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SENT VIA EMAIL (oal_amendRRP1@deltacouncil.ca.gov)

Erin Mullin, P.E., Senior Engineer
Anthony Navasero, P.E., Senior Engineer
Delta Stewardship Council
980 Ninth Street, Suite 1500
Sacramento, CA 95814

RE: Comments on Proposed Rulemaking to Implement Delta Levee Investment Strategy

Dear Ms. Mullin and Mr. Navasero:

Local Agencies of the North Delta ("LAND")[1] previously submitted comments on the prior Prioritization of State Investments in Delta Levees and Risk Reduction rulemaking, as well as comments on the Delta Levees Investment Strategy ("DLIS") Delta Plan Amendment. LAND continues to have concerns regarding the use of the DLIS priority matrix, which the proposed rule would incorporate into California Code of Regulations, Title 23, sections 5001 and 5012. The rigid priority system would lock out islands and tracts from necessary funding, endangering lives and businesses across the Delta.

The Delta Stewardship Council's ("Council") Economic and Fiscal Impact Analysis of Proposed Amendments to Prioritization of State Investments in Delta Levees and Risk Reduction ("Economic Analysis") is inadequate and fails to provide the "tools to determine whether the regulatory proposal is an efficient and effective means of implementing the policy decisions enacted in statute or by other provisions of law in the least burdensome manner." (See Gov. Code, § 11346.3, subd. (a), (b), (e).) Additionally, the Council lacks the legal authority for this rulemaking. For these reasons, LAND requests that the Council revise the Rulemaking Package to conform with applicable requirements prior to adoption and provide the public with an adequate opportunity to review and comment on those changes.

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[1] LAND is a coalition comprised of reclamation, water and levee maintenance districts covering about 100,000 acres in the northern geographic area of the Delta. Some of these agencies provide both water delivery and drainage services, while others only provide drainage services. These districts also assist in the maintenance of the levees that provide flood protection to homes and farms.

The Council Lacks the Authority for the DLIS Rulemaking

The Initial Statement of Reasons cites the Delta Reform Act provision, Water Code section 85306, which requires the Delta Plan to "recommend priorities for State investments in levee operation, maintenance, and improvements in the Delta," as the authority for this rulemaking. (Initial Statement of Reasons, p. 2.) Statutory direction to recommend priorities does not grant authority to codify a rigidly tiered priority matrix as a regulation. As the Council states in the Economic Analysis for the DLIS rulemaking, DWR would only be free to disperse state funds to Other and High Priority islands and tracts so long as no Very-High Priority projects are on the current grant cycle. (Economic Analysis, p. 7.) To recommend is to endorse or suggest a course of action, not to command. The Council is acting beyond its legal authority in making DLIS a legally enforceable regulation.

Further, the Council's assertions that "without a prioritization method, the apportionment of public resources into levees may not occur in a manner that reflects a broader, long-term approach." (Initial Statement of Reasons, p. 3.) The Council provides no evidence to support this assertion, which is merely a quote from the 2013 Delta Plan. Moreover, the Council fails to state exactly what the problem the DLIS priority system is supposedly correcting. While making a recommendation on prioritization is necessary under the Delta Reform Act, a recommendation that does not limit DWR's discretion would be superior to the DLIS priority system the Council intends to codify. This is particularly important in light of the need to make repairs after storms and flooding events. Such events affect large areas and impact levees irrespective of priority designation. Limiting DWR's discretion to respond to such events creates a higher risk of devastating impacts to the Delta economy and communities.

Comments on Cost Analysis and Economic Impacts of Rulemaking Package

Major regulations, those with an economic impact of $50 million or higher (Gov. Code, § 11342.548), undergo a separate economic analysis than non-major regulations. The Council asserts that the DLIS Rulemaking is not a major regulation. In doing so, the Council overlooks the potential large economic costs of the rigid priority system. A fundamental flaw in the Council's analysis of the DLIS Rulemaking is the failure to consider Delta levees as a system. "[T]he key to preserving the delta's physical characteristics is the system of levees defining the waterways and producing the adjacent islands." (Wat. Code, § 12981, subd. (b).) The DLIS priority system treats levees, islands and tracts as divisible and distinct entities.

Delta levees provide for or protect nearly every element of the Delta's economic assets and value, including: productive farmland and the ripple effect of the agricultural

economy; residential and commercial structures; reducing flood-control costs; critical infrastructure; water quality for municipal and industrial use; wildlife habitat; water conveyance; recreational opportunities; public safety; and preserving future beneficial uses. (See attached Exhibit A, Delta Sustainability Plan excerpt, p. 89; also available at: http://delta.ca.gov/wp-content/uploads/2016/10/Final_ESP_w_Appendices_2012.pdf.) Delta agriculture alone generates $5.372 billion in economic output. (*Id*. at 112.)

The DLIS priority system would result in some levees failing to meet adequate minimum engineering standards, and result in higher numbers of levee failures as Other and High Priority islands and tracts are ignored. Increasing the risks of levee failures would endanger the entire Delta economy to a degree that may vastly exceed the $50 million benchmark for major regulations. A significant flood event within the mean higher high water limits would cause approximately $6.7 billion in infrastructure damage alone. (See attached Exhibit B, Delta Risk Management Strategy Phase 1: Impact to Infrastructure Final Technical Memorandum, p. 1.) The Council must reevaluate the DLIS rulemaking by considering all impacts of withholding levee repair funds from a majority of islands and tracts.

As is, the Economic Analysis is incomplete and incorrect, and fails to disclose the large economic costs of the rigid DLIS priority system. The economic harm to in-Delta communities, industries and individual interests is not disclosed, as the Economic Analysis does not acknowledge the potential impacts of implementing DLIS.

The Economic Analysis demonstrates the Council's truncated perspective of DLIS. The Economic Analysis gives mere lip service to the economic effects of changes to "timing and distribution of Delta levee investments," characterizing them as "negligible." (Economic Analysis, p. 4.) As the Economic Analysis concedes, $47.1 million, or 60% of all state levee expenditures from 2008 to 2015, went towards Other Priority or High Priority islands and tracts. (Economic Analysis, pp. 6-7.) The DLIS priority system would jeopardize this funding so that the Very-High Priority islands and tracts' funding "would not be affected." (*Id*. at 7.) The "conservative" assumptions that, under DLIS, 100% of funds would go towards Very-High Priority islands and tracts, represents a harrowing scenario where significant portions of the Delta would be left at risk. (*Ibid*.)

The Council misrepresents the amount of discretion DWR would have to allocate funds in a manner other than the "conservative" assumptions in the Economic Analysis. The Council implies that only if "there are no proposed projects on Very-High Priority islands or tracts for a given grant cycle, then DWR can fund projects for High Priority islands or tracts (and Other Priority islands or tracts if there are no proposed projects for High Priority islands or tracts)." (*Id*. at 7.) This is not discretion; this is a description of a rigid tiering system. The Council's suggestion that DLIS only "could change the

timing of State investment in Delta levees but would not change the overall level of investment" contradicts the assumptions in the Economic Analysis. (*Id* at 8.)

Removing all $47.1 million in funding for Other and High Priority islands and tracts would risk costs exponentially higher than $1.77 million. Even without quantifying the true cost of leaving 60 percent of levees without repair funding, the Economic Analysis recognizes that shifting that funding to Very-High Priority would still provide a smaller benefit than the costs. The DLIS priority system could also disproportionately endanger legacy communities, another economic impact the Council has overlooked. The levees protecting Courtland, Clarksburg, Locke and the eastern side of Walnut Grove are all designated as Other Priority. This is inconsistent with protection of the Delta as a place as required by Public Resources Code section 29702, subdivision (a). (See also Cal. Code Regs., tit. 23, § 5011 [Respect Local Land Use].)

The Economic Analysis also overlooks potential costs, which would arise from a lack of State investment in Other and High Priority islands and tracts. Quantifying economic costs merely in terms of changes to land values treats the Delta as static. (Economic Analysis, p. 8.) Levee repairs and other projects, which would otherwise have been eligible for funding, will arise in Other and High Priority islands and tracts. However, with DLIS, the reclamation districts may be forced to absorb the entire cost of repairs. In response, reclamation districts responsible for Other and High Priority islands and tracts will need to raise assessment fees to meet these costs. The Economic Analysis fails to account for this cost to Delta landowners and businesses.

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Thank you for considering these comments; we are available to consult further regarding any questions staff may have about them.

Very truly yours,

SOLURI MESERVE
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By: 
Osha R. Meserve

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Attachments: Exhibit A, Economic Sustainability Plan for the Sacramento-San Joaquin Delta, Chapter 5, 6, 7.
Exhibit B, Delta Risk Management Strategy Phase 1: Impact to Infrastructure Final Technical Memorandum

EXHIBIT A

Chapter 5: Flood, Earthquake and Sea-Level Rise Risk Management

5.1 Overview and Key Findings

The present-day Delta is defined geographically and hydraulically by levees, creating a landscape that differs from that of the historic, natural Delta. In place since the early 20th century, the current-day levee system provides flood control, channels water for urban and agricultural uses, and creates an environment unique in California. According to the Delta Reform Act of 2009, it is the policy of the state to "protect, maintain, and, where possible, enhance and restore the overall quality of the Delta environment, including, but not limited to, agriculture, wildlife habitat, and recreational activities" and also to "improve flood protection by structural and non-structural means to ensure and increased level of public health and safety."[36] These goals require a robust levee system supplemented by a superior emergency flood-fighting and public safety system for limiting or preventing losses when floods or earthquakes present a threat to levee stability.

For the purposes of this plan, an up-to-date map of Delta levees was created. This map serves as the basis for an updated tabulation of levee lengths, which shows that in the Legal Delta, there are just under 1,000 miles of permanently maintained levees, of which 380 miles are project levees constructed or improved by the U.S. Army Corps of Engineers (USACE), and an additional 63 miles are urban non-project levees, as defined by recent state legislation. Within the overall total, there are 613 miles of "lowland" levees, defined as those levees that protect lands in the Delta that are below sea level. The lowland levees are the levees that are most critical to the preservation of the Delta and to achieving the coequal goals of water supply reliability and ecosystem restoration. Of these lowland levees, 143 miles are project levees located largely along the Sacramento River. The remaining 470 miles of non-project lowland levees need to be maintained and enhanced primarily by the state and the local reclamation districts.

Of the 470 miles of non-project, lowland levees, less than 100 miles fall below FEMA's Hazard Mitigation Plan (HMP) "standard" and another 100 miles or so are already at or about the Corps of Engineers Delta-specific PL 84-99 standard. While the first priority should be to bring all Delta levees up to at least the HMP standard, it has been the goal of the state and federal governments, working through the Department of Water Resources (DWR), the U.S. Army Corps of Engineers (USACE), and the local reclamation districts, to meet the higher Delta-specific PL 84-99 standard since 1982 when DWR and USACE produced a joint report on the Delta levees which recommended the basis for this standard. Funds currently available from the Federal government, voter-approved state bond measures, and local cost shares should bring all Delta levees close to achieving this goal. When funds currently in the immediate pipeline have been expended, more than $698 million will have been invested in improvements to the Delta levees since 1973. These improvements have created significantly improved Delta levees through modern engineering and construction, making obsolete the historic data that is still sometimes used for planning or predicting rates of levee failure.

Three approaches can help all jurisdictions and planners further reduce the risks resulting from the failure of the Delta levees. These approaches are: (1) build even more robust levees, (2) improve regular maintenance and inspections, flood-fighting and emergency response following earthquakes, and (3) improve preparedness for dealing with failures after they occur. In connection with the first approach, the big question with respect to the lowland levees in

[36] Delta Reform Act, 2009, W.C. 29702 (b), (d)

particular is not whether they should be improved to the Delta-specific PL 84-99 standard—that is already happening—but whether they should be improved to a higher standard in order to address hazards posed by floods, earthquakes, and sea-level rise. These improvements would also allow for planting vegetation on the water side of the levees—an essential component Delta ecosystem repair. These further-improved levees would have wider crowns to provide for two-way traffic and could easily be further widened at selected locations to allow the construction of new tourist and recreational facilities out of the statutory floodplain. Improvement of most lowland levees and selected additional levees to this higher standard is estimated to have base engineering and construction costs of $1-2 billion. Enhancements for ecosystem restoration and other purposes and program management could increase the cost to as much as $4 billion. In addition, it is suggested that $50 million per year should be provided for continuing maintenance and inspections and emergency preparedness, response and recovery and that a single Delta region-centric agency should assume the responsibility for allocating this funding. Three broad sources of ongoing, long term funding and economic justifications for the investments are discussed later in this chapter.

