US Army Corps of Engineers®

Sacramento District
Planning Division

Lower San Joaquin River Feasibility Report

San Joaquin County, California

APPENDIX A: ECONOMICS

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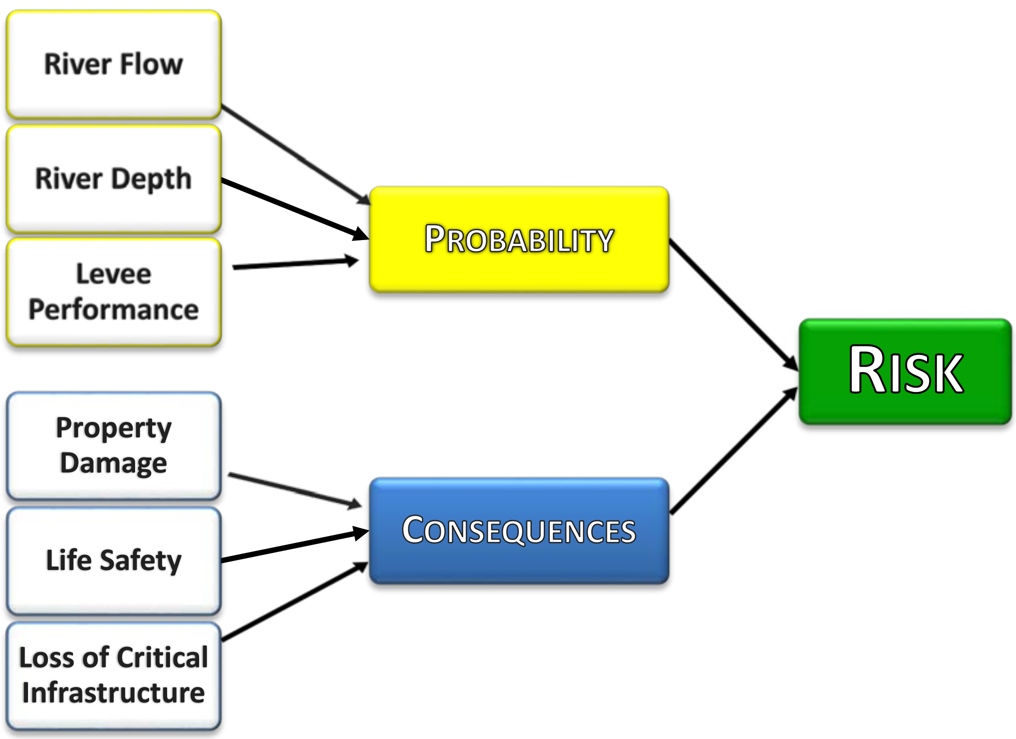
RISK ANALYSIS OVERVIEW

Risk is defined as the measure of the probabilities and consequences associated with uncertain future events. The objective of this economic analysis is to assess existing flood risk in the Lower San Joaquin River Basin and evaluate potential measures to reduce that risk.

The figure below provides a visual representation of the basic components driving the flood risk analysis summarized in this appendix. Each of these components will be described in detail in subsequent chapters.

COMPONENTS OF FLOOD RISK



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CHAPTER 1 — INTRODUCTION

1.1 PURPOSE & SCOPE

This Appendix documents the economic analysis conducted in support of the Lower San Joaquin River Feasibility Study (LSJRFS). The purposes of this report are:

- Describe major assumptions, data, methodologies, and tools used in the economic analysis
- Describe the flood risk associated with the without-project condition
- Describe the residual flood risk associated with each alternative.
- Summarize the net benefits and benefit-to-cost ratios of each alternative
- Identify the alternative that reasonably maximizes net benefits

1.2 STUDY AREA

The Lower San Joaquin study area is located in San Joaquin County, California, approximately 50 miles south of Sacramento. The geographical extent of the economic analysis was established using inundation boundaries of the 0.2% annual chance exceedance (ACE) events from the flooding sources described in Section 1.3 This analysis includes roughly 80 square miles of urban and agricultural lands in the communities of Stockton, Lathrop, and Manteca.

1.3 SOURCES OF FLOODING

The study area is susceptible to comingled flooding from six principal sources including the Sacramento-San Joaquin Delta, San Joaquin River, Mosher Slough, Calaveras River system, French Camp Slough system, and interior sources. Descriptions of each flood source can be found in Section 3.0 of the Hydraulic Design Addendum.

1.4 RELATED FEDERAL FLOOD RISK MANAGEMENT PROJECTS

Development of water resources in the basin began in the 1850s and currently includes large multiple-purpose reservoirs, extensive levee and channel improvements, bypasses, and local diversion canals (USACE, 1993). Numerous agencies have been involved in water resources development within the study area. Some of these agencies include the USACE, Bureau of Reclamation, the State of California, county irrigation districts, local reclamation districts, and local levee districts.

A discussion of existing Federal Flood Risk Management projects affecting the study area can be found in Section 3.0 of the Hydraulic Design Addendum.

1.5 SEPARABLE CONSEQUENCE AREAS

Flood risk in the study area was divided into three separable elements[1], or consequence areas, based on hydrologic and hydraulic characteristics with identifiable and distinct economic benefits. These Consequence areas are described below. A map of the Consequence area boundaries and existing levees is shown in Figure 1-1.

[1] "Separable element" is defined in 33 United States Code (U.S.C.) Section 2213(f) as a portion of the project that (1) is physically separable from other portions of the project; and (2)(a) achieves hydrologic effects, or (b) produces physical or economic benefits, which are separately identifiable from those produced by other portions of the project.

NORTH STOCKTON – The North Stockton area is defined by the right bank levees of the Calaveras River and the levees along the delta front traveling northward along Tenmile Slough, Fourteenmile Slough, crossing Fivemile Creek, and traveling north to tie into the Federal project levee across Mosher Slough at the Atlas Tract.

CENTRAL STOCKTON – The Central Stockton Area is defined by the left bank levees of the Stockton Diverting Canal, the left bank levees of the Calaveras River, the right bank levees of the San Joaquin River, and right bank levees of French Camp Slough.

RECLAMATION DISTRICT 17 (RD17) – The RD17 area is defined by the levees along the right bank of the San Joaquin River, the left bank levees of French Camp Slough, and a dry-land levee at the upstream end of the reclamation district.

1.5.1 SUBDIVISION OF CONSEQUENCE AREAS

The North Stockton and Central Stockton consequence areas were subdivided into damage reaches for economic analysis purposes. Total damages for each consequence area is the sum of damages in each reach. A map of the subdivided areas is shown in Figure 1-2.

FIGURE 1-1: CONSEQUENCE AREAS

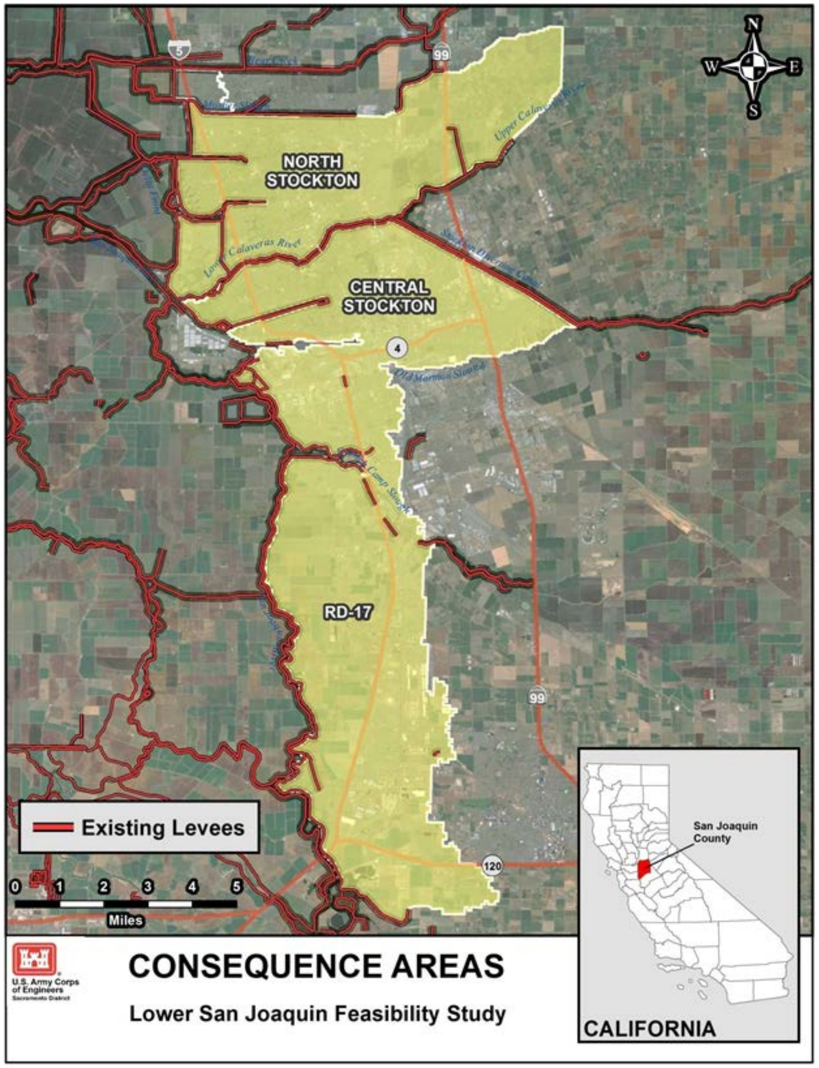
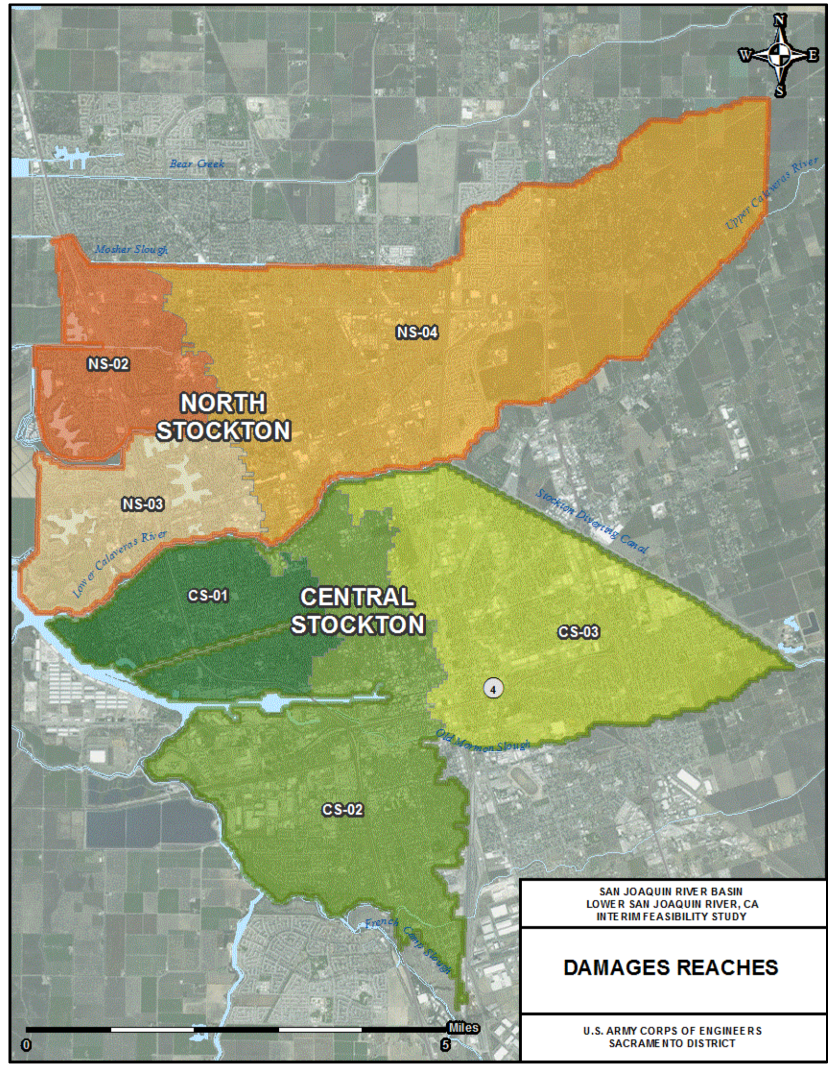


FIGURE 1-2: NORTH AND CENTRAL STOCKTON DAMAGE REACHES



1.6 POPULATION AT RISK

Population data for this study was obtained using a geographic information systems (GIS) layer containing 2010 census data by census block. This census data reports approximately 235,000 people residing within the study area in 2010. The population at risk (PAR) is comprised of individuals residing in an area that receives flooding for a given annual chance exceedance (ACE) event, regardless of inundation depth or levee performance (see section 2.6). PAR estimates do not include temporary population (*e.g.* individuals working or traveling in the area who live elsewhere).

The population at risk by ACE event is shown in Table 1-1. Reported values represent the number of people residing within the floodplain boundary for each event, regardless of inundation depth or levee performance.

