS

D.1 Analysis of Smaller Version of Identified NED Alternative – Alternative 2Aa

The proceeding analysis identified Alternative 2A as the NED plan. To confirm Alternative 2A's selection, an additional analysis on optimization was conducted to ensure increasing net benefits by analyzing a smaller version (Alternative 2Aa) of the plan. The analysis of Alternative 2Aa followed the same procedures as with the other alternatives analyzed during this study. Engineering runs of hydrology & hydraulics were computed for this alternative and were compiled with the economic data within HEC-FDA. The results of the HEC-FDA model are shown in the table below.

Table 1
Equivalent Annual Damages – Alternatives 2A & 2Aa

Values in $1,000's, October 2011 Prices, 4% Interest Rate, 50-Year Period of Analysis			
Alternative	**Equivalent Annual Damages**		**Annual Benefits**
	Without Project	**With Project**	
Upstream of I-680 - Damage Areas A, B, C, & D			
Without	2,536.73	2,536.73	0
Alt. 2A	2,536.73	2,536.73	0
Alt. 2Aa	2,536.73	2,536.73	0
Downstream of I-680 - Damage Areas E & F			
Without	11,823.26	11,823.26	0
Alt. 2A	11,823.26	886.62	10,936.64
Alt. 2Aa	11,823.26	2,082.29	9,740.97

A similar construction cost estimate to the others was prepared for Alternative 2Aa and is displayed below.

Table 2
Construction Cost Estimate – Alternatives 2A & 2Aa

Item	Alt - 2A	Alt - 2Aa
Total Construction Cost	$9,215,695	$7,576,284
Contingency	$2,764,708	$2,272,885
Design Phase/PED	$1,382,354	$1,136,443
Construction Mgt-Inspection & Admin/SI/SA	$737,256	$606,103
LERRD Acquisition Costs	$9,825,000	$8,351,250
LERRD Investigations cost	$200,000	$200,000
Total First Cost	$24,125,013	$20,142,964
Interest During Construction	$984,301	$821,833
Total Project Economic Cost	$25,109,313	$20,964,797
Annualized Project Economic Cost	$1,168,844	$975,916
Annual OMRR&R	$63,071	$53,610
Total Annual Economic Cost	$1,231,914	$1,029,526

The results of the above costs and benefits indicate Alternative 2A produces greater net benefits than Alternative 2Aa.

Table 3
Annual Benefits and Costs

Values are in October 2011 Prices in $1000s Based on a 50-year Period of Analysis (Discounted using 4 % interest rate)		
Item	**Alt 2A**	**Alt 2Aa**
Total Cost	$25,109	20,965
Annual Benefits Flood Damage Reduction	$10,937	9,741
Savings in NFIP Administration Costs	$0	0
Advanced Bridge Replacement	$13	0
Total Annual Benefits	$10,950	$9,741
Annual Costs	$1,232	$1,030
Net Benefits	$9,718	$8,711
B/C Ratio	8.89	9.46