These estimated costs are not dissimilar to that of the "Fortress Delta" strategy described in the 2007 "Envisioning Futures" report by the PPIC as one of the alternatives for increasing water supply. Provision of water supply reliability through improvement of the levee system now appears to be significantly cheaper than the proposed isolated conveyance. Regardless, a further-improved levee system will make a significant contribution to the achievement of the coequal goals of water supply reliability and ecosystem restoration that were stated in the Delta Reform Act rather than impeding it.

5.2 Background

The history of the Delta levees is relatively well-known (Thompson, 1957;[37] The Delta Atlas, 1995;[38] Mount and Twiss, 2005;[39] DRMS, 2009';[40] Delta Stewardship Council Flood Risk White Paper, 2010;[41] Zuckerman, 2011[42]) and is not repeated in its entirety here. Some of the levees in the Delta are flood-control project levees, built by the federal government and turned over to the state for maintenance, but most of the Delta levees were built or re-constructed and are maintained by local reclamation districts. There are only a few levees that are not maintained by local reclamation districts and are thus privately owned and maintained. The state has also passed responsibility for maintenance of most of the flood-control project levees to the local reclamation districts although it directly maintains some of the levees on the Sacramento River. Regardless of the state now relying on local reclamation districts for the execution of much of the work on Delta levees, much of this work is supported with state funds in recognition of the state's long-term interests and obligations. These obligations flow in part from the state's acceptance of the grant of federal lands in accordance with the Swamp and Overflowed Lands Acts. For example, in Kimball v. Reclamation Fund Commissioners,[43] the Supreme Court of

[37] Thompson, J., *Settlement Geography of the Sacramento-San Joaquin Delta*, *California,* Ph.D. dissertation, Stanford University, 1957.
[38] http://baydeltaoffice.water.ca.gov/DeltaAtlas/index.cfm
[39] Mount, J.F. and R. Twiss, *Subsidence, sea level rise, seismicity in the Sacramento-San Joaquin Delta*, San Francisco Estuary and Watershed Science, v. 3, article 5, 2005.
[40] California Department of Water Resources, Delta Risk Management Strategy Final Phase 1 Report, 2009, http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/phase1_information.cfm
[41] Delta Stewardship Council, Flood Risk White Paper, 2010, http://deltacouncil.ca.gov/delta-plan.
[42] Zuckerman, T., Comments on the Third Staff Draft of the Delta Plan, Delta Stewardship Council, 2011, http://deltacouncil.ca.gov/public-comments/read/195
[43] 45 Cal. 344, 1873

California held that he, Kimball "must be held to have known, when he took the title, that the state, by accepting the grant, had assumed an obligation to reclaim the land, and that it had already inaugurated a system for that purpose. He was bound in law to take notice of the public statues above mentioned, and must be deemed to have accepted the title in subordination to the paramount right and duty of the state to cause the land to be reclaimed. He cannot now, therefore, be permitted to set up his own wishes, nor his private interests, in opposition to the performance, by the state, of the obligation which it assumed to the Federal Government."

A good summary of the history and current status of the Delta levees is also provided in a technical memorandum prepared for the Department of Water Resources (DWR) by outside consultants,[44] and referenced subsequently as the DWR Technical Memorandum (2011). The Technical Memorandum finds that the existing Delta levees comprise a system and that it is misleading to evaluate the value of individual levees or islands without considering the benefits that the overall system of levees provides, and that the Delta levees now protect much more than agriculture. In this respect the draft Technical Memorandum is simply repeating points made in the CALFED Levee System Integrity Program Plan,[45] which said:

> *The benefits of an improved Delta Levee system include greater protection to the Delta agricultural resources, municipalities, infrastructure, wildlife habitat, and water quality as well as navigation and conveyance benefits. The wide range of beneficiaries of the Delta Levee System Integrity program include Delta local agencies; landowners; farmers; boaters; wildlife; and operators of railroads, state highway, utilities, and water distribution facilities. Delta Water users and exporters also benefit from increased protection to water quality. Federal interests benefit from improvements to conveyance, navigation, commerce, and the environment, and from reduced flood damage.*

In the language of the draft Technical Memorandum:

> *While some reports propose leaving islands flooded or state that it is too expensive to continue a state grants program for levee maintenance, the fact remains that a large portion of the state economy is dependent on export water, which in turn is dependent upon the Delta levees for preservation of water quality and for conveyance. If a decision were made today to address this single issue, it would require more than a decade before an alternative conveyance could be in place. During all of that time the purity and availability of export flow would remain dependent on the Delta levee system. Delta levees provide protection for a wide variety of benefits. If levees fail and several islands were flooded, adverse consequences would be expected far beyond direct loss due to flooding on islands and tracts. Most island surfaces are so far below sea level that the resulting deep water would contrast markedly with the 1850 "natural" Delta. The water body created by a levee failure may be good habitat for some species and poor habitat for others. Tidal exchange from Suisun and San Francisco Bays would be increased and Delta salinity would be likely to rise at least during dry seasons and dry years. Water supply conveyance to remaining Delta islands, to Contra Costa County, and to the State*

[44] California Department of Water Resources, Staff DRAFT, "Background/Reference Memoranda, Delta Region Integrated Flood Management Key Considerations and Statewide Implications," July 15, 2011. This document was released for limited public review on July 15, 2011. Both the technical memorandum and the related "Framework for Department of Water Resources Investments in Delta Integrated Flood Management" are in draft form and are subject to change, but the basic findings of the technical memorandum are unlikely to change and several of its findings are mentioned herein.
[45] http://calwater.ca.gov/content/Documents/library/305-1.pdf

Water Project and the Central Valley Project may be disrupted by salinity intrusion some of the time. Infrastructure systems, including Delta highways and pipelines, might be blocked. Delta towns and their economic activity might be jeopardized. Adjacent islands would become much more vulnerable due to seepage or increased wave action.

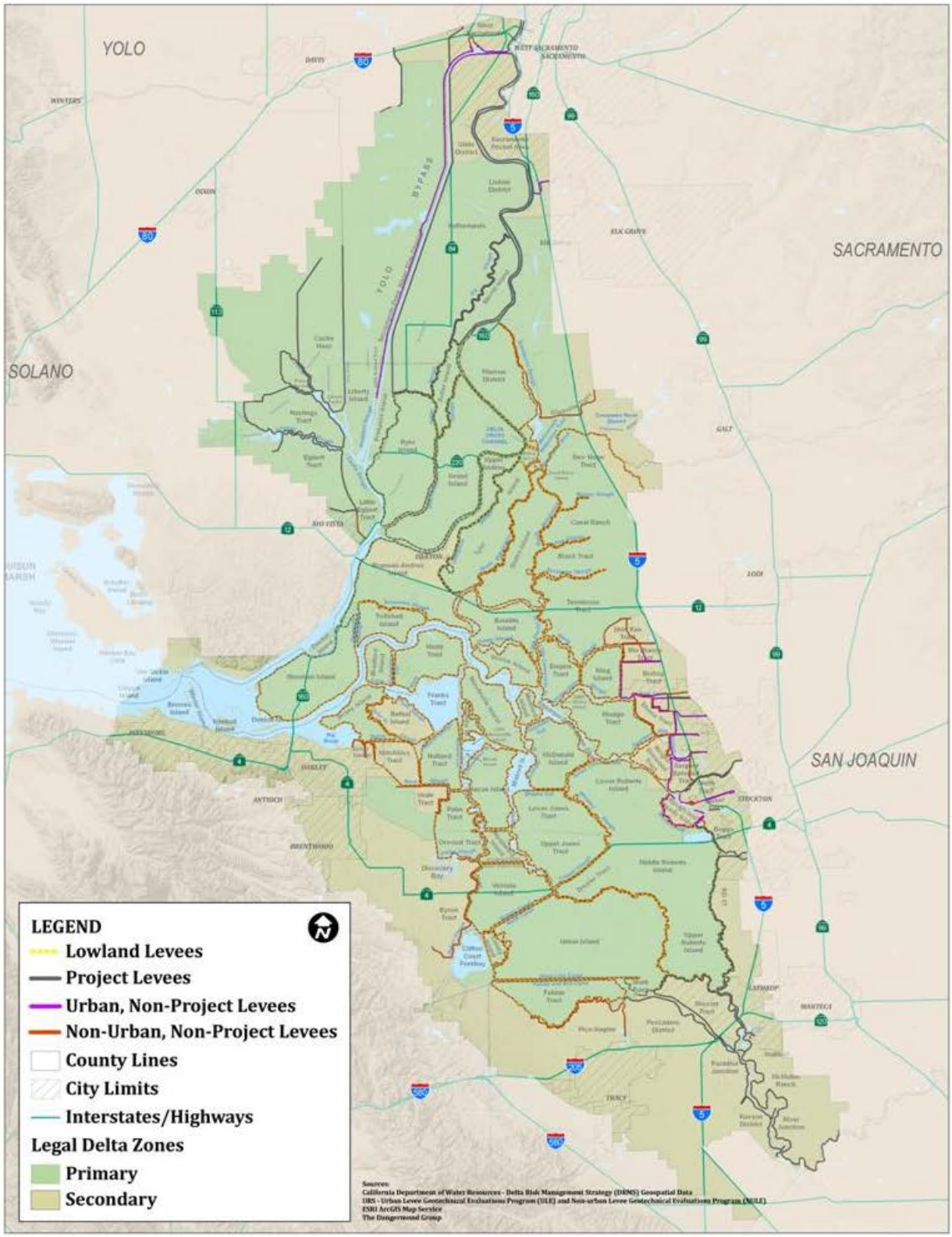
The principal Delta levees that are currently being maintained are shown in Figure 10 and are listed in Table 1. Previous listing of Delta levees have been provided in the Table 6 of the Delta Atlas and in Table 3 of The CALFED Levee System Integrity Program Plan, but these listings and any accompanying maps are not available in electronic form and the accuracy of some of the mileages involved is questioned by reclamation district engineers. Therefore, in order to provide a table that was consistent with a current map, an updated listing was prepared as part of this study. DWR does not maintain a centralized GIS system, but with the help of DWR staff three different GIS data sets, all based on the 2007 LiDAR surveys conducted for DWR, were obtained from two different offices of URS Corporation. The most complete of these was labeled "Division of Flood Management" and this was used as starting point in developing an updated map. However, because many embankments which do not represent levees that are currently being maintained, are height-limited levees, or are dry-land levees that are not considered to be primary flood control levees, these were deleted. It should be noted, however, that some dry-land levees may potentially perform important functions in reducing losses in the emergency response phase should there be a failure and such levees should be included as elements of the overall flood protection system. Canal embankments were also not mapped as levees in this data set but the embankments on either side of the Delta Cross Channel and the northern side of the Contra Costa Canal on Hotchkiss Tract have been counted as flood-control levees in our compilation. In a GIS system all lines are modeled as segments whose lengths can be calculated automatically so that the total lengths around each island or tract can readily be obtained and these are the lengths that are shown in Table 1. Thus the map in Figure 10 and the lengths listed in Table 1 are consistent with each other. To the extent possible, the lengths have been cross-checked with ground survey data provided by reclamation district engineers.[46]

By way of comparison with Figure 10, a reconstruction of the historic Delta based on Atwater (1982)[47] is shown in Figure 11. Figure 11 shows that the historic Delta contained no large expanses of open water, but instead was comprised of a dendritic system of channels and sloughs that traversed generally marshy terrain. Natural levees, created along the edges of major waterways, were overtopped only in high water events and supported riparian and even upland vegetation. When the modern Delta was created by diking and dredging in the late 19th century and very early 20th centuries, some of the man-made levees were constructed over the natural levees, but many were not. Those waterways that were created by dredging do not have bordering levees that were founded on natural levees. In many other cases the modern levees were not sited directly over the natural levees. Sketches developed by KSN Inc. illustrating the history of development of both the dredger cuts and other modern levees are shown as Figures 12 and 13.