TABLE 1-1: POPULATION AT RISK BY ANNUAL CHANCE EXCEEDANCE

POPULATION AT RISK BY ACE						
0.5	**0.10**	**0.04**	**0.02**	**0.01**	**0.005**	**0.002**
39,800	53,800	81,800	186,700	209,800	223,300	235,000

CHAPTER 2 — ECONOMIC ANALYSIS

2.1 CONSISTENCY WITH CURRENT REGULATIONS & POLICIES

The analysis presented in this document was performed using the most up-to-date guidance and is consistent with current regulations and policies. Various references were used to guide the economic analysis, including:

- The Planning Guidance Notebook (ER 1105-2-100, April 2000, with emphasis on Appendix D, Economic and Social Considerations, Amendment No. 1, June 2004) serves as the primary source for evaluation methods of flood risk management (FRM) studies
- EM 1110-2-1619, Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies (August 1996)
- ER 1105-2-101, Planning Risk-Based Analysis for Flood Damage Reduction Studies (Revised January 2006)
- Economic Guidance Memorandum (EGM) 01-03, Generic Depth-Damage Relationships (2000)
- Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships for Residential Structures with Basements (2003)
- Economic Guidance Memorandum (EGM) 09-04, Generic Depth-Damage Relationships for Vehicles (2009)

2.2 PRICE LEVEL, PERIOD OF ANALYSIS, AND DISCOUNT RATE

Values listed in this document are based on an October 2017 price level, unless otherwise noted. Annualized benefits and costs were computed using a 50-year period of analysis and a current federal discount rate of 2.75%. Unless otherwise noted, annualized values are presented in thousands of dollars.

2.3 HYDROLOGIC, HYDRAULIC, AND GEOTECHNICAL DATA

Flood inundation was modeled for eight ACE events at each breach location using FLO-2D software. FLO-2D stores the resulting inundation data for each model using an overlay of uniform grid cells. For this analysis, the maximum water surface elevation at each grid cell was used as an input into HEC-FDA to represent the inundation depth at each structure located within that cell.

The probability of flooding at a given breach location is driven by the following engineering inputs:

UNREGULATED FLOW PROBABILITY — the relationship between natural (unregulated) river flow and the probability of that flow being exceeded

UNREGULATED TO REGULATED FLOW TRANSFORM — the relationship between natural flow and regulated flow resulting from reservoir routing, channel routing, or channel diversion.

DISCHARGE-STAGE RELATIONSHIP — the relationship between regulated flow and corresponding river depth (stage)

GEOTECHNICAL PERFORMANCE — the relationship between river depth and the probability of levee overtopping and/or failure at that depth

2.4 SIMPLIFYING ASSUMPTIONS

Several assumptions were relied upon in order to make best use of scarce resources to reasonably and efficiently identify existing flood risk and evaluate potential solutions.

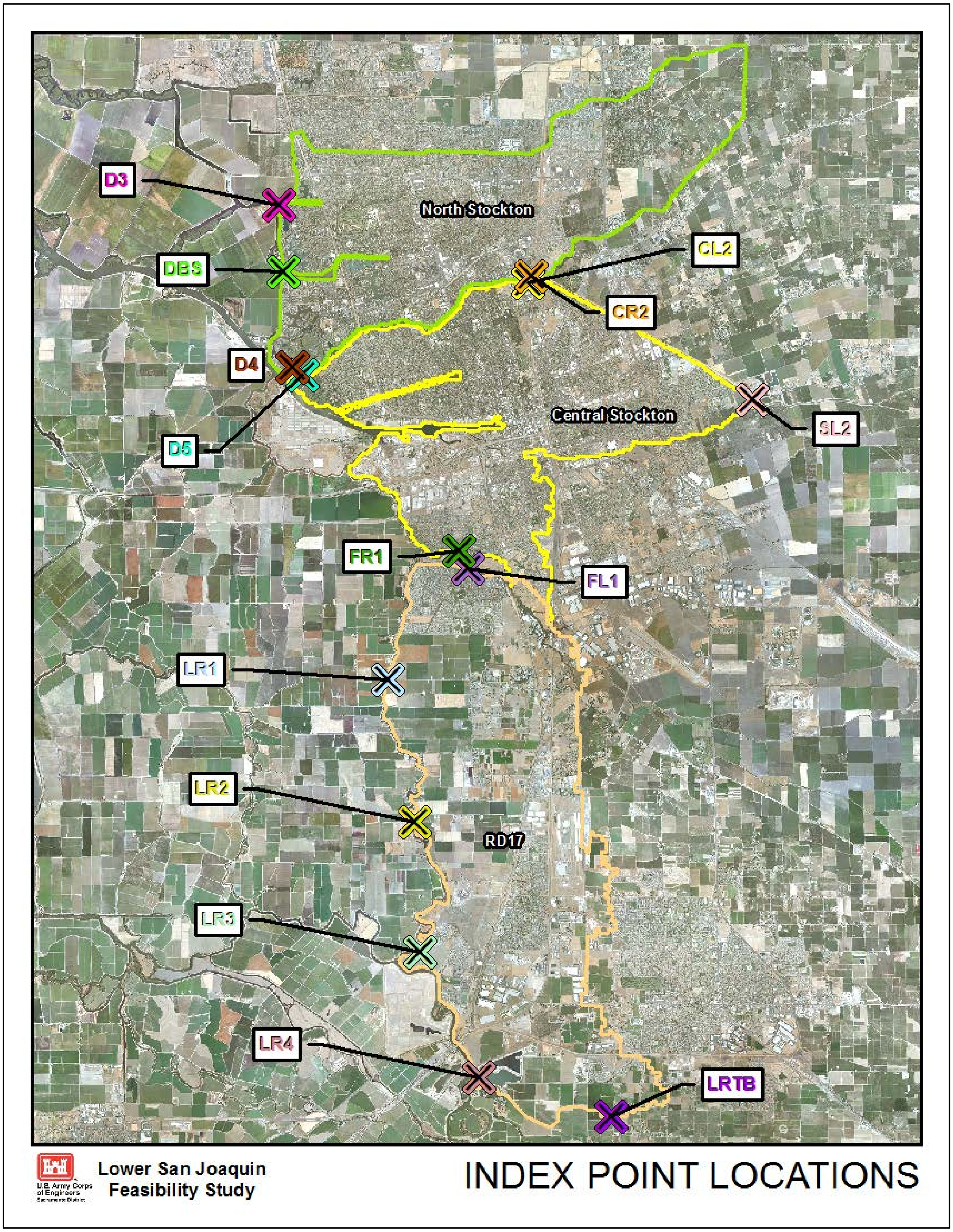
2.4.1 BREACH LOCATIONS

Existing levees in the study area were divided into 14 levee reaches. Breach and inundation characteristics of each levee reach were modeled using a representative index point. The use of index points is policy compliant and is considered the most reasonable method to efficiently model flood risk over a large geographical area. Index points are summarized geographically from upstream to downstream in Table 2-1 below. Figure 2-1 displays each of the index point locations.

TABLE 2-1: INDEX POINTS BY FLOODING SOURCE

FLOOD SOURCE	INDEX POINT
SAN JOAQUIN RIVER	LRTB
	LR4
	LR3
	LR2
	LR1
FRENCH CAMP SLOUGH	FR1-1
	FR1-2
	FL1
STOCKTON DIVERTING CANAL	SL2
CALAVERAS RIVER	CR2
	CL2
SACRAMENTO-SAN JOAQUIN DELTA FRONT	D3
	D4
	D5
	D-BS

FIGURE 2-1: INDEX POINT LOCATIONS



2.4.2 MULTIPLE-SOURCE FLOODING

Throughout this study, multiple sources of flooding exist within a single impact area. Each source has its own unique combination of probabilities and consequences. Within each impact area, the simplifying assumption was made that the flood source with the highest economic risk is deemed the driver of risk. If a feature of an alternative reduces the risk associated with one of the sources, the source with the next highest risk becomes the residual risk driver.

2.4.3 FUTURE WITHOUT-PROJECT CONDITION—ECONOMICS

For this feasibility study analysis, the future without-project condition assumes no additional development in the study area. The basis of this assumption is that existing developable land is reasonably built out to its full potential. Additionally, development forecasts were not made for currently undeveloped portions of the study area. This is due to the uncertainty surrounding public policy decisions that may limit or prohibit such development.

2.4.4 CLIMATE CHANGE

Sea level rise due to climate change is expected to impact stage-frequency at several breach locations in the study area. Stage-frequency relationships were adjusted for the future year condition based on sea level rise forecasts made in compliance with USACE EC 1165-2-212.

Hydraulic inputs for all alternatives use 2010 data to represent present-year conditions and forecasted data for the year 2070 to represent the future year. It is acknowledged that using 2010 data presents the risk of failing to capture sea level rise that may have already occurred. This risk is considered acceptable as the result is a slight underestimation of without-project damages and subsequent with-project benefits.

Please refer to the Hydraulic Design Addendum for a detailed account of the sea level rise analysis.

2.4.5 GEOTECHNICAL PERFORMANCE

Each geotechnical performance relationship curve represents the most likely levee failure mode for a given breach location. Performance relationships for all other potential failure modes are assumed to be captured within the most likely curve.

2.4.6 EQUIVALENT ANNUAL DAMAGES

All annual damages in this appendix are reported in average annual equivalent terms. Because sea level rise is expected to lead to an upward shift in the stage-frequency relationship, higher probabilities of flooding are expected in the future, all else being equal. To capture the consequent increase in expected annual damages, a linear relationship between future damage values was assumed. Future damages are interpolated between the base and future year and discounted back to the base year.

2.4.7 STRUCTURE LOCATIONS

Structure locations were estimated using a geographic information system (GIS) parcel layer containing the boundaries of every parcel of land in the study area. The spatial accuracy of the data was confirmed using aerial imagery. The simplifying assumption was made that structures are to be located at the geometric center, or centroid, of the parcel they are located on.

Figure 2-2 displays this structure placement process visually. It is important to note the location of the centroids in relation to the structures they represent.

FIGURE 2-2: STRUCTURE PLACEMENT

2.5 STRUCTURE INVENTORY DATA

An inventory of damageable property was developed for the study in two parts. The first part was completed in 2011 by USACE Los Angeles District for use in the 2012 preliminary screening analysis. This inventory was based on San Joaquin County Assessor parcel data and included 51,856 structures and covered most of the North and Central Stockton consequence areas. For consequence modeling purposes, each structure's value was computed as a function of replacement value minus depreciation.

The second part was developed in 2013 as a supplement to the existing inventory. This was critical to the study as the 2011 inventory did not include structures in RD17. Furthermore, a significant number of structures in North and Central Stockton were missing or inaccurately located. The supplementary inventory was also created using assessor parcel data, and structure values were computed by sampling the preliminary inventory and applying the weighted mean cost per square foot for each occupancy type to the supplementary inventory.

2.5.1 CONTENT-STRUCTURE VALUE RATIOS

The content to structure value ratio is the relationship between the value of a structure and the value of its contents. Content-structure value ratios are expressed as a percentage and are based on a structure's occupancy type.

The value of contents in residential structures was estimated using depth-damage functions and associated standard error estimates developed by the Institute for Water Resources (IWR).

The value of contents in non-residential structures was estimated using content-structure value ratios published in *Technical Report: Content Valuation and Depth Damage Curves for Nonresidential Structures* (USACE, May 2007). The ratios were developed during an expert-opinion elicitation process conducted by the Sacramento District for use in the American River Economic Reevaluation Report (2008).

2.6 RISK AND UNCERTAINTY

Uncertainty is especially prevalent in the estimation of flood risk. A list of all the potential sources of uncertainty would be nearly endless. However, primary sources of uncertainty evaluated in this study include: (1) Levels of Storm Water Discharge; (2) River Stage; (3) Levee Performance; (4) Depreciated Structure and Structure Content Values; and (5) Flood Damages to Structures and Structure Contents. Risk and uncertainty in this analysis was accounted for in compliance with USACE guidance.[2] The section below describes these sources of uncertainty and how each is accounted for in this analysis.

LEVELS OF STORM WATER DISCHARGE – Uncertainty in the level of rainwater discharge associated with a storm event with a given probability of occurrence is driven by a number of inconsistent factors. Storms with equal probabilities of occurrence can differ in the amount of rainfall they produce at various locations throughout the watershed. They can also differ in their intensity, the time that elapses while rain is falling. Ground permeability, soil moisture, ambient temperature and other physical factors at the time of the storm also play an important role in determining when and where rainwater enters the river's channel. All of these natural factors lead to variability in the level of discharge found at a particular location along the river, following any given storm event.

RIVER STAGE – For a given level of discharge, there is uncertainty in the expected water surface elevations for specific locations within the channel. The shape of the riverbed, water temperature, location and amount of debris as well as other obstructions in the channel all add uncertainty to the estimated water surface elevations associated with storms of otherwise equal levels of discharge. To address this uncertainty, engineering data inputs were used to estimate standard deviations for various river stages. These estimated standard deviations are based on level of discharge and location in the floodplain.

LEVEE PERFORMANCE – Geotechnical fragility curves were used to quantify the probability of failure at each breach location for river stages below the top of levee. For each river stage, there is uncertainty in the ability of the levees and banks to contain flood flows without structural failure. The geotechnical fragility curves used to quantify levee performance for this study were developed with uncertainty surrounding under-seepage reliability, through-seepage reliability, long-term stability, and engineering judgment. However, the resulting fragility curves used to model flood damage do not include uncertainty of performance probabilities at the various river stages on the curve.

STRUCTURE ELEVATIONS – The susceptibility of a structure to damage depends on a number of uncertain variables. One key variable, the structure elevation, can be decomposed into two error prone estimates: topographic and first floor elevations. The level of uncertainty in structures' topographic elevations is a function of the accuracy of data used to derive ground elevations. For example, elevation estimates derived from examining a five-foot contour map are likely to contain more error, and therefore have higher levels of uncertainty, than estimates derived using a two-foot aerial survey contour map. The second source of uncertainty in elevation data is the result of error in first floor or foundation height estimates. Foundation height data is important since structures built on land mounds or those with large crawl spaces may sustain little or no damage during floods that inundate surrounding areas and nearby properties. First floor height data error varies according to the precision of the method used to measure foundation heights. In practice, these methods range from best-guess estimates to windshield and professional surveys.

[2] ER 1105-2-101

DEPRECIATED STRUCTURE AND CONTENT REPLACEMENT VALUES – The magnitude of damages to a particular structure following a given flood event is a function of its current, depreciated replacement value and the value of its contents. The current or depreciated value of a structure is uncertain for several reasons. First, per square foot structure values are calculated by estimating the construction type, quality and condition of structures during field surveys. These estimates are subject to human error associated with incorrectly classifying a structure within each category. The type, construction quality and condition classifications themselves may further induce error if they do not adequately account for the proper range of possible per square foot values.

FLOOD DAMAGES TO STRUCTURES AND STRUCTURE CONTENTS – Finally, there is considerable uncertainty in evaluating structure and content damages that would occur given a particular level of flooding. Damages to residential structures were evaluated using depth-damage functions and associated standard error estimates developed by the Institute for Water Resources (IWR). These depth-damage functions and standard error estimates are based upon the damages that actually occurred during previous flood events in the United States.

2.7 HEC-FDA SOFTWARE

The primary analytical tool used to perform the economic analysis was the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software, version 1.2.5a. This program uses engineering and economic data to model flood risk with uncertainty and evaluate potential solutions in the study area.

2.8 PROJECT BENEFIT CALCULATION

Benefits for each alternative are based on the reduction in economic damages as compared to the future without-project condition.

The benefits of all alternatives are based on a 50-year period of analysis beginning the year that a federal project would likely be completed. It is possible that differing construction schedules will result in varying base years among the alternatives.

CHAPTER 3 — WITHOUT-PROJECT CONDITIONS ANALYSIS

3.1 CONSEQUENCE VARIABLES

Consequences in this study are defined as property damage, life-loss, and loss of critical infrastructure due to levee breach for a given annual chance exceedance (ACE) event. The variables that factor into consequence estimation are described in the following sections.

3.1.1 STRUCTURES AND CONTENTS

Structures were categorized by land use and classified as residential, commercial, industrial, or public. Structure counts by damage category and consequence area are shown in Table 3-1 below. The total base year value of structures, contents, and automobiles within the Lower San Joaquin study area is estimated at $28.7 billion. Total structure and content values are summarized by damage category and consequence area in Table 3-2.

TABLE 3-1: STRUCTURES IN THE 0.2% ACE FLOODPLAIN

CONSEQUENCE AREA	NUMBER OF STRUCTURES				
	COMMERCIAL	INDUSTRIAL	PUBLIC	RESIDENTIAL	TOTAL
NORTH STOCKTON	1,174	68	113	32,322	33,677
CENTRAL STOCKTON	1,585	605	360	30,843	33,393
RD 17	131	238	50	12,147	12,566
TOTAL	2,890	911	523	75,312	79,636

TABLE 3-2: VALUE OF DAMAGEABLE PROPERTY ($1,000S)

CONSEQUENCE AREA	STRUCTURE AND CONTENT VALUES					
	AUTOS	COMMERCIAL	INDUSTRIAL	PUBLIC	RESIDENTIAL	TOTAL
NORTH STOCKTON	414,000	2,154,000	115,000	359,000	8,856,000	11,898,000
CENTRAL STOCKTON	324,000	1,953,000	2,010,000	781,000	6,094,000	11,162,000
RD 17	120,000	291,000	1,944,000	111,000	3,172,000	5,638,000
TOTAL	858,000	4,398,000	4,069,000	1,251,000	18,122,000	28,698,000

3.1.2 DEPTH-PERCENT DAMAGE FUNCTIONS

Depth-percent damage functions represent the relationship between inundation depth at a structure and the percentage of damage caused by that depth. Economic damage is calculated as a percentage of damage specified by the depth-percent damage function multiplied by the total value of structure and contents. Residential depth-damage curves (structures and contents) were taken from Economic Guidance Memorandum (EGM) 01-03, *Generic Depth-Damage Relationships,* and 04-01, *Generic Depth-Damage Relationships for Residential Structure with Basements.* Mobile home curves were taken from the May 1997 Final Report, *Depth Damage Relationships in Support of Morganza to the Gulf, Louisiana Feasibility Study*. Non-residential structure curves were based on revised Federal Emergency Management Agency (FEMA) Flood Insurance Administration (FIA) curves.

3.2 PROBABILITY VARIABLES

The overall likelihood that flooding will occur in a given year is dependent on the probabilities associated with the engineering inputs described in section 2.3. Please refer to the Hydrologic, Hydraulic, and Geotechnical appendices for further details about the probability variables used in the HEC-FDA models.

3.3 ANNUALIZED DAMAGES

Equivalent annual damages for the Lower San Joaquin study area are estimated to be approximately $383 million. Damages by consequence area and damage category are shown in Table 3-3 below.

TABLE 3-3: EQUIVALENT ANNUAL DAMAGES BY CONSEQUENCE AREA ($1,000S)

CONSEQUENCE AREA	DAMAGE CATEGORY					
	AUTOS	COMMERCIAL	INDUSTRIAL	PUBLIC	RESIDENTIAL	TOTAL
NORTH STOCKTON	16,000	48,000	2,000	10,000	183,000	259,000
CENTRAL STOCKTON	4,000	11,000	18,000	6,000	57,000	96,000
RD17	1,000	1,000	13,000	1,000	12,000	28,000
TOTAL	21,000	60,000	33,000	17,000	252,000	383,000

3.4 FUTURE WITHOUT-PROJECT CONDITION

3.4.1 REPETITIVE DAMAGES

The current certified HEC-FDA model assumes future inventory will not be impacted by flooding that may occur over the period of analysis. In other words, structures that sustain flood damage in a given analysis year are assumed to be fully restored to pre-flood condition prior the next analysis year. This assumption is not supported by empirical evidence, which shows that complete restoration of all structures is unlikely in areas subjected to catastrophic flooding. By assuming a complete and immediate rebuild of damaged structures, the HEC-FDA model overestimates future year damages in simulations where more than one flood occurs over the period of analysis.

Impact areas NS-02, NS-03, and CS-01 each contain breach locations where without-project AEP values suggest a high likelihood of multiple floods over the period of analysis. Therefore, future without-project inventory values were adjusted to account for structures that may be abandoned or not fully restored after a flood. In order to qualify for future value adjustment, a structure must sustain a minimum of 50% value loss from an event with an annual chance exceedance of 10% or greater. Once the qualifying structures were identified for each impact area, future without-project inventory values were calculated using the following assumptions:

- Two floods will occur at index points D3, D4, D-BS, and D5 over the 50-year period of analysis.
- 80% of structures sustaining value loss of 50% or greater will be rebuilt or restored to pre-flood condition after each successive flood[3].
- Structures sustaining less than 50% damage are assumed to be fully restored

Table 3-4 summarizes future inventory values for damage areas impacted by repetitive damages.

TABLE 3-4: REPETITIVE DAMAGES—IMPACT ON FUTURE INVENTORY VALUE

DAMAGE AREA	INDEX POINT	EXPECTED RETURN PERIOD (YEARS)		TOTAL INVENTORY VALUE ($1,000s)		
		PRESENT YEAR	FUTURE YEAR	PRESENT YEAR	FUTURE YEAR	% DIFFERENCE
NS-02	D3	6.6	4.8	2,057,000	1,849,000	-10.1%
NS-03	D-BS	15.5	10.4	2,530,000	2,146,000	-15.2%
CS-01	D5	6.6	5.3	2,083,000	1,887,000	-9.4%

3.4.2 CLIMATE CHANGE

As discussed in Section 2.4.4, sea level rise due to climate change is expected to result in higher probabilities of flooding in the future at some index points. Table 3-5 compares annual exceedance probability for existing and future without-project conditions for index points that are expected to be affected by sea level rise. Index points CL2, CR2, and SL2 are not expected to be impacted by sea level rise and are not included in this table.

[3] Rebuilding/restoration assumptions are based on empirical data collected in New Orleans following Hurricane Katrina

TABLE 3-5: EXPECTED IMPACTS OF CLIMATE CHANGE

DAMAGE AREA	INDEX POINT	ANNUAL EXCEEDANCE PROBABILITY	
		PRESENT YEAR	FUTURE YEAR
NS-02	D3	0.1519	0.2091
NS-03	D4	0.0646	0.0962
	D-BS	0.1521	0.1890
CS-01	D5	0.1197	0.1582
	FR1-1	0.0228	0.0415
	FR1-2	0.0109	0.0352
CS-02	FR1-1	0.0228	0.0415
	FR1-2	0.0109	0.0352
RD17	FL1	0.0132	0.0202
	LR1	0.0126	0.0141
	LR2	0.0211	0.0257
	LR3	0.0095	0.0101
	LR4	0.0073	0.0075
	LRTB	0.0117	0.0075

CHAPTER 4 — ALTERNATIVE EVALUATION

4.1 INITIAL ARRAY OF ALTERNATIVES

An initial array of flood risk management alternative plans was developed, evaluated and compared to identify a plan that reasonably maximizes net benefits. This initial array of flood risk management alternative plans primarily consists of various upstream and downstream dry dam configurations, bypass alignments, setback levees, a ring levee, and channel modifications. Alternatives in the initial array were either screened out or retained based on parametric cost and benefit analysis.

The following alternatives were retained from the initial array. Refer to Chapter 3 of the main report for descriptions of alternatives that were screened out.

4.1.1 NO ACTION ALTERNATIVE

This alternative would have no federal action identified. It would be expected that the future without-project assumptions would be maintained. It is expected that current flood risk management structures would be maintained and existing flood risk would remain.

4.1.2 NORTH STOCKTON ALTERNATIVES

North Stockton-B: Delta Front North and South, and Calaveras River. This alternative addresses the delta and tidal portion of the Calaveras River as the flooding sources. The alternative includes a closure structure across Mosher Slough. The alternative covers a total 50,400 linear feet (9.545 miles) of levee.

North Stockton-F: Delta Front North and South, and Calaveras River. This alternative addresses the right bank of the Calaveras River and the delta front as flooding sources. This alternative includes closure structures across Mosher Slough and Fourteenmile Slough. This alternative covers a total 69,300 linear feet (13.125 miles) of levee.

4.1.3 CENTRAL STOCKTON ALTERNATIVES

Central Stockton-D: Calaveras River, Diverting Canal, and San Joaquin River. This alternative addresses the San Joaquin River, Stockton Diverting Canal, Calaveras River, French Camp Slough and Duck Creek as flooding sources and includes the Smith Canal closure structure. The alternative covers a total 88,900 linear feet (16.837 miles) of levee.

Central Stockton-F: Calaveras River and San Joaquin River. This alternative addresses the tidal portion of the Calaveras River, the San Joaquin River, French Camp Slough, and Duck Creek as flooding sources. The Smith Canal closure structure is also included. The alternative covers a total 51,600 linear feet (9.773 miles) of levee.

4.1.4 RECLAMATION DISTRICT 17 ALTERNATIVES

RD17-E: San Joaquin River North with Tieback and Extension. This alternative addresses the San Joaquin River and French Camp Slough as flooding sources. This alternative also extends the tie-back levee to address flanking issues. The alternative covers a total 106,900 linear feet (18.731 miles) of levee.

4.2 FOCUSED ARRAY OF ALTERNATIVES

The project delivery team (PDT) used measures retained from the initial array to develop a focused array of alternatives. Each alternative in the focused array was evaluated on its performance relative to planning criteria set forth in USACE guidance, which states that the plan most reasonably maximizing net economic benefits is identified as the National Economic Development (NED) plan. A plan other than the NED Plan may be selected based on additional criteria but would require approval by the Assistant Secretary of the Army for Civil Works (ASA[CW]).

The following alternatives were retained from the focused array. Refer to Chapter 3 of the main report for descriptions of alternatives that were screened out.

4.2.1 NO ACTION

This alternative would have no federal action identified. It would be expected that the future without-project assumptions would be maintained. It is expected that current flood risk management structures would be maintained and existing flood risk would remain.