[46] Copies of Figure 10 and some of the subsequent figures in this chapter are not particularly legible when reproduced at normal report size but high resolution copies may be obtained by following the instructions on the DPC web site. These figures have been designed for use as wall posters with dimensions of about 3 by 4 feet.

[47] Atwater, B., Geologic Maps of the Sacramento-San Joaquin Delta, California, USGS Miscellaneous Field Studies Map MF-1401, 1982.

Figure 10 Delta Levees[48]



[48] For high resolution image see http://forecast.pacific.edu/desp-figs.html

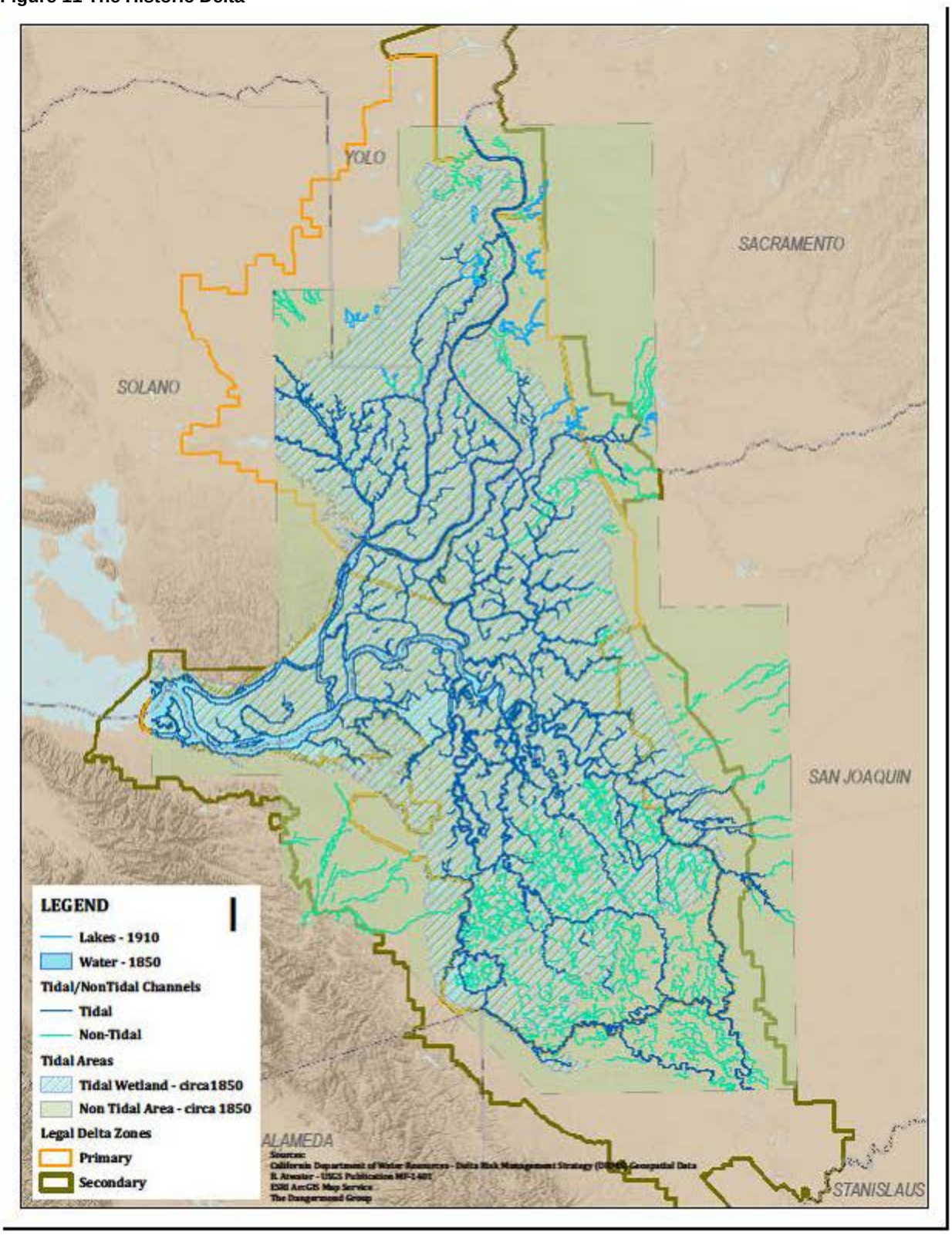
Table 1 Delta Levees (Part 1 of 2)

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(I)
List Number	District Number	Reclamation District	Miles of Levee				
			Project	Urban NP	NP-NU	Total	Lowland
1	556	Andrus Island	11.2	0.0	0.0	11.2	Yes
2	2126	Atlas Tract	0.0	2.3	0.0	2.3	No
3	2028	Bacon Island	0.0	0.0	14.3	14.3	Yes
4		Bear Creek	3.3	0.0	0.0	3.3	No
5		Bethel Island	0.0	0.0	11.5	11.5	Yes
6	2042	Bishop Tract	0.0	6.5	1.6	8.1	No
7	404	Boggs Tract	4.0	0.6	0.6	5.2	No
8	756	Bouldin Island	0.0	0.0	18.0	18.0	Yes
9	2033	Brack Tract	0.0	0.0	10.0	10.0	Yes
10	2059	Bradford Island	0.0	0.0	7.4	7.4	Yes
11	317/407	Brannan-Andrus	17.5	0.0	10.1	27.6	Yes
12	800	Byron Tract	0.0	0.0	9.5	9.5	No
13	2098	Cache Haas	10.9	0.0	0.0	10.9	No
14	2086	Canal Ranch	0.0	0.0	7.5	7.5	Yes
15	2117	Coney Island	0.0	0.0	5.5	5.5	Yes
16	2111	Dead Horse Is.	0.0	0.0	2.6	2.6	Yes
17	2137	Dutch Slough	0.0	0.0	4.1	4.1	No
19	536	Egbert Tract	10.6	0.0	1.8	12.4	No
20	813	Ehrheart	1.8	0.0	3.0	4.8	No
21	2029	Empire Tract	0.0	0.0	10.5	10.5	Yes
22	773	Fabian Tract	0.0	0.0	18.8	18.8	Yes
23	2113	Fay Island	0.0	0.0	1.6	1.6	Yes
24	1002	Glanville Tract	0.0	0.0	7.1	7.1	No
25	765	Glide	1.7	0.0	0.0	1.7	No
26	3	Grand Island	28.7	0.0	0.0	28.7	Yes
27	2060	Hastings Tract	15.6	0.0	0.0	15.6	No
28	999	Netherlands	32.2	0.0	0.0	32.2	No
29	2025	Holland Tract	0.0	0.0	11.0	11.0	Yes
30	799	Hotchkiss Tract	0.0	0.0	8.8	8.8	Yes
31	830	Jersey Island	0.0	0.0	15.5	15.5	Yes
32	2038/2039	Jones Tract	0.0	0.0	18.4	18.4	Yes
33	2085	Kasson	6.3	0.0	0.0	6.3	No
34	2044	King Island	0.0	0.0	9.1	9.1	Yes
35	369	Libby McNeil	1.0	0.0	2.8	3.8	Yes
36	1608	Lincoln Village	0.0	3.3	0.6	3.9	No
37	307	Lisbon	6.6	0.0	0.0	6.6	No
38		Maintenance Area 9	12.6	1.5	0.0	14.1	No
39	2027	Mandeville Island	0.0	0.0	14.3	14.3	Yes
40	2030	McDonald Island	0.0	0.0	13.7	13.7	Yes
41	2075	McMullin	7.4	0.0	0.0	7.4	No
42	2041	Medford Island	0.0	0.0	5.9	5.9	Yes
43	150	Merritt Island	17.7	0.0	0.0	17.7	No
44	2107	Mossdale 2	4.3	0.0	0.0	4.3	No
45	17	Mossdale Tract	15.8	0.0	0.0	15.8	No
46	348	New Hope Tract	0.0	0.0	15.1	15.1	Yes
47	2024	Orwood & Palm Tracts	0.0	0.0	14.4	14.4	Yes
48	2095	Paradise	4.9	0.0	0.0	4.9	No

Table 2 Delta Levees (Part 2 of 2)

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(I)
List Number	District Number	Reclamation District	Miles of Levee				
			Project	Urban NP	NP-NU	Total	Lowland
49	2058	Pesadero Tract	6.6	0.0	0	6.6	No
50	2104	Peters	6.8	0.0	0.0	6.8	No
51	551	Pierson District	6.8	0.0	7.3	14.1	Yes
52	1007	Pico-Naglee Tract	0.0	0.0	9.5	9.5	No
53	2090	Quimby Island	0.0	0.0	7.0	7.0	Yes
54	755	Randall	1.8	0.0	0.0	1.8	No
55	744	Rec District	3.9	0.0	0.0	3.9	No
56	673	Rec District	0.2	0.0	0.0	0.2	No
57	2037	Rindge Tract	0.0	0.0	15.8	15.8	Yes
58	2114	Rio Blanco Tract	0.0	1.8	4.1	5.9	No
59	2064	River Junction	9.7	0.0	0.0	9.7	No
60	524/544/684	Roberts Island	16.4	0.0	34.1	50.5	Yes
61		Rough/Ready Island	0.0	5.5	0.0	5.5	No
62	501	Ryer Island	20.2	0.0	0.0	20.2	Yes
63	2074	Sargent Barnhart	2.1	2.9	2.5	7.5	No
64	341	Sherman Island	9.6	0.0	9.9	19.5	Yes
65	2115	Shima Tract	0.0	7.0	7.3	14.3	No
66		Shin Kee Tract	0.0	0.0	7.0	7	No
67	1614	Smith Tract	5.9	3.3	1.0	10.2	No
68	2089	Stark	2.8	0.0	0.8	3.6	Yes
69	38	Staten Island	0.0	0.0	25.4	25.4	Yes
70	2062	Stewart Tract	12.2	0.0	0.0	12.2	No
71	349	Sutter Island	12.4	0.0	0.0	12.4	Yes
72	548	Terminous Tract	0.0	0.0	16.1	16.1	Yes
73	1601	Twitchell Island	2.5	0.0	9.3	11.8	Yes
74	563	Tyler Island	12.1	0.0	10.3	22.4	Yes
75	1	Union Island	1.1	0.0	28.8	29.9	Yes
76	2065	Veale Tract	0.0	0.0	5.0	5	No
77	2023	Venice Island	0.0	0.0	12.4	12.4	Yes
78	2040	Victoria Island	0.0	0.0	15.1	15.1	Yes
79	554	Walnut Grove East	0.9	0.0	2.5	3.4	Yes
80	2094	Walthall	3.2	0.0	0.0	3.2	No
81	2026	Webb Tract	0.0	0.0	12.9	12.9	Yes
82	828	Weber	0.0	1.7	0.6	2.3	No
83	900	West Sacramento	15.0	26.6	1.6	43.2	No
84	2096	Wetherbee	0.2	0.0	0.0	0.2	No
85	2072	Woodward Island	0.0	0.0	8.9	8.9	Yes
86	2119	Wright-Elmwood Tract	0.0	0.0	7.1	7.1	Yes
87	2068	Yolano	8.8	0.0	0.0	8.8	No
88		Yolo Bypass Unit 4	4.2	0.0	0.0	4.2	No
	Lowland Total		143.2	0.0	470.5	613.7	
	Grand Total		379.5	63.0	537.4	979.9	

Figure 11 The Historic Delta[49]



[49] For high resolution image see http://forecast.pacific.edu/desp-figs.html

It is well known that many of the Delta islands have subsided since they were first diked so that most of the land surfaces within these islands are now below sea level. However, the rates of subsidence have decreased markedly in recent years. That issue is discussed in more detail in Appendix E. Reasonably current land surface elevations interpreted from DWR's 2007 LiDAR surveys are shown in Figure 14.[50] The mostly deeply subsided land is about 30 feet below sea level, but only a fraction of the Legal Delta is more than 15 feet below sea level, as shown by the dark blue coloring in Figure 14. The subsidence has been restricted to the areas of the western and central Delta that are underlain by peat. There are also extensive areas to the north and the south within the Legal Delta that have not been affected by subsidence.