4.2.2 ALTERNATIVE LS-7A

This alternative combines the following alternatives to arrive at a comprehensive solution: North Stockton-B and Central Stockton-F. The alternative would implement levee improvements without implementing either of the Mormon Channel or Paradise Cut bypasses. The alternative would combine the levee improvement measures of cutoff wall, deep soil mixing (seismic), seepage berm, and levee geometry improvements. In addition to the levee improvements, this alternative would address projected sea level change by including raises in levee height where needed. The proposed levee improvements in this alternative are comparable to Alternative 7b, with the exception that the RD17 components are not included.

4.2.3 ALTERNATIVE LS-7B

This alternative combines the following alternatives to arrive at a comprehensive solution: North Stockton-B, Central Stockton-F, and RD17-E. The alternative would implement levee improvements without implementing either of the Mormon Channel or Paradise Cut bypasses. The alternative would combine the levee improvement measures of cutoff wall, deep soil mixing (seismic), seepage berm, and levee geometry improvements. In addition to the levee improvements, this alternative would address projected sea level change by including raises in levee height where needed. There would also be approximately 2.2 miles of new levee constructed to extend the RD-17 tie-back levee and the secondary levee at the Old River flow split. The new levees would also include a cutoff wall to address potential seepage issues.

4.2.4 ALTERNATIVE LS-8A

This alternative combines the following alternatives to arrive at a comprehensive solution: North Stockton-F and Central Stockton-D. The alternative would implement levee improvements without implementing either of the Mormon Channel or Paradise Cut bypasses. The alternative would combine the levee improvement measures of cutoff wall, deep soil mixing (seismic), seepage berm, and levee geometry improvements. In addition to the levee improvements, this alternative would address projected sea level change by including raises in levee height where needed. The proposed levee improvements in this alternative are comparable to Alternative 8, with the exception that the RD17 components are not included.

4.2.5 ALTERNATIVE LS-8B

This alternative combines the following alternatives to arrive at a comprehensive solution: North Stockton-F, Central Stockton-D, and RD17-E. The alternative would implement levee improvements without implementing either of the Mormon Channel or Paradise Cut bypasses. The alternative would combine the levee improvement measures of cutoff wall, deep soil mixing (seismic), seepage berm, and levee geometry improvements. In addition to the levee improvements, this alternative would address projected sea level change by including raises in levee height where needed. There would also be approximately 2.2 miles of new levee constructed to extend the RD-17 tie-back levee and the secondary levee at the Old River flow split. The new levees would also include a cutoff wall to address potential seepage issues.

4.2.6 ALTERNATIVE LS-9A

This alternative combines the following alternatives to arrive at a comprehensive solution: North Stockton-B, Central Stockton-F, and the Mormon Channel Bypass. The alternative would implement levee improvements along with restoration of the Mormon Channel including a diversion control structure at the Stockton Diverting Canal. The alternative would combine the levee improvement measures of cutoff wall, deep soil mixing (seismic), seepage berm, and levee geometry improvements. In addition to the levee improvements, this alternative would address projected sea level change by including raises in levee height where needed. The diversion control structure for Mormon Channel at the Stockton Diverting Canal would consist of pipe culverts with gates to control releases to a maximum flow of approximately 1,200 cubic feet per second to Mormon Channel. The proposed levee improvements in this alternative are comparable to Alternative 9b, with the exception that the RD17 components are not included.

4.2.7 ALTERNATIVE LS-9B

This alternative combines the following alternatives to arrive at a comprehensive solution: North Stockton-B, Central Stockton-F, RD17-E, and the Mormon Channel Bypass. The alternative would implement levee improvements along with restoration of the Mormon Channel including a diversion control structure at the Stockton Diverting Canal. The alternative would combine the levee improvement measures of cutoff wall, deep soil mixing (seismic), seepage berm, and levee geometry improvements. In addition to the levee improvements, this alternative would address projected sea level change by including raises in levee height where needed. There would also be approximately 2.2 miles of new levee constructed to extend the RD-17 tie-back levee and the secondary levee at the Old River flow split. The new levees would also include a cutoff wall to address potential seepage issues. The diversion control structure for Mormon Channel at the Stockton Diverting Canal would consist of pipe culverts with gates to control releases to a maximum flow of approximately 1,200 cubic feet per second to Mormon Channel.

4.3 WITH-PROJECT DAMAGES

The residual damages and project benefits for each final alternative are summarized in Table 4-1. Note that Table 4-1 contains unindexed damages and benefits. The values shown are the same as they were presented at the time the final array of alternatives was evaluated.

TABLE 4-1: FINAL ARRAY OF ALTERNATIVES—RESIDUAL DAMAGES ($1,000S)

ALTERNATIVE	RESIDUAL ANNUAL DAMAGES				ANNUAL BENEFITS*	ANNUAL DAMAGE REDUCTION
	NORTH STOCKTON	CENTRAL STOCKTON	RD-17	TOTAL		
NO ACTION	244,000	92,000	26,000	362,000	0	-
LS-7a	12,000	25,000	26,000	63,000	299,000	82.6%
LS-8a	2,000	20,000	26,000	48,000	314,000	86.7%
LS-9a	8,000	23,000	26,000	57,000	305,000	84.3%
LS-7b	14,000	21,000	2,000	37,000	325,000	89.8%
LS-8b	1,000	16,000	2,000	19,000	343,000	94.8%
LS-9b	7,000	20,000	2,000	29,000	333,000	92.0%

* Does not include benefits during construction

4.3.1 PROJECT COSTS

Project costs were estimated by USACE cost engineers. Total first cost and construction duration for each alternative are shown in Tables 4-2 through 4-7 below. These estimates do not include interest during construction.

TABLE 4-2: FIRST COST ESTIMATE—ALTERNATIVE LS-7A

FIX	START YEAR	END YEAR	TOTAL FIRST COST ($1,000S)
NORTH STOCKTON	2018	2028	$616,800
CENTRAL STOCKTON	2017	2020	$210,500
RD17	N/A	N/A	$0

TABLE 4-3: FIRST COST ESTIMATE—ALTERNATIVE 8A

FIX	START YEAR	END YEAR	TOTAL FIRST COST ($1,000S)
NORTH STOCKTON	2018	2028	$669,400
CENTRAL STOCKTON	2017	2020	$291,500
RD17	N/A	N/A	$0

TABLE 4-4: FIRST COST ESTIMATE—ALTERNATIVE 9A

FIX	START YEAR	END YEAR	TOTAL FIRST COST ($1,000S)
NORTH STOCKTON	2018	2028	$607,200
CENTRAL STOCKTON	2017	2020	$248,300
RD17	N/A	N/A	$0

TABLE 4-5: FIRST COST ESTIMATE—ALTERNATIVE 7B

FIX	START YEAR	END YEAR	TOTAL FIRST COST ($1,000s)
NORTH STOCKTON	2018	2028	$599,700
CENTRAL STOCKTON	2017	2020	$204,000
RD17	2024	2030	$410,100

TABLE 4-6: FIRST COST ESTIMATE—ALTERNATIVE 8B

FIX	START YEAR	END YEAR	TOTAL FIRST COST ($1,000s)
NORTH STOCKTON	2018	2028	$644,000
CENTRAL STOCKTON	2017	2020	$280,000
RD17	2024	2030	$410,000

TABLE 4-7: FIRST COST ESTIMATE—ALTERNATIVE 9B

FIX	START YEAR	END YEAR	TOTAL FIRST COST ($1,000s)
NORTH STOCKTON	2018	2028	$594,000
CENTRAL STOCKTON	2017	2020	$242,000
RD17	2024	2030	$406,000

4.3.2 INTEREST AND BENEFITS DURING CONSTRUCTION

As delivered, the total project costs did not include interest during construction or benefits during construction.

Interest during construction (IDC) accrues each year between the start of construction and the base year. Total IDC is annualized over the period of analysis and added to the annual project cost.

Benefits during construction (BDC) are benefits that accrue annually between the year that one or more elements of the project begin to realize benefits and the base year. Total BDC is annualized over the period of analysis and added to the annual project benefits.

IDC and BDC were calculated using the Institute for Water Resources (IWR) Planning Suite software using the FY2018 discount rate of 2.75% and a 50 year period of analysis. IDC and BDC for each alternative is shown in Table 4-8.

TABLE 4-8: INTEREST AND BENEFITS DURING CONSTRUCTION ($1,000S)

ALTERNATIVE	INTEREST DURING CONSTRUCTION		BENEFITS DURING CONSTRUCTION	
	Total	Annual	Total	Annual
NO ACTION	$0	$0	$0	$0
LS-7a	$185,000	$7,000	$616,000	$25,000
LS-8a	$224,000	$9,000	$662,000	$26,000
LS-9a	$196,000	$8,000	$631,000	$25,000
LS-7b	$288,000	$11,000	$1,317,000	$52,000
LS-8b	$337,000	$13,000	$1,403,000	$56,000
LS-9b	$301,000	$12,000	$1,350,000	$54,000

4.4 NET BENEFITS AND BENEFIT-TO-COST RATIO

Once benefit and cost calculations are complete, each alternative can be evaluated based on its net benefits (total return on investment) and benefit-to-cost ratio (return on each dollar invested). These metrics may provide the basis for decision-makers when selecting a plan. The net benefits and benefit-to-cost ratios for each final alternative are reported in Table 4-9. Note that Table 4-9 contains unindexed damages, costs, and benefits. The values shown are the same as they were presented at the time the final array of alternatives was evaluated.

TABLE 4-9: FINAL ARRAY OF ALTERNATIVES—ECONOMIC SUMMARY

ALTERNATIVE	RESIDUAL DAMAGES ($1,000s)	ANNUAL BENEFITS* ($1,000s)	ANNUAL COST† ($1,000s)	NET BENEFITS ($1,000s)	BENEFIT TO COST RATIO
NO ACTION	362,000	0	0	0	0.0
LS-7a	65,000	322,000	39,000	283,000	8.26
LS-8a	48,000	340,000	46,000	294,000	7.39
LS-9a	57,000	330,000	41,000	289,000	8.05
LS-7b	37,000	378,000	59,000	319,000	6.41
LS-8b	19,000	399,000	66,000	333,000	6.05
LS-9b	29,000	387,000	60,000	327,000	6.45

* Includes benefits during construction

† Includes interest during construction

4.5 REFINEMENTS TO THE RECOMMENDED PLAN

Alternative LS-7a was identified as the Recommended Plan. USACE cost engineers conducted a detailed analysis to estimate the cost and schedule of constructing the plan. Final cost estimates were reviewed and certified by the USACE Walla Walla District Cost Engineering Mandatory Center of Expertise.

The certified cost estimates for the Recommended Plan are summarized in Table 4-10. Detailed interest during construction calculations are shown in tables 4-11 and 4-12. Detailed benefits during construction calculations are shown in Table 4-13. A summary of the refined economic benefit/cost analysis for the Recommended Plan is provided in Table 4-14.

TABLE 4-10: RECOMMENDED PLAN—REFINED COST ESTIMATE – VALUES IN $1,000S

FIX	FIRST COST	IDC†	TOTAL ECONOMIC COST	OMRR&R	ANNUAL COST‡
NORTH STOCKTON	684,234	180,629	864,863	596	32,631
CENTRAL STOCKTON	386,075	51,200	437,275	466	16,663
RD17	0	0	0	0	0
TOTAL	1,070,309	231,829	1,302,138	1,062	49,294

† Interest calculated using FY2018 discount rate of 2.75%

‡ Includes annual OMRR&R cost of $1.06 million

Table 4-11: Recommended Plan—Interest During Construction[‡]—North Stockton
Values in $1,000s

YEAR	PRESENT WORTH FACTOR	COSTS PRIOR TO BASE	PRESENT VALUE OF COSTS	INTEREST
2021	1.442297	$62,203	$89,715	$27,513
2022	1.403695	$62,203	$87,314	$25,111
2023	1.366127	$62,203	$84,977	$22,774
2024	1.329564	$62,203	$82,703	$20,500
2025	1.293979	$62,203	$80,490	$18,286
2026	1.259347	$62,203	$78,335	$16,132
2027	1.225642	$62,203	$76,239	$14,036
2028	1.192839	$62,203	$74,198	$11,995
2029	1.160914	$62,203	$72,212	$10,009
2030	1.129843	$62,203	$70,280	$8,077
2031	1.099604	$62,203	$68,399	$6,196
2032	1.070174	$0	$0	$0
2033	1.041532	$0	$0	$0
2034	1.013657	$0	$0	$0
TOTAL		$684,233	$864,862	$180,629

[†] Interest calculated using FY2018 discount rate of 2.75%

Table 4-12: Recommended Plan—Interest During Construction[‡]—Central Stockton
Values in $1,000s

YEAR	PRESENT WORTH FACTOR	COSTS PRIOR TO BASE	PRESENT VALUE OF COSTS	INTEREST
2026	1.259347	$42,897	$54,023	$11,125
2027	1.225642	$42,897	$52,577	$9,679
2028	1.192839	$42,897	$51,169	$8,272
2029	1.160914	$42,897	$49,800	$6,903
2030	1.129843	$42,897	$48,467	$5,570
2031	1.099604	$42,897	$47,170	$4,273
2032	1.070174	$42,897	$45,908	$3,010
2033	1.041532	$42,897	$44,679	$1,782
2034	1.013657	$42,897	$43,483	$586
TOTAL		$386,073	$437,276	$51,200

[†] Interest calculated using FY2018 discount rate of 2.75%

TABLE 4-13: RECOMMENDED PLAN—BENEFITS DURING CONSTRUCTION‡
VALUES IN $1,000S

YEAR	PRESENT WORTH FACTOR	BENEFITS PRIOR TO BASE	PRESENT VALUE OF BENEFITS
2017-2031	-	$0	$0
2032	1.084790	$245,469	$266,283
2033	1.055756	$245,469	$259,156
2034	1.027500	$245,469	$252,220
2035	1.000000	$0	$0
TOTAL		$736,407	$777,659

TABLE 4-14: RECOMMENDED PLAN—ECONOMIC SUMMARY
MONETARY VALUES IN $1,000S

ANNUAL BENEFITS*	ANNUAL COSTS	NET BENEFITS	BENEFIT TO COST RATIO
345,024	49,294	295,730	7.0

***** Includes benefits during construction

4.5.1 IMPACTS OF CLIMATE CHANGE ON THE RECOMMENDED PLAN

The consideration of sea-level rise analysis resulted in the identification of a higher performing NED plan than had sea-level rise not be considered.