Figure 12 Construction of Delta Levees

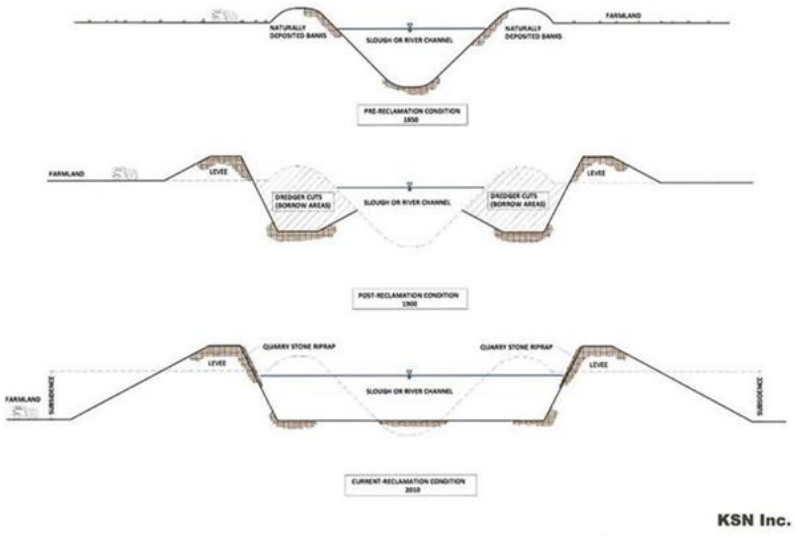
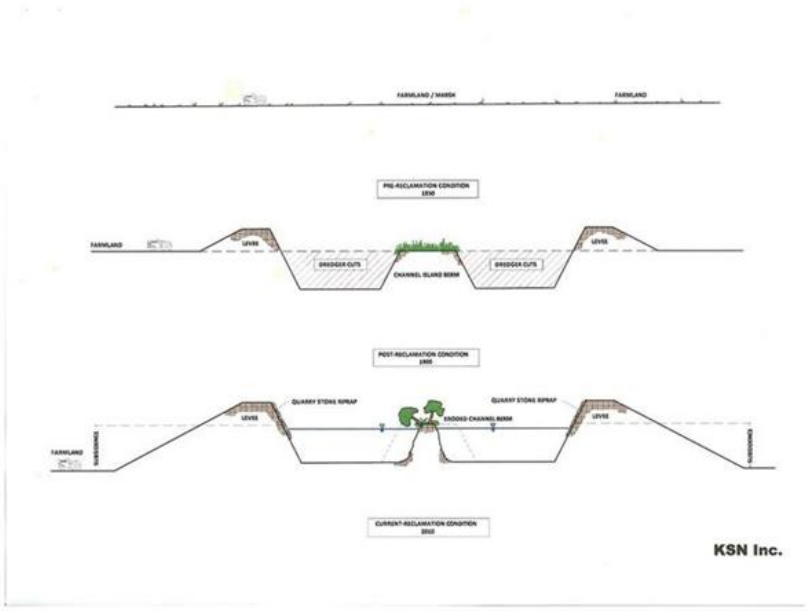
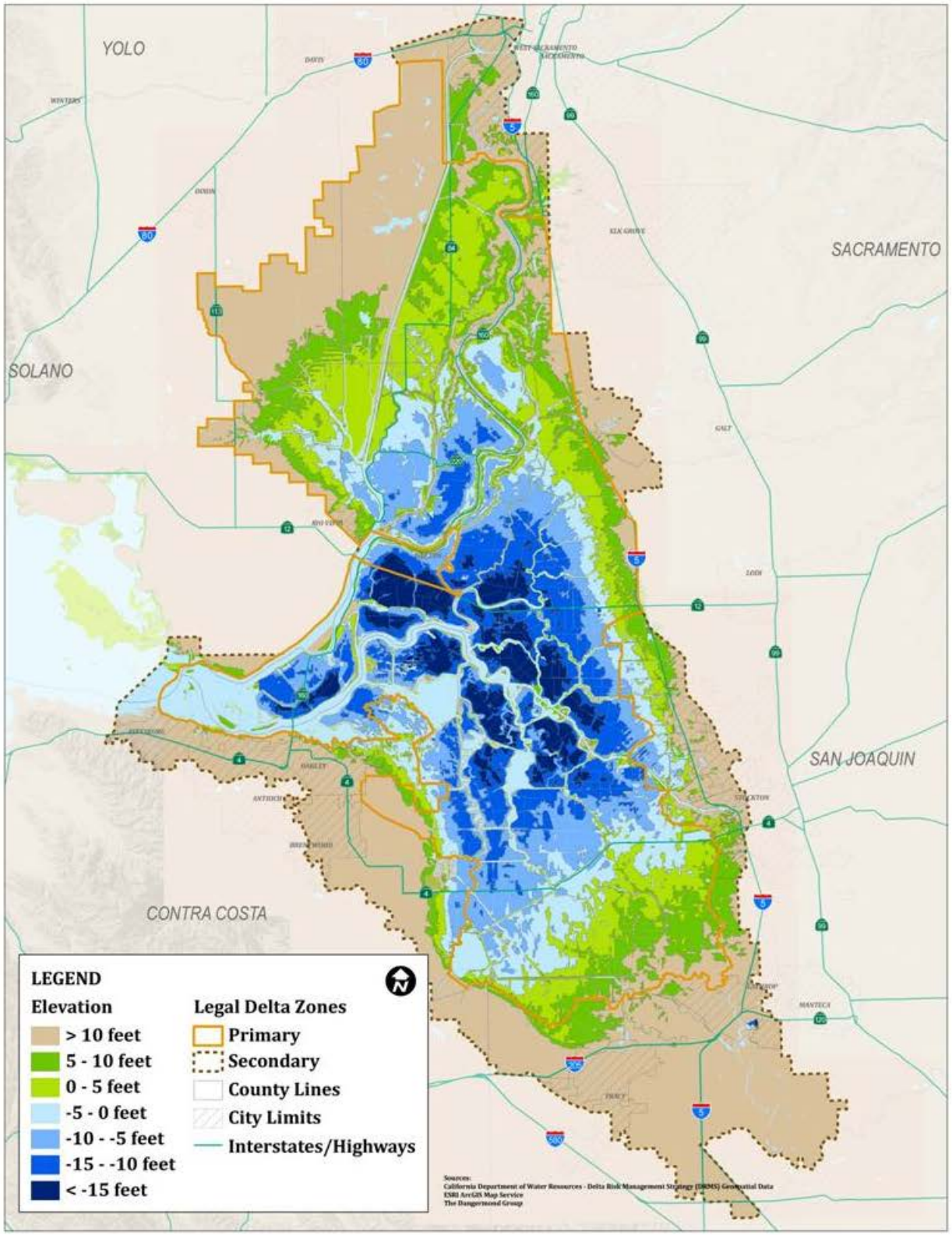


Figure 13 Construction of Dredger Cuts



[50] Based on DRMS GIS data set developed by URS Corporation and provided by DWR.

Figure 14 Current Elevations of Delta Land Surface[51]



[51] For high resolution image see http://forecast.pacific.edu/desp-figs.html

There is a popular impression that there are 1,100 miles of Delta levees all in poor condition. This has led to concern that there is a high probability of widespread failures in the event of flooding, earthquakes, or sea-level rise. While most Delta levees need further improvement, many miles of the Delta levees are actually in quite good condition.[52] Only the levees within the Legal Delta that are currently being maintained and are candidates for further improvement are shown in Figure 10. Levees such as those around Liberty Island and Prospect Island, which lie within the Yolo Bypass, and the levees around the McCormack-Williamson Tract, which have always been height limited and are slated for removal, are not shown. With the removal of levees that are not being maintained and dry-land levees, the total length of the Delta levees is 980 miles, that is, just under 1,000 miles. The division of these levees into project, non-project urban, and other non-project levees and their significance is explained in the following sections. While the levees can be broken into different classifications, it is important to recognize that they all work together as a system. The draft DWR Technical Memorandum (2011) states: "The Delta's system of levees … and interconnected channels operate as a single, multi-function, flood management system. The failure of one levee can increase the risk of other levee failures, increasing the need for levee maintenance on adjoining islands in an effort to prevent additional levee failures. In addition, the large benefits to regions outside the Delta make it difficult to consider one island or tract separately from all others."

5.3 Status of Delta Levees

5.3.1 Categories of Levees

5.3.1.1 Project Levees

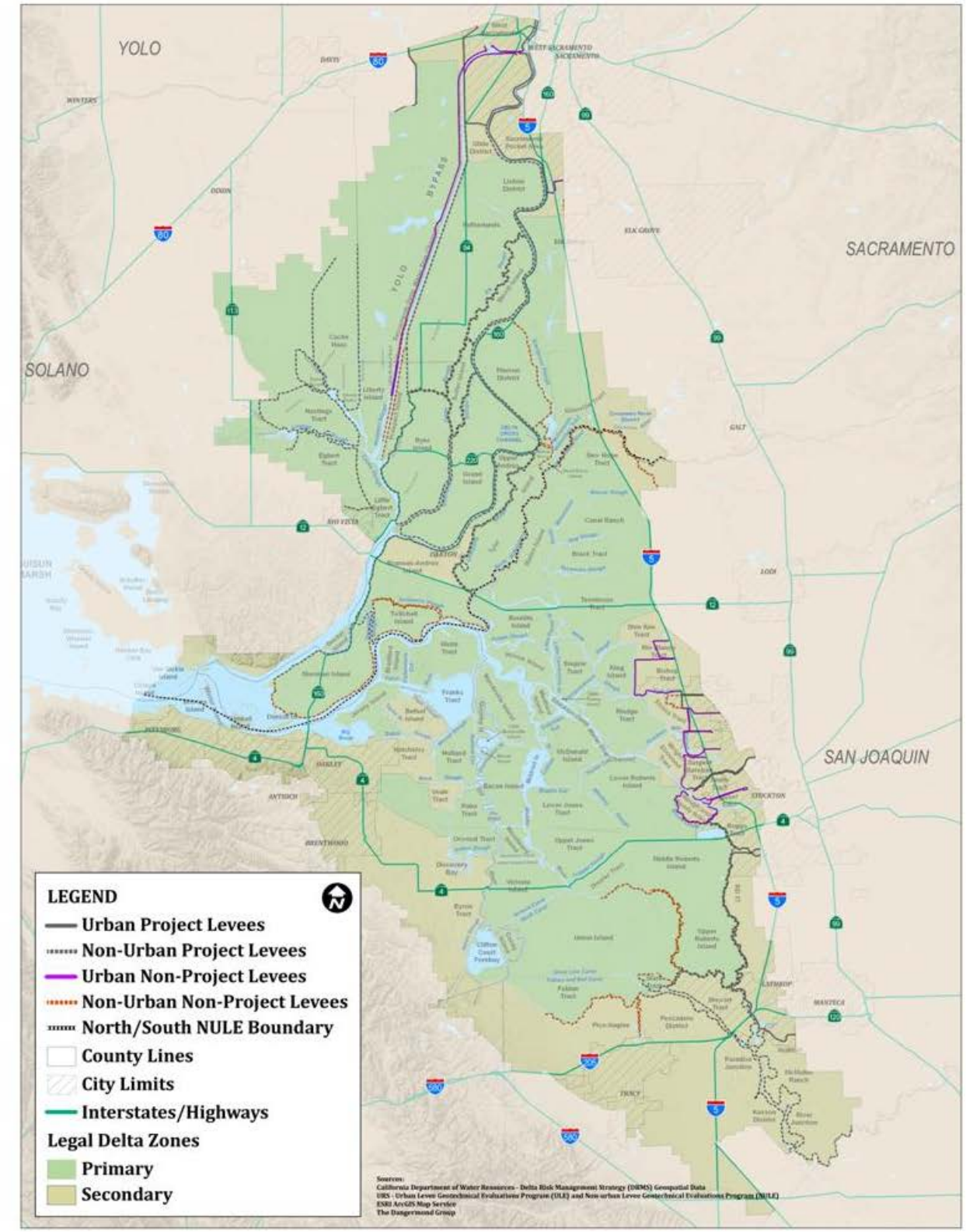
Project levees were constructed or improved by the U.S. Army Corps of Engineers (USACE) as part of federal-state flood-control projects and were turned over to the state for operations and maintenance. The state has in turn generally passed on the responsibility for routine maintenance to local reclamation districts, although the Paterno Decision[53] confirmed the state's continued basic liability with respect to these levees. The State Plan of Flood Control Descriptive Document, dated November 2010, delineates project levees and provides the names of the local maintenance agencies. Project levees within the Delta, as delineated in the GIS data set obtained through DWR, are identified in Figure 10. These levees were built to standards that generally exceed the PL 84-99 criteria described below.