The Recommended Plan is also no regrets plan in terms of the potential impacts of sea-level rise. Sea-level rise is expected to impact all alternatives equally, as each alternative in the final array includes identical fixes for the index points affected by sea-level rise.

4.5.2 SENSITIVITY TO SEA-LEVEL RISE

The impacts of sea-level rise were estimated by running HEC-FDA with discharge-stage functions adjusted for the future year condition using intermediate stage increase estimates over the period of analysis.

The sensitivity of the Recommended Plan's economic outputs were assessed by running HEC-FDA with discharge-stage functions adjusted using low and high sea-level rise estimates. Results showed the range of net benefits between the low and high curve to be roughly $62 million.

The Recommended Plan is believed to include measures that offer robust performance into the future across the range of potential climate change outcomes.

ATTACHMENT 1: OTHER SOCIAL EFFECTS

OTHER SOCIAL EFFECTS

The objective of the Other Social Effects (OSE) assessment is to provide a portrait of the social landscape of the Lower San Joaquin Feasibility Study area and offer a glimpse into the potential vulnerability of the people who live there. Table OSE-1Table OSE-1: Elements of OSE Analysis below summarizes the elements commonly included in the OSE account and the metrics used to evaluate them.

TABLE OSE-1: ELEMENTS OF OSE ANALYSIS

SOCIAL ELEMENT	METRICS
Social connectedness	Gender, race, ethnicity, age, rural versus urban communities, rental versus owner-occupied dwellings, and occupation
Community social capital	Education, family structure, rural vs. urban communities, and population growth
Community resilience	Income, political power, neighborhood prestige, employment loss, residential property characteristics, infrastructure and lifelines, family structure, and medical services
Life safety risk	Calculated as a function of the annual probabilities of various flood events and the associated life safety consequences

This assessment compares the other social effects associated with the without-project and with-project conditions. The 1% annual chance exceedance (ACE) floodplain serves as the baseline to assess effects.

CURRENT SOCIAL LANDSCAPE

Describing the social landscape of the area provides an understanding of who lives in the study area, who has a stake in the problem or issue, and why it is important to them. A demographic profile of the area is performed using social statistics, and the information is presented in a meaningful way through the use of comparisons and rankings. It is important to note that the profile itself is not an OSE analysis but rather a data collection step that provides a basic level of understanding about the social conditions in the area; the data provides input into a more in-depth analysis that targets areas of special concern or relevance to the water resources issue at hand. The basic social statistics of the study area are summarized in Table OSE-2 below. These statistics, along with the social elements listed in Table OSE-1, are indicators used to portray basic information about the social life and the processes of the study area.

TABLE OSE-2: BASIC SOCIAL CHARACTERISTICS OF THE STUDY AREA

SOCIAL STATISTIC	STOCKTON			CALIFORNIA		
	2000	2010	% Δ	2000	2010	% Δ
Population						
Total	243,771	291,707	19.7%	33,871,648	37,253,956	10%
Age						
Median	29.8	30.8	3.4%	33.3	35.2	5.70%
% >65	10.20%	10.00%	-2.0%	10.60%	11.40%	7.50%
% <18	32.40%	29.90%	-7.7%	27.30%	25.00%	-8.40%
Race & Ethnicity						
Asian	19.90%	21.50%	8.0%	10.90%	12.80%	17.40%
Black	11.20%	12.20%	8.9%	6.70%	5.80%	-13.40%
Hispanic	32.50%	40.30%	24.0%	32.40%	37.60%	16%
White	32.20%	22.90%	-28.9%	46.70%	40.10%	-14.10%
Other	4.20%	3.10%	-26.2%	4.30%	3.70%	86%
Education						
% HS Graduates	68.2%	73.70%	8.1%	81%	80.80%	-0.20%
% College Graduates	15.4%	17.50%	13.6%	30.50%	30.20%	-0.90%
Income and Poverty						
% Unemployed	7.3%	10.50%	43.8%	4.30%	7.10%	65.00%
Median Household Income	35,453	$47,246	33.3%	61,400	61,632	0.00%
% Below Poverty	38.4%	23.30%	-39.3%	15.30%	14.40%	-5.90%
Housing						
% Own	51.60%	51.90%	0.6%	56%	55.90%	0%
% Rent	48.40%	48.10%	-0.6%	44%	44.10%	0%
Quality of Life						
Avg. Household Size	3.04	3.17	4.3%	2.98	3.45	16%
Language Other than English Spoken at Home	41.5%	45.1%	8.7%	43.50%	43.20%	-0.70%
Mean Travel Time to Work (minutes)	27.2	26.4	-2.9%	27.1	27	-0.40%

Source: US Census Bureau

SOCIAL EFFECTS ASSESSMENT

A social effects assessment considers the social vulnerability and resiliency of a population. Social vulnerability refers to the sensitivity of a population to natural hazards, whereas social resiliency refers to the population's ability to respond to and recover from the impacts of a natural hazard. The characteristics that are recognized as having an influence on social vulnerability and resiliency generally include age, gender, race, and socioeconomic status as well as population segments with special needs or those without the normal social safety nets typically necessary to recover from a disaster. The quality of human settlements (*e.g*., housing type and construction, infrastructure, and lifelines) and the built environment also play an important role in assessing social vulnerability and resiliency, especially as these characteristics influence potential economic losses, injuries, and fatalities from natural hazards. Tables OSE-3 and OSE-4 provide a discussion of factors that may influence social vulnerability and resiliency and also provides a qualitative assessment of the Lower San Joaquin River Feasibility study area based on indicator statistics from the 2010 U.S. Census. The discussion column is from the article, *Social Vulnerability to Environmental Hazards*, which was published in the June 2003 edition of Social Science Quarterly.

TABLE OSE-3: SOCIAL VULNERABILITY AND RESILIENCY FACTORS

INDICATOR	DISCUSSION	ASSESSMENT
Income, Political Power, and Prestige	This measure focuses on the ability to absorb losses and enhance resilience to hazard impacts. Wealth enables communities to absorb and recover from losses more quickly due to insurance, social safety nets, and entitlement programs.	The median household income of the area is 30% less than the median for the state of California; however, the city's proximity to the state's Capital of Sacramento may provide significant access to political resources.
Gender	Women can have a more difficult time during recovery than men, often due to sector-specific employment, lower wages, and family care responsibilities.	Women make up 46.0% of the work force while men make up 54.0%; the median income for women in the area is $42,824, which is 89% of the median income for men.
Race and Ethnicity	Race and ethnicity may impose language and cultural barriers that affect access to post-disaster funding	The area is highly diverse in terms of race and ethnicity. Over 40% of the residents speak a language other than English at home; this may contribute to the vulnerability and possibly the resiliency of the community.
Age	Extremes on the age spectrum inhibit the movement out of harm's way. Parents lose time and money caring for children when daycare facilities are affected; the elderly may have mobility constraints or mobility concerns increasing the burden of care and lack of resilience.	Those age 65 and over make up a slightly lower percentage of the community's population as compared to the percentage for the same age category for the state as a whole; the percentage of residents younger than 18 (29.9%) is slightly higher than the state statistic (25%).
Employment Loss	The potential loss of employment following a disaster exacerbates the number of unemployed workers in a community, contributing to a slower recovery from the disaster.	The latest Census indicates that the current unemployment rate in the area may be significantly higher than the state's. A flood event which causes additional unemployment may exacerbate the current unemployment rate.
Rural/Urban	Rural residents may be more vulnerable due to lower incomes, and may be more dependent on locally-based resource extraction economies (farming and fishing). High-density areas (urban) complicate evacuation from harm's way.	The area is highly urbanized and close to many resources.
Residential Property	The value, quality, and density of residential construction affect potential losses and recovery. For example, expensive homes are costly to replace, while mobile homes are easily destroyed and less resilient to hazards.	The area is comprised of a full spectrum of homes – from average quality to excellent. Medium density neighborhoods are typical, with higher density neighborhoods in the downtown area.
Infrastructure and Lifelines	Loss of sewers, bridges, water, communications, and transportation infrastructure may place an insurmountable financial burden on the smaller communities that lack the financial resources to rebuild.	Many of the neighborhoods within the study area are well-established and would most likely have access to the many resources available within the city itself as well as within the greater Sacramento area to the north.

TABLE OSE-4: SOCIAL VULNERABILITY RESILIENCY FACTORS (CONTINUED)

INDICATOR	DISCUSSION	ASSESSMENT
Renters	People that rent typically do so because they are either transient or do not have the financial resources for home ownership. They often lack access to information about financial aid during recovery. In the most extreme cases, renters lack sufficient shelter options when lodging becomes uninhabitable or too costly to afford.	The number of rentals in the area is significant (about 48%), and is higher than the state average of about 44%. The high rental population may contribute to communication cohesion issues; research indicates that renters do not have the same level of community pride as owners do, which may lead to more challenges in redeveloping a community after a flood event.
Occupation	Some occupations, especially those of resource extraction, may be severely impacted by a hazard event. Self-employed fishermen suffer when their means of production is lost and may not have the requisite capital to resume work in a timely fashion and thus will seek alternative employment. Migrant workers engaged in agriculture and low skilled service jobs (e.g., housekeeping, childcare, and gardening) may similarly suffer, as disposable income fades and the need for services decline. Immigration status also affects occupational recovery.	The number of people that live in the area and work in resource extraction occupations is fairly low; the 2010 Census indicates that around 4,329 people (or 3.2% of the total work force) work in the farming, fishing, and forestry occupations.
Family Structure	Families with large numbers of dependents or single-parent households often have limited finances to outsource care for dependents, and thus must juggle work responsibilities and care for family members. All affect the resilience to recover from hazards.	The literature indicates that families having greater than four persons have more financial difficulty than smaller families. Accordingly, community planners need to be aware of issues that may arise.
Education	Education is strongly linked to socioeconomic status, with higher educational attainment resulting in greater lifetime earnings. Lower education constrains the ability to understand warning information and access to recovery information.	Nearly 74% of the population has graduated from high school and 17.5% hold a bachelor's degree.
Population Growth	Counties experiencing rapid growth lack available quality housing; its social services network may not have had time to adjust to increased populations. New migrants may not speak the language and not be familiar with bureaucracies for obtaining relief or recovery information, all of which increases vulnerability.	Stockton has grown considerably over the past 10-15 years. The population has grown by about 20%--nearly double the state's population growth rate. Rapid growth is highly correlated with low community cohesion. The sense of belonging, cooperation, and community pride are dynamic factors which help with community resilience but which may not be as strong in cities that have experienced rapid growth.
Medical Services	Health care providers, including physicians, nursing homes, and hospitals are important post-event sources of relief. The lack of proximate medical services will lengthen immediate relief and result in longer recovery from disasters.	The residents of Stockton would have access to medical facilities in nearby areas, which include the greater Sacramento metropolitan area approximately 45 miles to the north.

LIFE SAFETY EVALUATION

A life safety evaluation was conducted for both the No Action alternative and Alternative LS-7a. Life safety was evaluated based on the following variables: (1) the probability of an annual chance exceedance (ACE) event occurring; (2) the probability of levee failure given the occurrence of an ACE event; (3) the depth of flooding that would occur following a levee failure; and (4) the population density in the flooded area.

Life safety risk was evaluated in two parts. First, a risk matrix was developed based on flood probabilities and inundation depths. Probabilities range from the highly improbable to the very likely, while flood depths range from very shallow to catastrophically deep. The risk matrix and associated qualitative risk factors are shown in Figure OSE-1 below.