5.3.1.2 Urban Levees

SB 5,[54] enacted in 2007, calls for a minimum of 200-year flood protection for urban and urbanizing areas in the Sacramento-San Joaquin Valley. SB 5 also limits the conditions for further development if this level of flood protection has not been achieved, conditions have not been imposed on the development to provide this level of flood protection, or adequate progress towards achieving this level of protection cannot be shown. DWR is developing criteria for these urban levees that will generally be more stringent than the current criteria for project levees. These criteria are discussed below.

[52] Selected photographs taken during a period of relatively high water in March 2011 are shown in Appendix C.
[53] *Paterno v. State of California* (2003) 113 Cal.App.4th 998.
[54] SB 5 (Machado) was the centerpiece of a far-reaching flood-control package of legislation. It requires the Department of Water Resources to prepare a Central Valley Flood Protection Plan and allows local jurisdictions to prepare their own plans only if they include specified elements that are consistent with the state plan.

Figure 15 Urban and Non-Urban Levee Evaluation Programs[55]



[55] For high resolution image see http://forecast.pacific.edu/desp-figs.html

Recognizing the need for higher levels of flood protection, the major urban areas in the Sacramento-San Joaquin Valley have each formed a Joint Powers Authority (JPA) to implement levee improvements, in part using funds from the DWR Early Implementation Program. Three of these JPAs overlap the Legal Delta—West Sacramento Area Flood Control Agency (WSAFCA), Sacramento Area Flood Control Agency (SAFCA), and San Joaquin Area Flood Control Agency (SJAFCA).

Prompted by the Paterno Decision and SB 5, DWR is undertaking a major investigation of both riverine and Delta levees that is divided into two components, the Urban Levee Evaluations (ULE), and the Non-Urban Levee Evaluations (NULE) (Inamine et al., 2010).[56] These evaluations include detailed site investigations and some analyses and are intended to inform the Central Valley Flood Protection Plan (CVFPP) as to the likely level of effort that will be required for final design and the construction of improvements. Those levees within the legal Delta that are included in ULE and NULE, as identified in a GIS data set specifically obtained through DWR for this purpose, are shown in Figure 15,[57] superimposed on the mapping of project and non-project levees. Some of these DWR-designated urban levees are project levees and some are not. Because there are special requirements for urban levees, as well as special sources of funding for improvements, the urban levees that are not also project levees are identified in Figure 10 and Table 1. There are a total of 122 miles of urban levees in the Delta of which 63 miles are non-project levees.

5.3.1.3 Other Special Levees

While the Delta levees were originally constructed to protect agricultural lands and the small communities that developed primarily along the shipping routes up the Sacramento River, they now are critically important to preserving water quality, to through-Delta conveyance of water, and to the vast array of infrastructure that criss-cross the Delta. The islands that are critical to these functions are discussed and illustrated in Appendix D. It may be seen in Appendix D that most, if not all, islands are also critical to something else besides agriculture and the Legacy Communities. It should also be noted that the mapping of infrastructure in Appendix D is taken from DRMS and is not necessarily complete. For security and other reasons, some data such as the location of liquid fuel pipelines and fiber-optic cables are closely held and are not included on publically available maps. Urban infrastructure in the Secondary Zone is also not shown.

5.3.1.4 Summary and Discussion

As may be seen in Table 1, just under 1,000 miles of levees are currently being maintained within the Legal Delta. But of these, 443 miles are either project or urban levees. If these levees are subtracted from the total of 980 miles, there are only 537 miles that need to be maintained and perhaps improved primarily by the state and the reclamation districts. The DWR draft Technical Memorandum (2011) makes a distinction between non-project levees that have special status in the California Water Code and are eligible for state assistance and other levees that might be owned by public agencies or private entities that are not eligible for state assistance. The technical memorandum indicates that those levees eligible for state assistance are shown on page 38 of the Delta Atlas.[58]

If urban areas and levees that are primarily flood-control levees in the north and south Delta are excluded from the total count, there are only 613 miles of “lowland” levees which protect lands

[56] Inamine, M. et al., California’s Levee Evaluation Program, US Society of Dams, 30th Conference, Sacramento, April 2010.

[57] Based on GIS data set provided by DWR and URS Corporation.

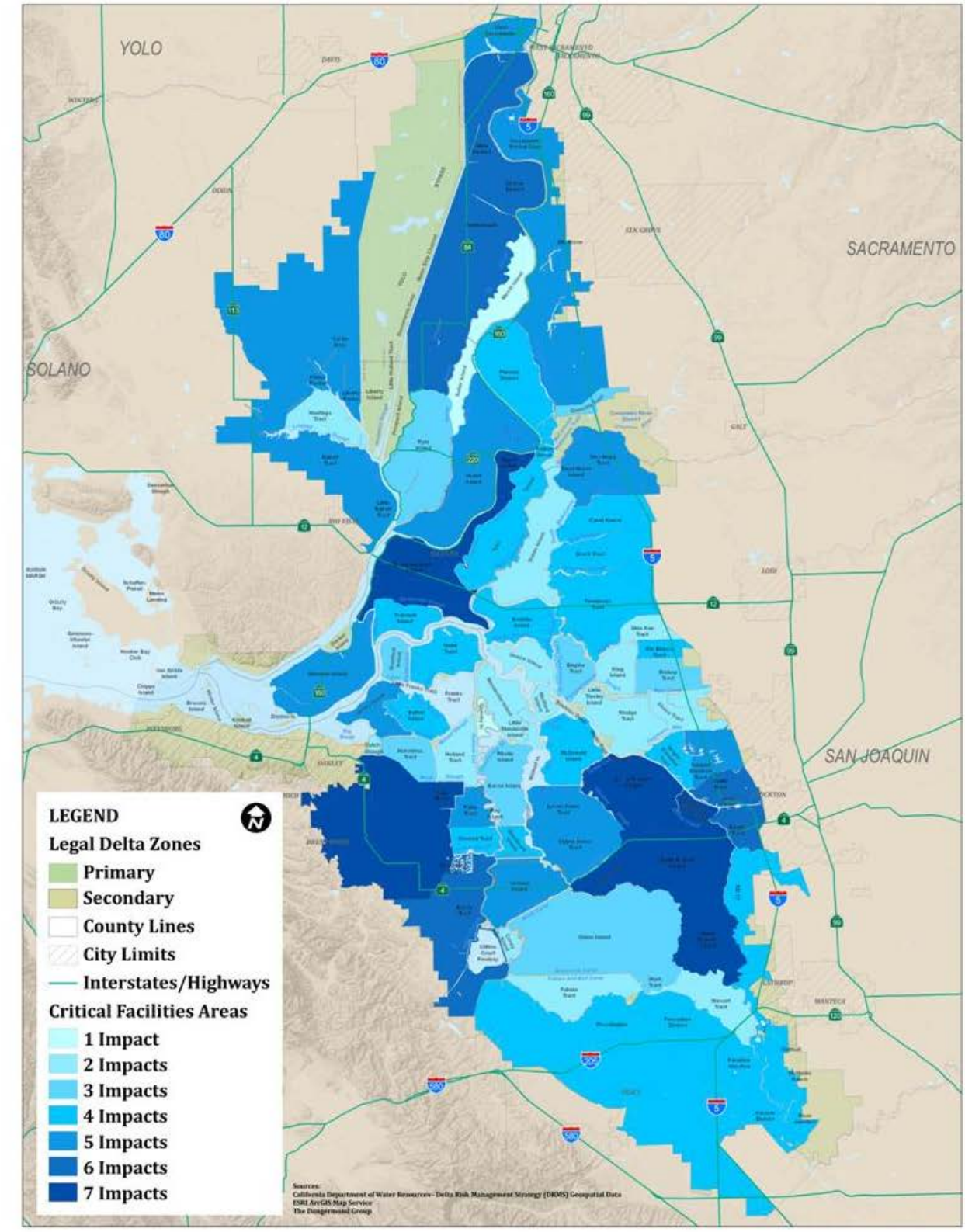
[58] http://baydeltaoffice.water.ca.gov/DeltaAtlas/index.cfm

below sea level. These are levees that are largely founded on peat and thus surround lands that have subsided. They are identified in Figure 10 by yellow dotted lines that are superimposed on either the black or red lines. Of these lowland levees, 143 miles are project levees, primarily located along the Sacramento River. That leaves approximately 470 miles of lowland levees that need to be maintained and enhanced primarily by the state and the local reclamation districts. Even this number errs on the high side because we have counted levee miles by island or tract and some islands or tracts that we have included in the "lowland" count, like Roberts Island for instance, have substantial areas above sea level. Thus, not all lowland levees are equally important but their definition is a significant step in prioritizing the relative importance of the various Delta levees. The 470-mile length might also be reduced by combining some of the existing islands and tracts into larger polders. Of this sub-set of the lowland levees, over 100 miles already exceed the PL 84-99 standard that is discussed below, leaving perhaps 350 miles in need of improvement to the PL 84-99 standard.[59] While the project and urban levees may have issues with encroachments, penetrations, and vegetation and otherwise be in need of improvement, there are other mechanisms for dealing with these issues, and the project and urban levees are fundamentally flood-control levees rather than levees that are key to protecting water quality, the conveyance of water through the Delta, and protecting and enhancing the Delta as a place.

The definition of certain levees in Table 1 as "lowland" levees is not exact and at present has no legal significance. Most of the levees that have been called out as lowland levees are in the Primary Zone, although Bethel Island and Hotchkiss Tract have been included because they are two of the eight western island and tracts that are judged to be critical for preventing salinity intrusion; Wright-Elwood Tract also has been included because of its importance in protecting already urbanized areas to the east. The definition of these lowland levees is very useful for planning purposes because it is the islands that have significant land areas below sea level that are most exposed to the increasing risk posed by possible sea-level rise and that also serve to prevent salinity intrusion. Unlike islands and tracts where the land surface is above sea level, these islands cannot be drained naturally and have to be pumped out after first repairing the levee. Further, failure and flooding of even one of these islands potentially increases both the wave action and the seepage forces on the adjacent islands so that if the island is not repaired and drained promptly, progressive failure of additional islands may occur. Clear evidence of the effect of a single flooded island on adjacent islands was provided by the fact that levee integrity on Woodward and Victoria Islands was compromised by the failure and flooding of Upper Jones Tract in 2004.[60] Thus, the maintenance and improvement of the lowland levees are critical to the achievement of the coequal goals set forth in the Delta Reform Act of 2009. The concept of defining lowland levees is similar in purpose to the designation in the 2008 PPIC report[61] of 34 islands as core or significant islands.