FIGURE OSE-1: FLOOD RISK MATRIX

-RISK-		DEPTH (FT)				
		0-2	2-5	5-10	10-15	15-20
PROBABILITY	1:10,000	VERY LOW	VERY LOW	VERY LOW	VERY LOW	LOW
	1:1,000	VERY LOW	VERY LOW	LOW	LOW	LOW
	1:500	VERY LOW	LOW	LOW	LOW	MEDIUM
	1:250	VERY LOW	LOW	LOW	MEDIUM	HIGH
	1:100	VERY LOW	LOW	MEDIUM	HIGH	VERY HIGH
	1:25	LOW	MEDIUM	HIGH	VERY HIGH	VERY HIGH
	1:10	LOW	HIGH	VERY HIGH	VERY HIGH	VERY HIGH

The tables and figures below are provided to compare flood risk to the population of the LSJRFS study area for the Recommended Plan. Tables OSE-5 and OSE-6 list the number of people in each risk category for the existing and future condition. The maps in figures OSE-2 and OSE-3 show existing and future flood risk based on the probability and depth of flooding.

TABLE OSE-5: POPULATION BY FLOOD RISK CATEGORY—EXISTING CONDITION

FLOOD RISK	ALTERNATIVE	
	NO ACTION	LS-7A
Very Low	77,192	87,594
Low	80,214	121,202
Medium	61,798	16,628
High	8,230	2,030
Very High	21	0

TABLE OSE-6: POPULATION BY FLOOD RISK CATEGORY—FUTURE CONDITION

FLOOD RISK	ALTERNATIVE	
	NO ACTION	LS-7a
Very Low	77,192	80,982
Low	78,565	127,815
Medium	62,714	16,628
High	8,946	2,030
Very High	38	0

FIGURE OSE-2: FLOOD RISK—ALTERNATIVE LS-7A—EXISTING CONDITION

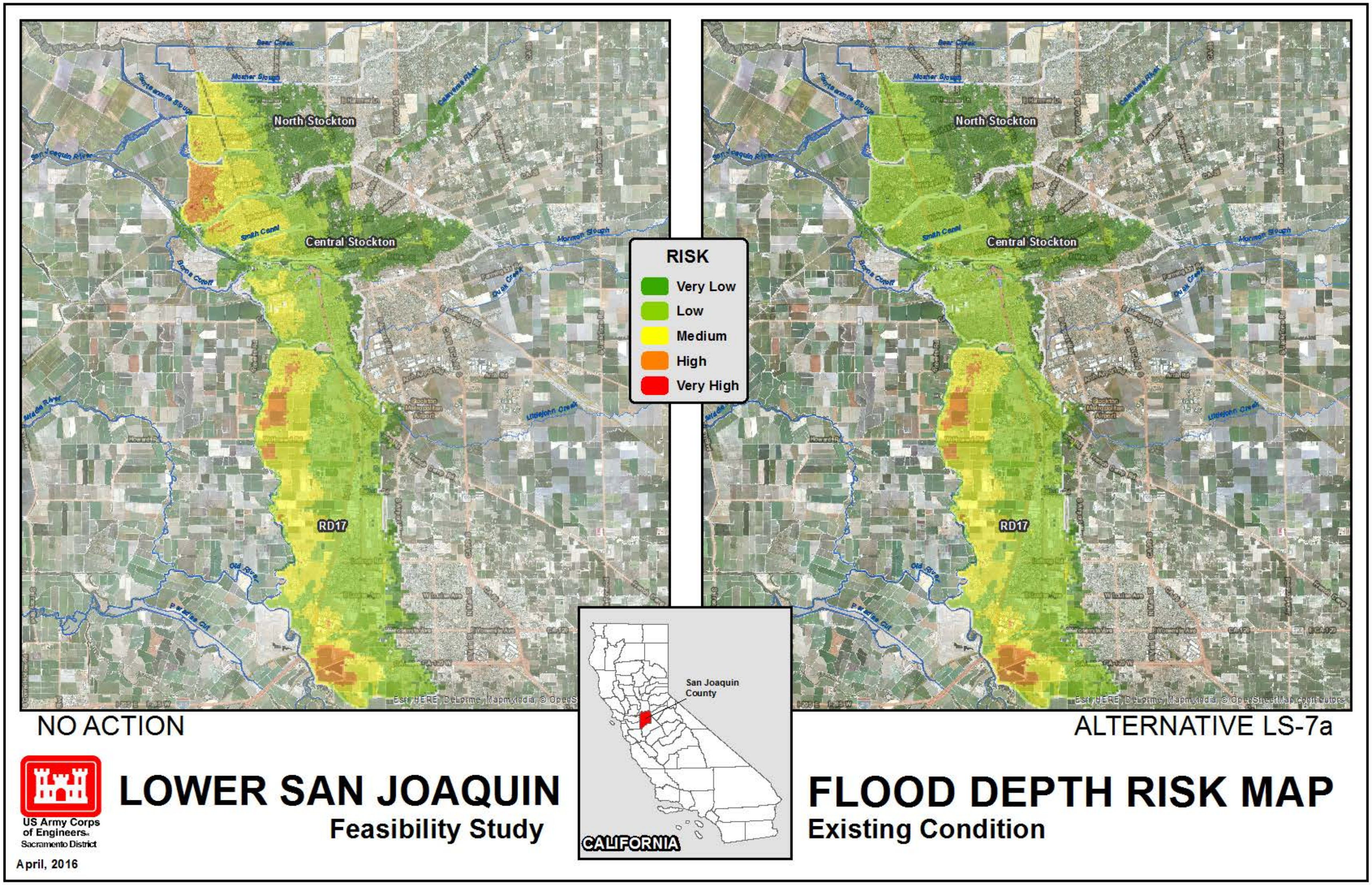
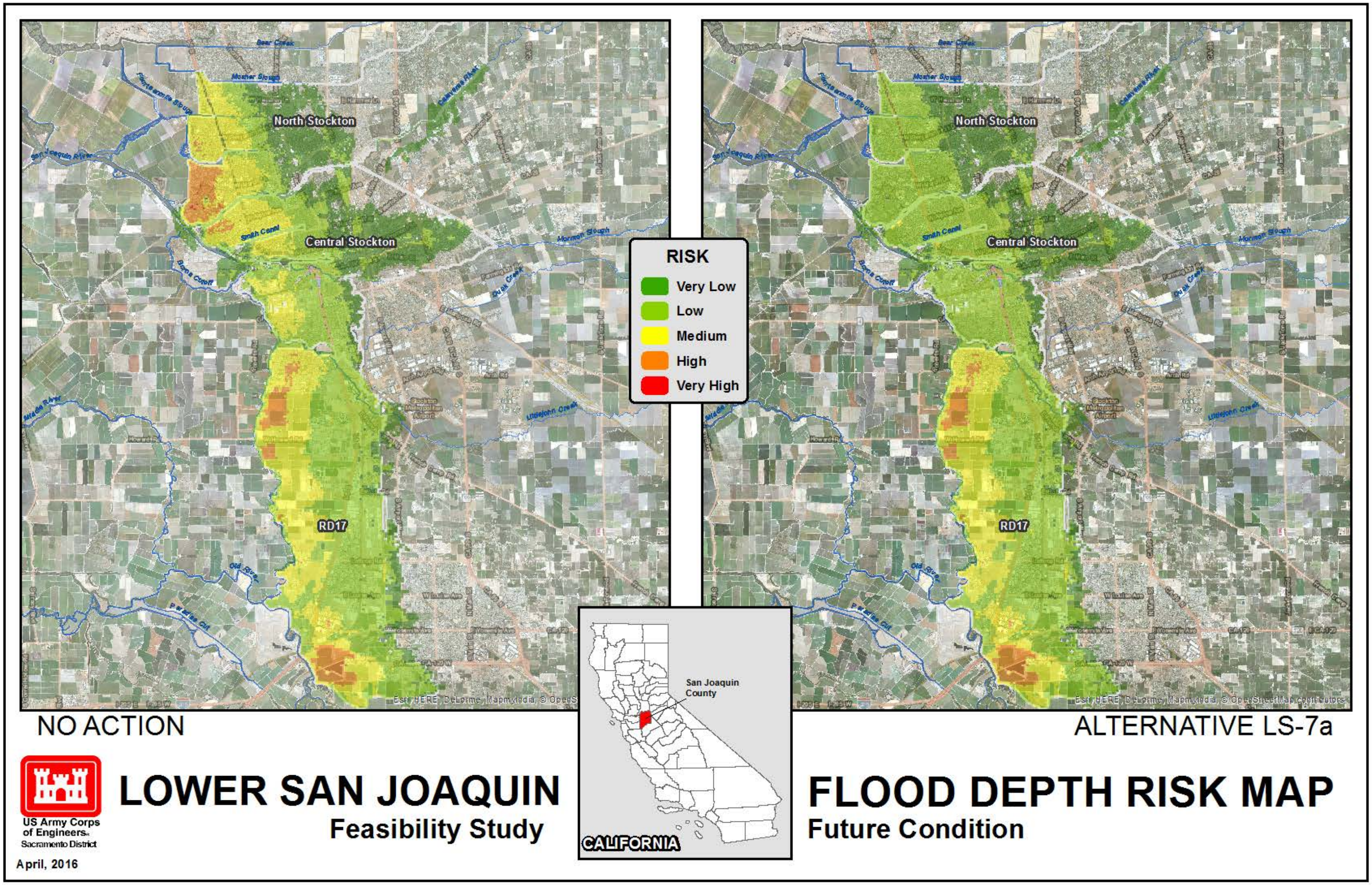


FIGURE OSE-3: FLOOD RISK— ALTERNATIVE LS-7A FUTURE CONDITION



The second part of the life safety evaluation was to adjust the flood risk factors up or down based on population density in the affected area. The population density metric was selected because it represents the severity of consequences in the risk equation. In other words, the more people living in a flooded area, the higher the life safety risk, all else being equal. Conversely, the fewer people living in a flooded area, the lower the life safety risk, all else being equal.

According to the US Census Bureau, the average metropolitan statistical area (MSA) has a population density of roughly 4,400 people per square mile[1]. The population density of the LSJRFS study area is reasonably close to that estimate with an average of 4,126 people per square mile.

The risk matrix on page xxxv is designed to describe flood risk in an area of average population density. For life safety risk estimation purposes, portions of the study area with a population density within one standard deviation below or two standard deviations above the mean population density were deemed average. Flood risk was assessed for these areas using the risk factors as shown in the matrix.

For areas more than two standard deviations above the mean, the risk factor was increased by one increment (medium becomes high, high becomes very high, etc.) For areas more than one standard deviation below the mean[2], the risk factor was reduced by one increment (medium becomes low, low becomes very low, etc.) Risk factors were not adjusted below very low or above very high.

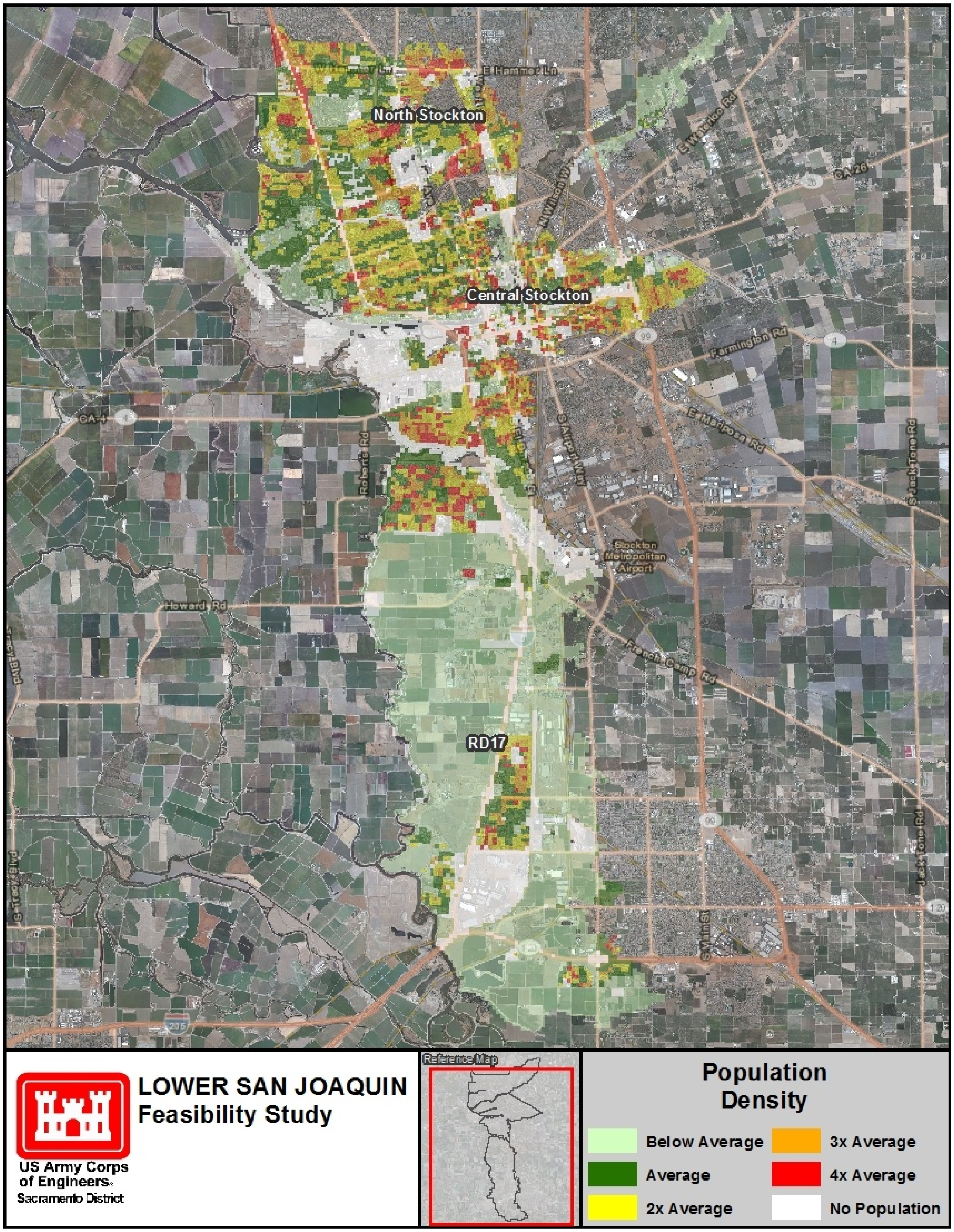
Table OSE-7 summarizes the risk adjustment factors and the total population affected by each factor adjustment. The map in Figure OSE-4 provides graphic representation of the population density classifications shown in Table OSE-7.