[59] Based on discussions with reclamation district engineers. These estimates will be refined and formalized in the 5-year plans that are now required as a prerequisite for state funding but the preparation of these 5-year plans has been delayed by delays in releasing the funding to develop them.
[60] Neudeck,Christopher, KSN, Inc., personal communication.
[61] Lund, J., et al., *Comparing Futures for the Sacramento-San Joaquin Delta*, Public Policy Institute of California, San Francisco, CA, August 2008.

Figure 16 All Islands Containing Critical Facilities[62]



[62] For high resolution image see http://forecast.pacific.edu/desp-figs.html

All of the islands shown in Appendix D, which have levees protecting infrastructure or critical facilities of one form or another, are superimposed in Figure 16. Figure 16 is not necessarily complete and does not attempt to weight the relative value of the various kinds of infrastructure, but it illustrates the widespread distribution of significant infrastructure in the Delta and shows that most, if not all, islands or tracts house significant infrastructure or border important shipping or conveyance pathways.

5.3.2 Levee Standards

A detailed discussion of the various standards that might apply to Delta levees was given by Betchart (2008).[63] Betchart's list can be simplified into the five standards listed below. Because the Delta is a unique place with unique soil conditions, some levee standards that are applicable elsewhere are not applicable in the Delta. These unique considerations are discussed in Appendix E.

Hazard Mitigation Plan (HMP)

The Hazard Mitigation Plan (HMP) "standard" is not an engineering standard but is a simple geometric levee description that was devised by FEMA in order to establish minimum requirements for federal disaster relief. It provides for a 16-foot crown width, a 1-foot freeboard above the 100-year water surface elevation, minimum 1.5-to-1 waterside slopes, and minimum 2-to-1 landslides slopes. Most existing Delta levees generally meet this standard, but because Delta levees built of or over peat are subject to on-going settlement, there is continuing argument over how literally this standard should be interpreted. The current regulatory position is stated in a MOU signed in February 2010 between Cal EMA and FEMA, as discussed by Betchart (2011).[64] However, notwithstanding its importance to disaster-relief funding, no engineer familiar with the Delta considers the HMP geometry to be adequate for even basic flood protection, and the reclamation districts are generally working towards full compliance with the higher PL 84-99 standard. While there are some miles of levees that, pending further improvement, waver around the HMP geometry, there are at present only about 50 miles that fall below HMP,[65] and even those levees fall short only by about a foot of elevation. As noted in the DWR Technical Memorandum, while achieving the HMP geometry is not really a goal from an engineering perspective, consistently meeting it is not only a first step towards the real short-term goal, which is PL 84-99, but is also important from the point of view of the state in maximizing federal assistance following any disaster.

While levee standards are generally thought of in engineering terms and vegetation on levees is discouraged, the treatment of levee vegetation is critical in the Delta (and elsewhere in California) where preservation or restoration of riparian habitat is an important goal. Vegetation management guidelines for local, non-project Delta levees that were adopted in 1994 require that the crown and the landside slope and a ten-foot strip along the landside toe must be cleared of visually obstructive vegetation, although mature trees may be retained. All vegetation except for grasses must be removed from the top five feet of the waterside slope. The guidelines suggest that naturally growing vegetation below the cleared area should be pruned or removed only to the extent necessary to insure levee safety and ease of inspection.

[63] Betchart, W., Delta Levees – Types, Uses and Policy Options, Prepared for Delta Vision, August 2008.
[64] Betchart, W., Memo to Delta Levees and Habitat Advisory Committee with attached MOU, 2011.
[65] Based on discussions with reclamation district engineers. See previous footnote regarding the development of 5-year plans.

Public Law (PL) 84-99

Among other actions, Public Law 84-99 allows the Corps of Engineers to rehabilitate flood protection systems during a disaster. In order to qualify, the flood system must have already been enrolled into the Corps' Rehabilitation and Inspection Program. In 1987, the Sacramento District of USACE established a Delta-specific standard for levees, based on the Bulletin 192-82 joint DWR-USACE study that is described below, but with the requirement for 1.5 feet of freeboard reduced to being over the 100-year water surface elevation rather than the 300-year water surface elevation. Within the legal Delta this standard plus various maintenance and inspection requirements must be met in order to qualify for rehabilitation under PL 84-99. The Corps was careful to note that "the recommended guidelines are Delta-Specific and they are not intended to establish design standards for the 537 miles of non-federal levees in the Sacramento-San Joaquin Legal Delta, but to provide uniform procedures to be used by the Corps of Engineers in determining eligibility under PL 84-99, as amended." In the preceding Bulletin 192-82 study it had been stated that "while the Corps' design has accounted for small earthquakes, the lack of actual experience of the impacts of earthquakes on Delta soils leaves some doubt that levees, even after rehabilitation, could withstand an earthquake of Richter magnitude 5 or greater if the epicenter occurred in the Delta, or of magnitude 8 on the San Andreas or Hayward faults." Thus, earthquakes were considered but not fully accounted for.

While sometimes referred to as the PL 84-99 Ag standard, this standard actually applies to both agricultural and urban levees within the Legal Delta. The standard adds a stability requirement to what is otherwise principally a geometric standard. It provides for a crown width of 16 feet, freeboard of 1.5 feet over the 100-year water surface elevation, a minimum waterside slope of 2-to-1, and landside slopes that vary as a function of the depth of peat and the height of the levee such that the static factor of safety on slope stability is not less than 1.25. Very approximately, the landslide slope can be 2-to-1 for levee heights no greater than 5 feet, can be 3-to-1 for levee heights no greater than 10 feet, can be 4-to-1 for levee heights no greater than 20 feet, and has to be 5-to-1 for levee heights of 25 feet or greater. Alternately, the minimum factor of safety can be achieved by construction of a landside toe berm. While this standard only calls for a minimum crown width of 16 feet, some reclamation districts are already planning for or are constructing improved levees with a 22-foot crown width, adequate for a two-lane, all-weather road. This allows for two-way traffic in emergency situations and is much to be encouraged. While this standard does not fully address earthquake loadings, the flatter slopes and/or landslide berms that are required for levees built over peat means that they are fundamentally less likely to suffer major distress as a result of earthquake loadings. This Delta-specific standard leads to the result that levees in the western and central Delta which overlie peat are likely to be less susceptible to damage in earthquakes than levees in the north and south Delta, which both overlie more sandy soils and tend to be composed of sandy soils and thus are more susceptible to liquefaction. While the Delta-specific PL 84-99 standard includes no specific guidelines on vegetation, it is assumed that the Corps national standards on levee vegetation, which basically ban all significant vegetation on both land and watersides, apply unless a specific variance from those standards is obtained. This question is currently the subject of a significant debate between the State of California and USACE, with the state arguing for the positive engineering and environmental benefits of vegetation on the waterside slopes of levees. The state's position is indicated by the proposed provisions for urban levees which are noted below.

Sacramento District (SPK)

While not directly applicable to Delta levees, the Geotechnical Levee Practice of the Sacramento District of USACE (designated SPK) has some relevance because it informs both the Urban and Non-Urban Levee Evaluation programs and the DWR Urban Levee Design

Criteria that are presently being developed. This SPK Practice calls for a minimum crown width of 20 feet for main-line levees and minimum water and landside slopes of 3-to-1. Existing levees, with landside slopes as steep as 2-to-1, may be retained in rehabilitation projects if their historic performance has been satisfactory. This move to 3-to-1 slopes is driven by maintenance issues as much as slope stability and seepage issues. The practice also suggests minimum requirements for geotechnical investigations and analyses. Although it describes recommended standard practice, it also makes it clear (and this aspect is often overlooked) that the responsible engineers should use appropriate judgment as a function of site-specific conditions and experience.

Urban Levee Design Criteria (ULDC)

DWR was directed by SB 5 to develop appropriate standards for urban levees, and version four of the Interim Levee Design Criteria for Urban and Urbanizing Areas in the Sacramento-San Joaquin Valley was published in December 2010. These criteria are now being finalized as the Urban Levee Design Criteria which will eventually become a state regulation. The ULDC is generally consistent with the SPK Practice and has the same geometric requirements. However, the ULDC goes much further in defining required practice in a number of other areas including seismic loadings, encroachments, penetrations and vegetation. With regard to vegetation, the draft ULDC language generally prohibits vegetation in accordance with the USACE national policy but allows woody vegetation on portions of the waterside slope and riverbank or berm for a newly constructed levee if a specially-designed waterside planting berm is added or the levee section is otherwise widened. In the case of the repair or improvement of existing levees, the draft ULDC language allows trees and other vegetation to be preserved over the long term if they provide important or critical habitat or erosion protection, soil reinforcement or sediment recruitment. In order to mitigate possible adverse effects of roots, where feasible the overall width of the levee should be widened landward by at least 15 feet or an effective root or seepage barrier shall be installed within the upper 10–15 feet below the levee crown. For other levees with pre-existing vegetation, the UDLC requires inspection and thinning in accordance with the Central Valley Flood System Improvement Framework. It is suggested that these provisions are generally applicable to Delta levees.

Proposed Higher Delta Levees Standard

With the exception of the ULDC, which addresses design and/or quick repair of levees for 200-year return period earthquakes, none of the above standards explicitly address seismically-resistant design, or design for greater than 100-year water surface elevations and possible sea-level rise. The 1983 Delta Levees Investigation (see Section5.3.3.1 below) did suggest that Delta levees should be designed for 300-year water surface elevations but that suggestion has not been included in subsequent standards or revisions. Although updated estimates of water surface elevations from the Central Valley Flood Protection Plan are still pending, it is commonly believed that water surface elevations in much of the Delta are strongly influenced by tides and that 300- or even 500-year water surface elevations are only a foot or two higher than 100-year elevations. Pyke (2011)[66] has suggested that an appropriate standard for the design of Delta levees might be to design for 500-year flood and earthquake loadings. Likely, adoption of the ULDC requirement for three feet of freeboard over the 100-year water surface elevation coupled with superior flood-fighting would effectively provide 500-year flood protection. Building to this standard and increasing the crown width to a minimum of 22 feet would increase the cost only marginally over the cost of complying with the Delta-specific PL 84-99 standard and this “PL 84-99 plus” standard may be sufficient for many Delta levees long-term. If the levee in question

[66] Pyke, R., Comments of the First Staff Draft of the Delta Plan, Delta Stewardship Council, February 2011, http://deltacouncil.ca.gov/public-comments/read/143?page=1

does not contain or is not underlain by loose sands that are susceptible to liquefaction, these PL 84-99 plus levees should be considered to be seismically robust. However, in order to more fully address earthquake loadings, possible sea-level rise and to provide the option for adding vegetation on the water side of levees, a higher Delta levees standard is required. This standard should particularly be required of most of the lowland levees which face the biggest hazard due to possible sea-level rise and are also the most critical to salinity intrusion, but it might be selectively applied to other Delta levees.

As an example of a levee with increased seismic resistance that also meets other objectives, the cross-section of a proposed seismically-resistant levee taken from a report by Hultgren-Tillis Engineers (HTE) for Reclamation District 2026 (Webb Tract)[67] is shown in Figure 17. Even when assuming that some liquefaction might occur both in the embankment and the foundation, this study indicates that deformations would be limited by the addition of a landslide buttress, as shown in the figure. A key feature of the design shown in Figure 17 is the wide crest. Wider crests not only provide a more robust levee, but also allow for more efficient emergency levee patrol and response when it includes an all-weather traffic surface. Levees with wider crests are also the most economical way to provide for possible sea-level rise. While it is the policy of the state to plan for 55 inches of sea-level rise by the year 2100, the probability of that magnitude of sea-level rise is actually very small. While it is not cost-effective or rational to construct levees to those elevations today, the provision of a wider crest with an all-weather traffic surface today has at least three benefits: providing a more robust levee immediately; allowing more room and accessibility for patrol, flood-fighting or emergency response following earthquakes; and allowing a choice of methods for raising the crest elevation in the event of need in flood events and in the long term case of actual sea-level rise. In addition, the provision of a wider crest also allows for retaining or planting vegetation on the waterside of the levee in accordance with the ULDC guidelines. Such planting should be an essential component of any comprehensive plan to repair the Delta ecosystem. Local widening of these levees would also allow for the construction of new recreational and tourist facilities out of the flood plain.

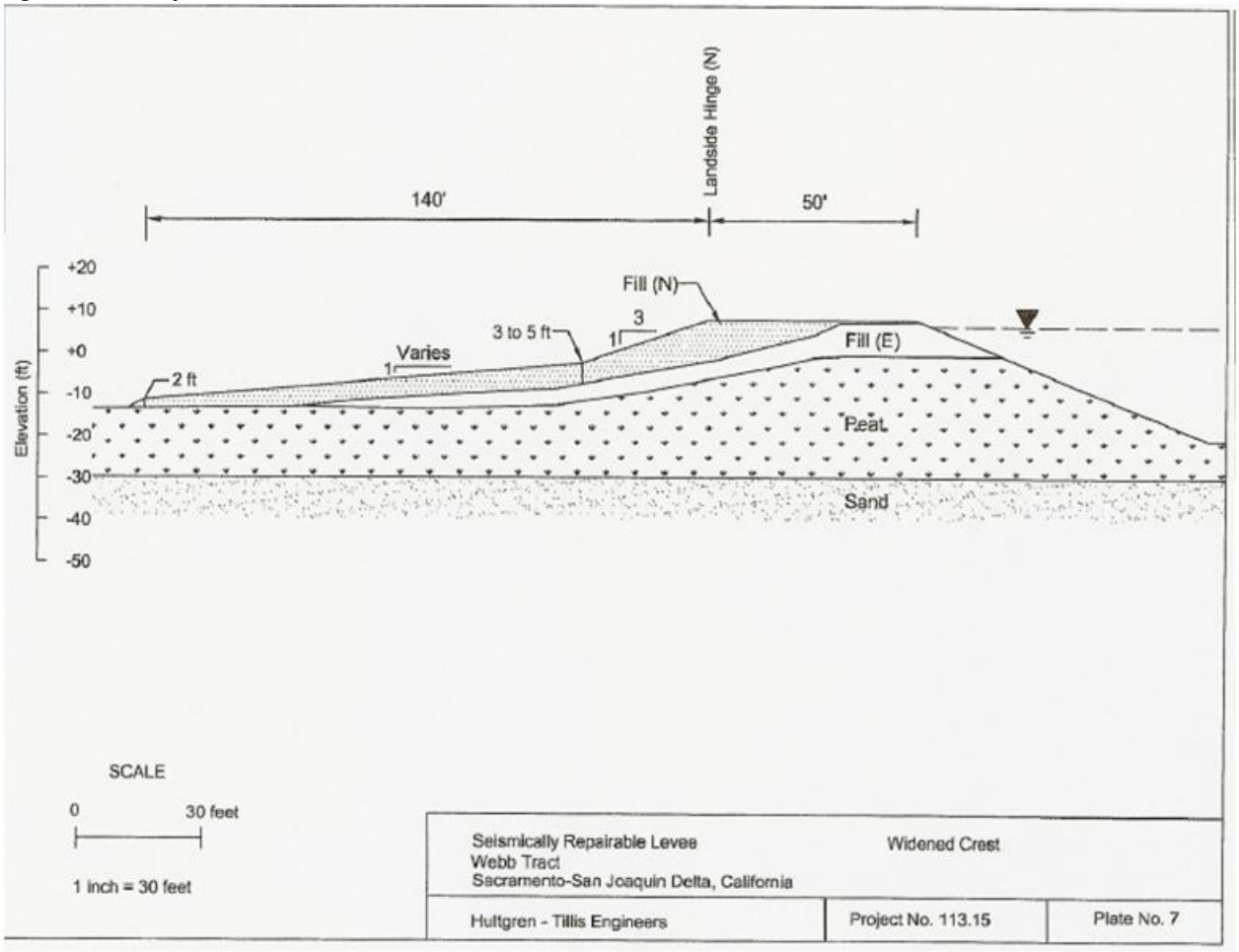
HTE estimated that this design would cost approximately $2 million per mile in 2009. HTE also looked at more elaborate designs which included either or both of a slurry trench wall or an internal drain. Those designs added up to $5 million per mile to the incremental cost but we believe that the additional features are not generally required and that an average cost of $2-3 million per mile is a reasonable estimate at this time. While the HTE report was only conceptual in nature, the cost estimates were conservative estimates based on recent actual construction costs for lesser improvements. HTE estimated that the fill required would range from 125,000 to 150,000 cubic yards per mile. That translates to a cost per cubic yard of $13-16 per cubic yard. The actual cost of just the fill has consistently been around $6 per cubic yard for some time so that HTE more than doubled that figure to provide for the need for some additional rip-rap, an all-weather two land road, road and the need to move siphons, pumps and drains, and so on. We applied an additional contingency of 50 percent to obtain the figure of $2-3 million per mile. This figure easily accommodates engineering as well as construction costs when performed at the local level.

If it is assumed that anywhere from 300-600 miles of levees need to be upgraded to this standard, the basic engineering and construction cost would be in the order of $1-2 billion although the overall program cost might well be higher.

[67] Hultgren-Tillis Engineers, Geotechnical Evaluation, Seismically Repairable Levee, Webb Tract, Report to Reclamation District 2026, December 2009.

By comparison the 2007 PPIC report "Envisioning Futures"[68] listed in Table 8.2 an alternative labeled Fortress Delta (Dutch standards) which had a total cost greater than $4 billion and in Appendix E it is explained that was based on an estimated cost of $10 million per mile, applied to 300 to 500 miles of levees. The $10 million per mile figure was obtained by taking a $5 million per mile figure based on "recent informal estimates by water managers … including significant structural work" and doubling it because "Dutch levels of levee protection … would probably involve changes in many islands and channels, straining current construction and levee material capacity". If it is assumed that "structural work" means including a slurry trench wall or internal drain then the $5 million per mile estimate is not inconsistent with the HTE estimates and these measures are in fact likely to be required to obtain "Dutch levels of levee protection" since currently Dutch levees are variously designed for 2,500 to 10,000 year levels of protection. However, the societal and economic considerations in the Netherlands are even more demanding than those in the Delta and we believe that a lesser upgrade to something like a 500 or 1000-year level of protection coupled with improved and more effective inspection and flood fighting capabilities is appropriate for the Delta.

Figure 17 Example Delta Levee Cross Section



[68] Lund, J., et al., *Envisioning Futures for the Sacramento-San Joaquin Delta*, Public Policy Institute of California, San Francisco, CA, 2007.

5.3.3 Previous Studies of Delta Levees

5.3.3.1 Delta Levees Investigation, DWR Bulletin 192-82

In 1976 the legislature directed DWR to prepare a plan for the preservation of the Delta levees. After a joint study with USACE, a definitive plan for the improvement of all Delta levees was completed six years later and published as Bulletin 192-82,[69] which recommended a levee standard similar to the current Delta-specific PL 84-99 standard but with a requirement for 1.5 feet of freeboard over the 300-year water surface elevation. The forward to the report, signed by Ronald Robie, then Director of DWR, states in part:

> *Now is the time for a decision. The most significant element in a decision on what action to take is how much can we afford and who will pay? These questions can only be answered by the Legislature, the local landowners, and the Congress.*
>
> *There is a danger that taking a short-term view of Delta flooding problems will merely pass the tough issues on to the next generation. Short-run economic decisions may serve to subsidize private interest as the expense of the general public. The great challenge for the Delta is to find an equitable way of financing a very uncertain long-term future. The political process is the traditional arena for handling these kinds of issues and is the right forum for the next step in Delta deliberations.*
>
> *These policy issues must be addressed today. In the event the Legislature determines that a major responsibility for levee restoration should fall upon the State, a bond issue or other form of capital financing must be developed and approved by the people.*

At that time, it was estimated that improving all levees to the proposed Bulletin 192-82 standard would cost $930 million if implemented immediately. However, although funding of the subventions program continued at a relatively low level, financing was never put in place to implement this more significant levee-improvement plan.

5.3.3.2 CALFED Levee System Integrity Program

A similar study, called the CALFED Levee System Integrity Program, was subsequently conducted as part of the CALFED program.[70] The executive summary of the Levee System Integrity Program Plan, dated July 2000, contains the following statements:

> *The benefits of an improved Delta Levee system include greater protection to the Delta agricultural resources, municipalities, infrastructure, wildlife habitat, and water quality as well as navigation and conveyance benefits. The wide range of beneficiaries of the Delta Levee System Integrity program include Delta local agencies; landowners; farmers; boaters; wildlife; and operators of railroads, state highway, utilities, and water distribution facilities. Delta Water users and exporters also benefit from increased protection to water quality. Federal interests benefit from improvements to conveyance, navigation, commerce, and the environment, and from reduced flood damage.*
>
> *Recognizing these potential benefits, state and local agencies formed a partnership to reconstruct Delta levees. This effort has resulted in a steady improvement in the Delta levee system. The success of the Delta in the 1997 and 1998 flood events illustrates the value of the approximately $100 million of improvements made with SB 34 funds and*

[69] Delta Levees Investigation, Department of Water Resources, Bulletin 192-82, December 1982.
[70] Op. cit.

over $10 million in emergency PL 84-99 work performed for the U.S. Army Corps of Engineers. These funds, in addition to local funds, have resulted in over $160 million in improvements to Delta levees since the SB program's inception in 1988.

However, the summary continues with:

Many Delta levees do not provide a level of flood protection commensurate with the high value of beneficial uses they protect. As mandated by the California State legislature and adopted by CALFED, the physical characteristics of the Delta should be preserved essentially in their present form. This is necessary to protect the beneficial uses of the Delta. The key to preserving the Delta's physical characteristics and to achieving CALFED's objectives is the levee system. Over the next 30 years CALFED will invest billions of dollars in the Delta. The levees must protect this investment.

*The existing levee program (*the subventions program*) was intended to improve Delta levees up to the California/Federal Emergency Management Agency (FEMA) Hazard Mitigation Plan (HMP) Standard. As of January 1998, 36 of 62 (58%) Delta islands and tracts were in compliance with the HMP standard. This has resulted in a significant improvement in the ability to protect the beneficial uses of the Delta. However, as CALFED invests in the Delta, more is at risk. Therefore CALFED has chosen to improve the Delta levees to a higher level.*

The CALFED Levee program will institute a program that is cost-shared among the beneficial users to reconstruct Delta levees to the Corps' PL 84-99 Delta Specific Standard. This action will increase levee reliability and reduce emergency repair costs. In addition, levee districts meeting this standard are eligible for federal emergency assistance under PL 84-99.

The plan to improve the levees to the PL 84-99 standard was not new. It had been recommended in Bulletin 192-82. The CALFED study estimated that the cost of improving all the Delta levees to the PL 84-99 standard ranged from $367 million to $1.051 billion, not inconsistent with the $930 million estimated in 1982. But again, no funding materialized until in 2006, in the wake of the Paterno Decision, Propositions 84 and 1E provided for up to $615 million to be spent on Delta levees.[71] The slow pace of disbursement of these funds is discussed subsequently but, in effect, this was the funding that had been recommended first by Bulletin 182-92 and then by CALFED.

The CALFED plan also discussed the fact that funding for levee work is insufficient, inconsistent, and often delayed; that dredging is required to increase channel capacity and to provide material for levee reconstruction, habitat restoration and creation, and subsidence control, but that dredging had been curtailed due to regulatory constraints, causing dredging equipment and trained manpower to leave the Delta; that emergency response capabilities need to be continuously refined and funding increased; that levee reconstruction and maintenance sometimes conflicts with management of terrestrial and aquatic habitat resources; that obtaining permits for levee work can sometimes be difficult and time consuming; and that while subsidence may adversely affect levee integrity, this can be corrected.