TABLE OSE-7: RISK ADJUSTMENT BY DEVIATION FROM NATIONAL MEAN POPULATION DENSITY

POPULATION DENSITY DEVIATIONS FROM MEAN	RISK FACTOR ADJUSTMENT	POPULATION IMPACTED
More than 1 below	-1	8,978
1 below to 1 above	0	37,053
1 above to 2 above	0	62,547
2 above to 3 above	+1	45,618
More than 3 above	+1	73,258

[1] Data is from the report Distance Profiles for U.S. Metropolitan Statistical Areas: 2000 and 2010 (US Census Bureau).
[2] Zero is 1.05 standard deviations below the mean. Therefore one standard deviation below the mean was deemed an appropriate threshold to define areas of low population density.

FIGURE OSE-4: POPULATION DENSITY MAP—STUDY AREA



In this analysis, flood risk adjusted for population density will be referred as life safety risk. The tables and figures below compare life safety risk for the Recommended Plan. Tables OSE-5 and OSE-6 list the number of people in each risk category for the existing and future condition. The maps in figures OSE-7 and OSE-8 show existing and future life safety risk.

TABLE OSE-5: POPULATION BY LIFE SAFETY RISK CATEGORY—EXISTING CONDITION

FLOOD RISK	ALTERNATIVE	
	NO ACTION	LS-7A
Very Low	41,845	48,427
Low	84,256	118,501
Medium	71,939	50,720
High	27,757	9,165
Very High	1,658	643

TABLE OSE-6: POPULATION BY LIFE SAFETY RISK CATEGORY—FUTURE CONDITION

FLOOD RISK	ALTERNATIVE	
	NO ACTION	LS-7A
Very Low	41,845	44,039
Low	82,913	120,667
Medium	72,287	52,942
High	28,693	9,165
Very High	1,718	643

FIGURE OSE-7: LIFE SAFETY RISK— ALTERNATIVE LS-7A —EXISTING CONDITION

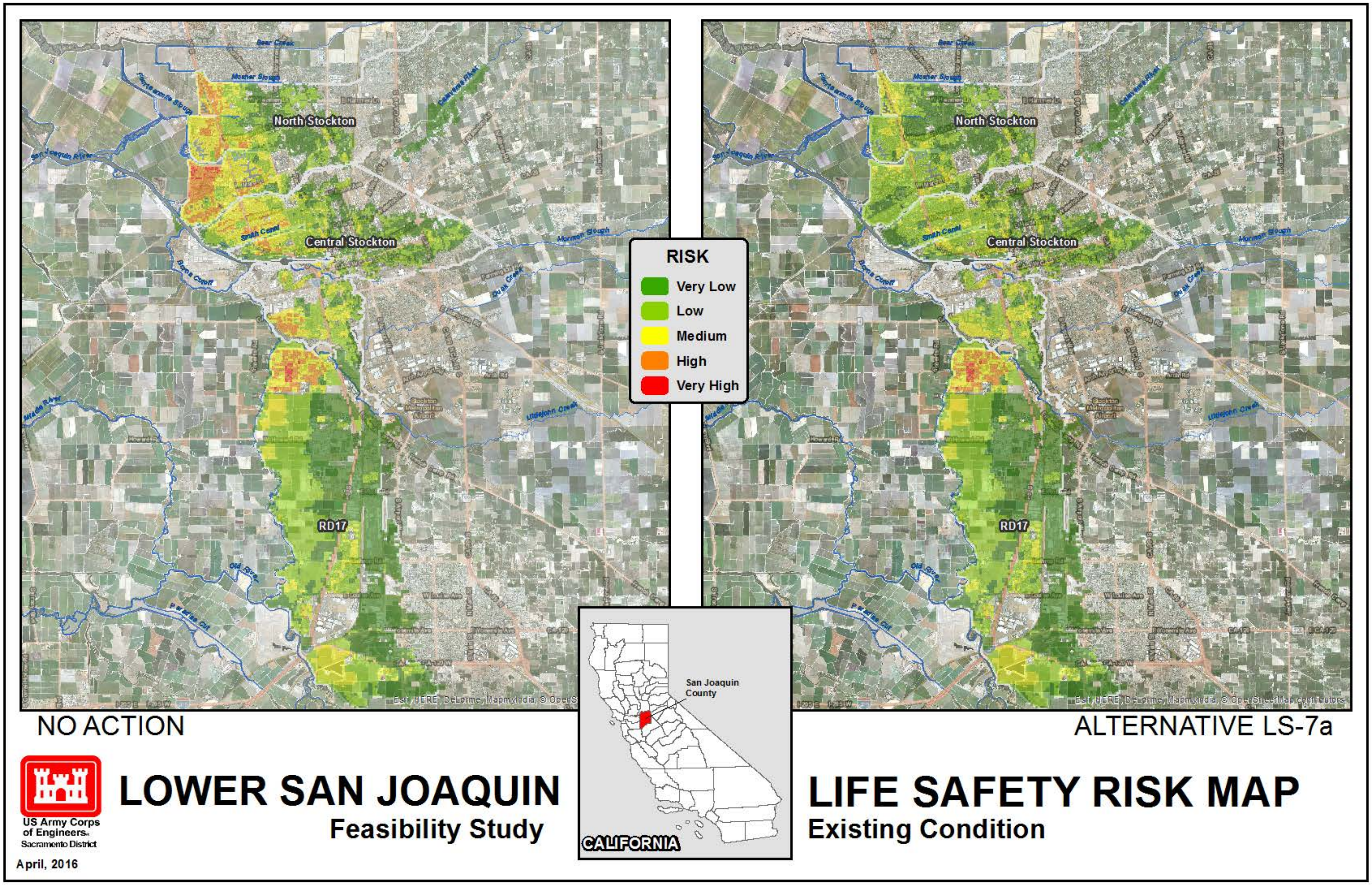
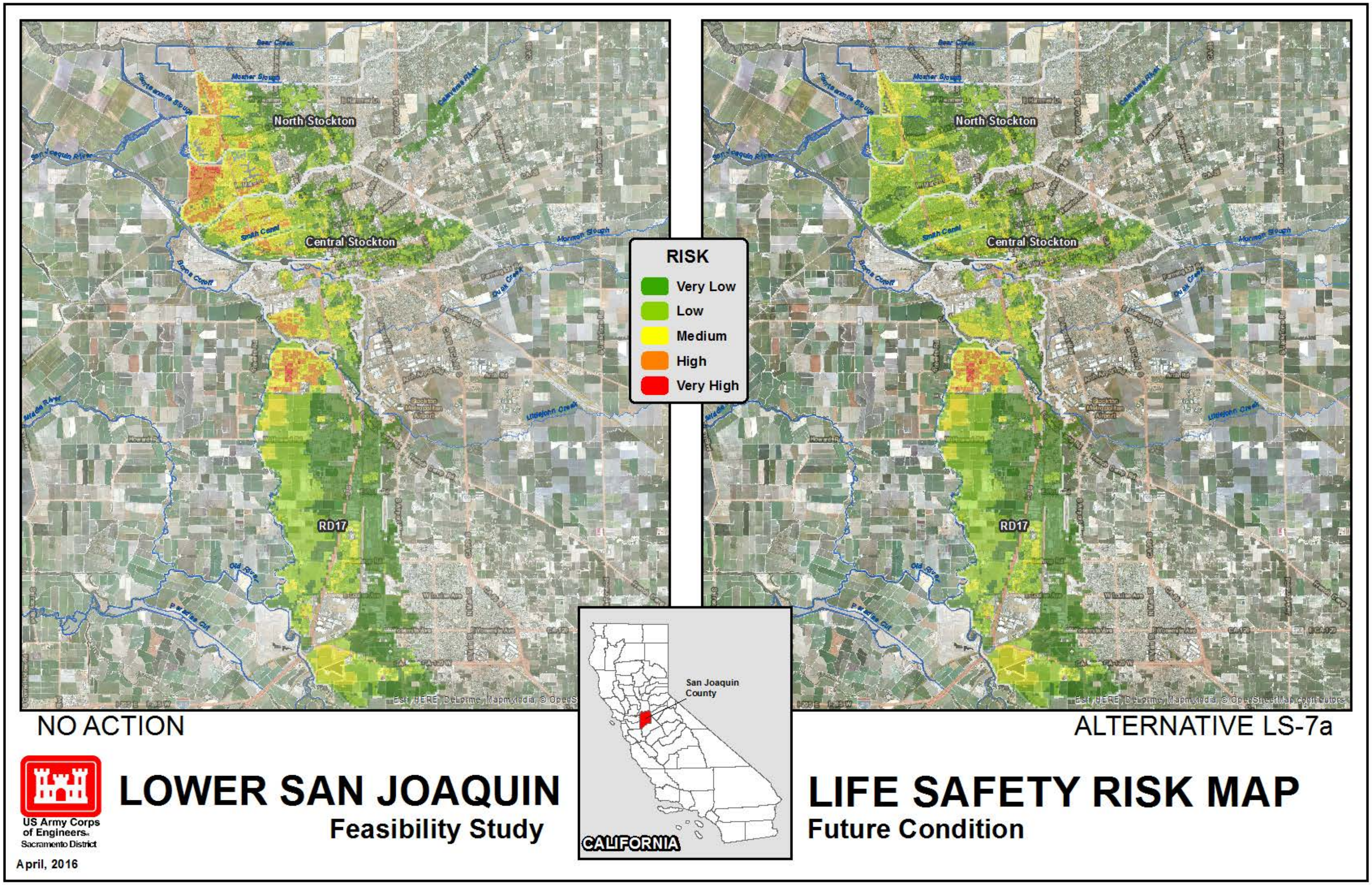


FIGURE OSE-8: LIFE SAFETY RISK— ALTERNATIVE LS-7A —FUTURE CONDITION



ATTACHMENT 2: REGIONAL ECONOMIC DEVELOPMENT

REGIONAL ECONOMIC DEVELOPMENT

PURPOSE AND METHODOLOGY

The U.S. Army Corps of Engineers (USACE) Planning Guidance Notebook (ER 1105-2-100) states that while the National Economic Development (NED) and Environmental Quality (EQ) accounts are required, display of the Regional Economic Development (RED) effects are discretionary. The Corps' NED procedures manual affirms that RED benefits are real and legitimate; however, the concern (from a Federal perspective) is that they are often offset by RED costs in other regions. Nevertheless, for the local community these benefits are important and can help them in making their preferred planning decisions.

Although the RED account is often examined in less detail than NED, it remains useful. For example, Hurricane Katrina caused a significant economic hardship to not just the immediate Gulf Coast but for entire counties, watersheds, and the state of Louisiana. Besides the devastating damage to homes (which are often captured by the NED account), hundreds of thousands of people lost their jobs, property values fell, and tourism and tax revenues declined significantly and were transferred to other parts of the U.S. In this example, the RED account can provide a better depiction of the overall impact to the region.

The distinction between NED and RED is a matter of perspective, not economics. A non-federal partner may consider the impacts at the state, regional, and local levels to be a true measure of a project's impact or benefit, whereas from the Corps' perspective, this may not constitute a national benefit. Gains in RED to one region may be partially or wholly offset by losses elsewhere in the nation. For example, if a Federal project enables a firm to leave one state to relocate to a newly-protected floodplain of another state, the increase in regional income for the project area may come at the expense of the former area's loss. In this case, there is no net increase in the value of the nation's output of goods and services and should be excluded from NED computations.

The following sections describe the impacts of the final array of alternatives from a regional perspective. The impacts were evaluated using the Corps' certified Regional Economic System (RECONS) software.

KEY RED CONCEPTS

Econometric analysis allows for the evaluation of a full range of economic impacts related to specific economic activities by calculating effects of the activities in a specific geographic area. These effects are:

- Direct effects, which consist of economic activity contained exclusively within the designated sector. This includes all expenditures made by the companies or organizations in the industry and all employees who work directly for them.
- Indirect effects, which define the creation of additional economic activity that results from linked business, suppliers of goods and services, and provisions of operating inputs.
- Induced effects, which measure the consumption expenditures of direct and indirect sector employees.

Input-output (I/O) models are characterized by their ability to evaluate the effects of industries on each other. Unlike most typical measures of economic activity that examine only the total output of an industry or the final consumption demand provided by a given output, I/O models provide a much more comprehensive view of the interrelated economic impacts. I/O analysis is based on the notion that there is a fundamental relationship between the volume of output of an industry and the volume of the various inputs used to produce that output. Industries are often grouped into production, distribution, transportation, and consumption categories. Additionally, the I/O model can be used to quantify the multiplier effect, which refers to the idea that an increase in spending can lead to an even greater increase in income and consumption, as monies circulate (or multiply) throughout the economy.

FLOOD RISK MANAGEMENT RED CONSIDERATIONS

There are particular effects for each type of project improvement as they relate to the RED account. The estimation of RED flood-related effects can be very complex. At a minimum, the RED analysis should include a qualitative description of the types of businesses at risk from flooding, particularly those that could have a significant adverse impact (output, employment, etc.) upon the community or regional economies if their operations should be disrupted by flooding and how this would be affected by the recommended project. The potential RED effects to flood risk management projects are summarized in Table RED-1 below.

TABLE RED-1: POTENTIAL RED EFFECTS TO FLOOD RISK MANAGEMENT

RED FACTOR	POTENTIAL RED EFFECTS
Construction	Additional construction related activity and resulting spillovers to suppliers
Revenues	Increased local business revenues as a consequence of reduced flooding, particularly from catastrophic floods
Tax Revenues	Increased income and sales taxes from the direct project and spillover industries
Employment	Short-term increase in construction employment; with catastrophic floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains)
Population Distribution	Disadvantage groups may benefit from the creation of a flood-free zone
Increased Wealth	Potential increase in wealth for floodplain residents as less is spent on damaged property, repairs, etc.; potential increase in property values.

RECONS SOFTWARE

A variety of software programs are available to measure the RED impacts of a project. The Corps of Engineers' Institute for Water Resources (IWR) along with the Louis Berger Group has developed a regional economic impact modeling tool called Regional Economic System (RECONS) that computes estimates of regional and national job creation, retention, and other economic measures. The expenditures made by the USACE for various services and products generate economic activity that can be measured in jobs, income, sales, and gross regional product (GRP). The software automates calculations and generates estimates of economic measures associated with USACE's annual civil works program spending. RECONS was built by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations by the Minnesota IMPLAN Group. These multipliers were then imported into a database. The software ties various spending profiles to the matching industry sectors by location to produce economic impact estimates. The RECONS program is used to document the performance of direct investment spending of the USACE, and allows users to evaluate project and program expenditures associated with annual expenditures.

REGIONAL PROFILE

The economic impacts presented below show the Lower San Joaquin River Feasibility study area and the state of California's interrelated economic impacts resulting from an injection of flood risk management construction funds. For this assessment, the study area and the state of California were both used as the geographic designation to assess the overall impacts to the regional economy from constructing the TSP. This places a frame around the economic impacts where the activity is internalized; leakages, which are payments made to imports or value added sectors that do not in turn re-spend the dollars within the area, are not included in the total impacts.

Table summarizes the complex nature of the regional economy of the Stockton, CA Metropolitan Statistical Area (MSA), which has a population of approximately 750,000. There are approximately 288,000 people employed in the MSA who provide an output to the nation of nearly $40 billion annually.

TABLE RED-2: REGIONAL PROFILE – STOCKTON, CA MSA
(DOLLAR VALUES IN $MILLIONS, OCTOBER 2014 PRICE LEVEL)

INDUSTRY	OUTPUT	LABOR INCOME	GRP	EMPLOYMENT
Accommodations and Food Service	$968	$328	$495	17,075
Administrative and Waste Management Services	$929	$482	$606	16,388
Agriculture, Forestry, Fishing and Hunting	$2,197	$614	$1,046	19,679
Arts, Entertainment, and Recreation	$227	$64	$104	2,872
Construction	$2,773	$1,151	$1,260	18,849
Education	$823	$609	$681	14,617
Finance, Insurance, Real Estate, Rental and Leasing	$3,348	$783	$2,222	18,799
Government	$3,041	$2,348	$2,665	34,727
Health Care and Social Assistance	$2,735	$1,503	$1,762	30,375
Imputed Rents	$3,022	$447	$1,904	17,145
Information	$1,787	$196	$387	3,219
Management of Companies and Enterprises	$303	$132	$176	1,492
Manufacturing	$9,093	$1,335	$2,155	21,820
Mining	$74	$23	$45	230
Professional, Scientific, and Technical Services	$1,215	$505	$682	9,394
Retail Trade	$2,362	$1,015	$1,616	32,939
Transportation and Warehousing	$2,033	$897	$1,268	16,116
Utilities	$1,082	$176	$408	1,235
Wholesale Trade	$1,871	$703	$1,208	11,425
Total	$39,883	$13,311	$20,690	288,396

INPUT COSTS

The RED analysis requires the adjustment of costs for two items: (1) interest during construction (IDC) and (2) purchases of land. Interest during construction is used in the NED analysis to estimate the opportunity cost of using money for one economic endeavor (*e.g.*, building a FRM project) instead of another (*e.g.*, building a bullet train); IDC is not actually expended within the region and therefore is not included in the RED analysis. Similarly, the purchase of land, not including administrative costs, is considered a transfer payment from one party to another and therefore is also not included in the RED analysis.

Tables RED-3 shows the regional expenditures expected over the construction period for the Recommended Plan. Local capture rates are provided by RECONS and show where the output from expenditures is realized.

TABLE RED-3: INPUTS ASSUMPTIONS—STOCKTON, CA MSA—ALTERNATIVE LS-7A

CATEGORY	SPENDING	SPENDING AMOUNT ($)	LOCAL PERCENTAGE CAPTURE		
			LOCAL	STATE	NATIONAL
Aggregate Materials	8.3%	43,076,775	74%	77%	97%
Other Materials	1.1%	5,916,871	100%	100%	100%
Equipment	29.2%	150,993,640	82%	99%	100%
Construction Labor	46.1%	238,602,790	100%	100%	100%
Explosives Materials	0.1%	439,572	8%	47%	86%
Cement Materials	0.3%	1,794,919	7%	73%	92%
Metals and Steel Materials	1.2%	6,263,901	18%	56%	90%
Machinery Materials	0.5%	2,710,694	13%	46%	79%
Electrical Materials	0.6%	3,150,266	19%	44%	80%
Lumber Materials	0.1%	439,572	24%	56%	90%
Fish Hatcheries, Wildlife Facilities, and Sanctuaries Maintenance and Upgrades	9.6%	49,820,000	100%	100%	100%
Cultural Resources Protection Activities	2.8%	14,592,000	40%	99%	99%
TOTAL	**100.0%**	**517,801,000**	**88.5%**	**96.4%**	**99.3%**

RECONS OUTPUT

The expenditures made by the Corps of Engineers for various services and products are expected to generate additional economic activity, which can be measured in jobs, income, sales, and GRP. Regional, state, and national impacts are summarized in Table RED-4. Detailed accounts of these economic impacts are shown in Tables RED-5 through RED-7.

TABLE RED-4: SUMMARY OF ECONOMIC IMPACTS (MONETARY VALUES IN $1,000S)

IMPACT	IMPACT		
	REGIONAL	STATE	NATIONAL
Output	$802,935	$1,016,661	$1,371,534
Jobs	8,795	9,955	11,906
Labor Income	$433,463	$510,647	$624,475
GRP	$571,958	$694,794	$888,589

TABLE RED-5: REGIONAL ECONOMIC IMPACTS—ALTERNATIVE LS-7A (MONETARY VALUES IN $1,000S)

Industry Sector	Sales	Jobs	Labor Income	GRP
Direct Effects				
Scientific research and development services	$5,882	43	$2,447	$2,450
Maintenance and repair construction of nonresidential structures	$49,796	317	$22,545	$28,368
All other chemical product and preparation manufacturing	$5	0	$0	$1
Cement manufacturing	$0	0	$0	$0
Steel product manufacturing from purchased steel	$406	1	$85	$101
Other industrial machinery manufacturing	$51	0	$16	$19
Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$15,675	74	$9,334	$10,445
Switchgear and switchboard apparatus manufacturing	$233	1	$52	$108
Wholesale trade businesses	$1,484	9	$560	$1,119
Retail Stores - Furniture and home furnishings	$23	0	$8	$14
Retail Stores - Electronics and appliances	$69	1	$22	$37
Retail Stores - Building material and garden supply	$4	0	$2	$3
Transport by air	$1	0	$0	$0
Transport by rail	$1,151	3	$353	$611
Transport by water	$327	1	$83	$159
Transport by truck	$14,937	109	$7,253	$8,543
Construction of other new nonresidential structures	$5,917	34	$2,488	$3,096
Commercial and industrial machinery and equipment rental and leasing	$123,305	382	$34,237	$69,882
Labor	$238,603	5,301	$238,603	$238,603
Engineered wood member and truss manufacturing	$51	0	$17	$21
Total Direct Effects	457,921	6,276	318,106	363,580
Secondary Effects	345,014	2,520	115,357	208,378
Total Effects	**802,935**	**8,796**	**433,463**	**571,958**

TABLE RED-6: STATE ECONOMIC IMPACTS—ALTERNATIVE LS-7A (MONETARY VALUES IN $1,000S)

Industry Sector	Sales	Jobs	Labor Income	GRP
Direct Effects				
Scientific research and development services	$14,400	104	$7,624	$7,630
Maintenance and repair construction of nonresidential structures	$49,796	317	$22,545	$28,368
All other chemical product and preparation manufacturing	$162	0	$25	$37
Cement manufacturing	$1,122	2	$251	$510
Steel product manufacturing from purchased steel	$2,456	5	$513	$609
Other industrial machinery manufacturing	$742	3	$239	$279
Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$16,536	79	$9,847	$11,019
Switchgear and switchboard apparatus manufacturing	$768	2	$172	$356
Wholesale trade businesses	$2,582	15	$1,044	$1,974
Retail Stores - Furniture and home furnishings	$33	0	$13	$21
Retail Stores - Electronics and appliances	$108	1	$42	$63
Retail Stores - Building material and garden supply	$4	0	$2	$3
Transport by air	$11	0	$3	$5
Transport by rail	$1,151	3	$353	$611
Transport by water	$340	1	$86	$165
Transport by truck	$14,937	109	$7,253	$8,543
Construction of other new nonresidential structures	$5,917	34	$2,488	$3,096
Commercial and industrial machinery and equipment rental and leasing	$149,354	465	$41,470	$84,645
Labor	$238,603	5,301	$238,603	$238,603
Engineered wood member and truss manufacturing	$163	1	$54	$68
Total Direct Effects	499,184	6,442	332,625	386,605
Secondary Effects	517,476	3,512	178,022	308,189
Total Effects	**1,016,661**	**9,954**	**510,647**	**694,794**

Table RED-7: National Economic Impacts—Alternative LS-7a (Monetary values in $1,000s)

Industry Sector	Sales	Jobs	Labor Income	GRP
Direct Effects				
Scientific research and development services	$14,406	104	$7,628	$7,634
Maintenance and repair construction of nonresidential structures	$49,806	317	$22,549	$28,374
All other chemical product and preparation manufacturing	$331	1	$55	$80
Cement manufacturing	$1,464	3	$328	$666
Steel product manufacturing from purchased steel	$4,538	9	$947	$1,125
Other industrial machinery manufacturing	$1,634	7	$525	$614
Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$23,911	126	$14,239	$15,933
Switchgear and switchboard apparatus manufacturing	$1,899	5	$447	$922
Wholesale trade businesses	$2,617	15	$1,059	$2,001
Retail Stores - Furniture and home furnishings	$34	0	$13	$22
Retail Stores - Electronics and appliances	$108	1	$42	$63
Retail Stores - Building material and garden supply	$4	0	$2	$3
Transport by air	$15	0	$4	$7
Transport by rail	$1,359	4	$420	$723
Transport by water	$492	1	$125	$239
Transport by truck	$15,727	115	$7,636	$8,995
Construction of other new nonresidential structures	$5,917	34	$2,488	$3,096
Commercial and industrial machinery and equipment rental and leasing	$150,773	471	$41,864	$85,450
Labor	$238,603	5,301	$238,603	$238,603
Engineered wood member and truss manufacturing	$311	2	$102	$129
Total Direct Effects	513,950	6,516	339,077	394,679
Secondary Effects	857,584	5,389	285,399	493,910
Total Effects	**1,371,534**	**11,905**	**624,475**	**888,589**