With respect to seismic loadings, the plan said:

[71] Some sources indicate that $775 million was intended to be spent on Delta levees but the draft DWR Technical memorandum indicates that only $615 million was made available by these propositions.

Some CALFED stakeholders are concerned that earthquakes may pose a catastrophic threat to Delta levees, that seismic forces could cause multiple levee failures in a short time, and that such a catastrophe could overwhelm the current emergency response system.

CALFED agrees that earthquakes pose a potential threat. In addition, Delta levees are at risk from floods, seepage, subsidence, and other threats. To address this concern, CALFED has begun a risk assessment to quantify these risks and to develop a risk management strategy.

The plan listed 10 possible risk management options which included improving emergency response capabilities and reducing the fragility of the levees and indicated that the final Risk Management Plan might include a combination of the 10 options. CALFED never completed the Risk Management Plan, and the effort evolved into the Department of Water Resources' Delta Risk Management Strategy.

With respect to emergency response, Appendix F, Emergency Management and Response, in the CALFED Record of Decision issued in 2000, stated:

Lack of specific funding sources and obstacles within federal public assistance re-imbursement rules have hindered direct involvement in flood fight activities by counties, cities and State agencies. Creation of funding to support a delta levee emergency response plan would eliminate past hesitation and inefficiencies….

A detailed response plan should be developed for the Delta that would allow an immediate, simultaneous response to a serious incident (such as a major flood or an earthquake) by all levels of government within a single integrated organizational structure.

5.3.3.3 Delta Risk Management Strategy

AB 1200 (authored by John Laird, the current California Secretary for Natural Resources) required that DWR evaluate the potential impacts on water supplies derived from the Delta based on 50-, 100-, and 200-year projections for each of the following possible impacts: subsidence, earthquakes, floods, climate change and sea-level rise, or a combination of these impacts. This legislation had the effect of changing the CALFED recommended study into what became the Delta Risk Management Strategy (DRMS) and the Risk Management Plan envisioned by CALFED has never been completed.

DRMS was conducted for the Department of Water Resources (DWR) by a team of consultants led by URS Corporation and Jack R. Benjamin & Associates.[72] The study was designed to have two phases. The first phase was an assessment of the then-current (2005) risks to the Delta and the second phase was to have been a projection of future risks assuming various scenarios. The Phase One draft generated a great volume of critical comments, and the effort required to respond to them cut into the available funding for Phase 2. The Phase 1 Risk Analysis Report was released in 2009, but the report on the modified Phase 2 study has only just been released.

[72] http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/

Although led by very competent principal investigators, the DRMS effort was always hampered by being schedule-driven rather than quality driven. The DRMS Phase One report was extensively reviewed, including a review by an independent review panel (IRP) assembled by the Cal-Fed Science Program. The reviews were generally critical of the study. After revisions had been made, the IRP review[73] concluded that "the revised DRMS Phase 1 report is now appropriate for use in DRMS Phase 2 and serves as a useful tool to inform policymakers and others concerning possible resource allocations and strategies for addressing risks in the Delta." But the IRP expressed concerns:

> "*This conclusion, however, is subject to some important caveats. First, the IRP cautions users of this revised DRMS Phase 1 report that future estimates of consequences must be viewed as projections that can provide relative indicators of directions of effects, not predictions to be interpreted literally. Second, anyone using the results of the DRMS scenarios must be aware that ecosystem effects are not fully captured in the analysis....*"

Although the DRMS developed a good framework for assessing risks to the Delta levees, the effort had data gaps that were never filled, as acknowledged in the note on page 1-1 of the report. Gaps such of these in data and knowledge tend to drive the estimates of fragilities down, and the risks up. However, despite the warning from the IRP, the numerical results from the DRMS Phase 1 report are widely quoted and used in other studies, painting a more pessimistic picture of the Delta levee system than is warranted. Just one example of the questionable results is presented by the last map in the DRMS Executive Summary depicting a high probability of flooding for Sargent-Barnhart Tract, which houses Stockton's most expensive neighborhood, known as Brookside. This tract has had modern levees that meet 200-year urban standards and is shown as having a mean annual probability of failure of greater than 7 percent, while the adjacent Wright-Elmwood Tract, which is undeveloped and has relatively poorer levees, is shown as having a mean annual probability of failure of only 1-3 percent. In addition, recent improvements have been made to many urban levees in addition to recent and on-going improvements to non-urban levees under the Delta levees subventions and special projects programs and these improvements are not reflected in the DRMS Phase 1 assessment.

The DRMS Phase 2 study focuses on risk reduction as opposed to risk analysis and evaluates the costs and benefits of four alternative scenarios for levee improvement and conveyance. Although Phase 2 was not released until June 2011, the forward to the report notes that it was completed in 2009, which explains why it utilizes costs for isolated conveyance that are less than half more current cost estimates.

As discussed below, the awkward construction of scenarios limit the value of the final conclusions of the Phase 2 report. However, the DRMS phase 2 report is still a wealth of detailed information regarding individual components of the scenarios and the economic consequences of flood and earthquake events in the Delta. In fact, the key findings relative to the two types of levee upgrades that were considered (and are listed below) are not inconsistent with the present study.

- *Most of the Delta levees already meet the HMP standard.*
- *Some of the levees in the central Delta (project levees) already meet the PL 84-99 standards.*

[73] The independent review panel (IRP) comments on the DRMS Phase I draft report are published on the state's archived CALFED website: http://calwater.ca.gov/science/drms/drms_irp.html.

- *The cost of upgrading 764 miles of selected non-project levees (levees that do not meet PL 84-99 standards) in the central Delta to PL 84-99 standards is about $1.2 billion.*
- *The cost of upgrading 187 miles of selected levees around urban centers to UPL standards is $750 million.*
- *Upgrading levees to meet the target standards will reduce the probability of failure due to flooding. However, these upgrades do not guarantee that the upgraded levees, particularly those upgraded to PL 84-99 standards, will not fail during a 100-year flood. The 1.5 feet of freeboard is insufficient for regions subject to high winds during floods.*
- *Upgrading levees to meet the PL 84-99 and UPL standards does not reduce the seismic risk of levee failure.*

Elsewhere the report says that "upgrading the levees to the Pl 84-99 and UPL standards would do little to reduce the risk of failure under seismic loading." However, curiously, the report says nothing about what it would take to further upgrade the critical levees so that they are more robust under seismic loadings.

However, a January 2008 progress report to the Legislature required by AB 1200[74] reported that a Seismically Improved Levees "building block" was one of three high-ranking building blocks that were the basis for the DRMS Phase 2 trial scenarios. The "Improved Levees" scenario in the AB 1200 progress report featured 100 miles of seismically resistant levee upgrades to south Delta islands, a significant difference from the "Improved Levees" scenario in the final report that did not include levee improvements beyond the PL 84-99 standard. The January 2008 report did not report quantitative results, but described the rankings of the scenarios on page 24:

> "The ranking of the preliminary DRMS scenarios is shown in the following table. These rankings were developed by DWR and DFG staff based on DRMS analyses, with adjustments based on the BDCP analyses. Scenario 1 (Improved Levees) ranks moderate for reducing risk and is the least expensive of the three. Scenario 2 (Armored Pathway) and Scenario 3 (Isolated Conveyance Facility) rank high and very high respectively for reducing risk, but also cost more than Scenario 1."

Because information on seismic levee upgrades were not in the final DRMS phase 2 report, we requested a copy of the preliminary quantitative results described in the ranking above from DWR in a December 15, 2011 letter. DWR responded and provided a copy of the August 20, 2007 preliminary draft of DRMS Phase 2. The January 9, 2012 transmission letter states:

> "Please note the information dates back to 2007 and is stamped as preliminary. It was also not part of the DRMS Phase 2 public draft, because it was not further considered for in-depth analysis in Phase 2. Therefore, I do not recommend using this information for either planning or design purposes. With these caveats in mind, we hope you still find the attached information useful."[75]

The preliminary draft confirmed that Scenario 1 (Improved Levees) was evaluated as the least expensive, but the quantitative risk reduction results in the preliminary draft were the opposite of

[74] "Risks and Options to Reduce Risks to Fishery and Water Supply Uses of the Sacramento/San Joaquin Delta." A Report Pursuant to Requirements of Assembly Bill 1200, Laird. Department of Water Resources & Department of Fish and Game. January 2008.
http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/docs/AB1200_Report_to_Legislature.pdf
[75] The correspondence and material provided by DWR is included in Appendix N.

what was reported in the AB 1200 report to the Legislature. Specifically, Table 18-13 in the preliminary draft evaluated the risk reduction benefits of Scenario 1 (Improved Levees) as $7.9 billion, nearly 40% higher than the $5.7 billion in risk reduction benefits from scenario 2 or scenario 3 (isolated conveyance facility). While the AB 1200 progress report states that adjustments were made based on the BDCP analysis, the quantitative results show that the adjustment was to reverse the risk reduction rankings of the alternatives to match the proposed isolated conveyance strategy in the BDCP.

The 4 scenarios that were evaluated in the final, public DRMS phase 2 report illustrate the extreme cost of strategies that focus on individual risk-reduction strategies for each infrastructure system rather than seismic upgrades to the existing levee system. For example, Scenario 1, "Improved Levees," in the public DRMS phase 2 report assumes that the levees are not robust under seismic loadings and estimates the cost of hardening the state highways that cross the Delta, by putting them on piles like the elevated section of the Yolo Causeway, and the BNSF railway and the Mokelumne Aqueducts, either by building seismically-resistant embankments with a 50-foot crown width on either side of the existing railway and aqueducts, or by placing the railway and aqueducts on a single embankment with a 180-foot crown width. The cost of these hardening measures was estimated to be $6.1 billion for the highways and $3.3-3.9 billion for the infrastructure corridor. Adding these figures to the cost of improving levees to the PL 84-99 standard and selected ecosystem enhancements resulted in a stated total capital cost for Scenario 1 of $10.4 billion, as reported in Table 1 of the executive summary. Thus, the "Improved Levees" scenario is not a broad improvement of Delta levees as described in this report, but has 60 percent of the total cost allocated to putting a few state highways on piers, a strategy that the report notes does not generate benefits equal to the costs and creates numerous problems for the network of local Delta roads. It should be titled an "elevated highways" scenario since that is its most prominent feature, as highways do not have to be elevated for the type of improved levees strategy described in the ESP.

Likewise Scenario 2, which is titled "Through Delta Conveyance (Armored Pathway)," ignores the possibility of a general upgrade to levees that are more robust under seismic loading and instead assumes the construction of 115 miles of new seismically-resistant setback levees, at a cost of $38 million per mile. The total capital cost of the scenario is $15.6 billion, because this strategy is also paired with $5 billion in costs to put roads on piers.

Scenarios 3 and 4 examine isolated and dual conveyance, and greatly misrepresent the costs of these strategies as being comparable to or cheaper than through Delta conveyance strategies. First, they utilize out-of-date costs for isolated conveyance that are under $5 billion compared to current estimates of $12 billion or more. Second, these scenarios also reduce cost by not including the $3.3 billion armored infrastructure corridor included in Scenarios 1 and 2. As a result, the costs and composition of the four illustrative scenarios are constructed in such a way that the final conclusions are of little value.

Despite the limitations created by the scenario composition, the DRMS Phase 2 results still have interesting implications. In addition, the consequences analysis is very comprehensive and provides more details on the distribution of the costs of consequences of floods and earthquakes than were provided in Phase 1. Below are some key findings from the DRMS Phase 2[76]:

[76] These findings are not what is highlighted by the Department of Water Resources in the Executive Summary of DRMS phase 2, but are easily found and calculated from the results tables in the analysis. The benefit-cost ratios are easily calculated from Table 1 in the executive summary, Table 18-2a shows

- Improving levees had the highest benefit-cost ratio of any Delta risk reduction strategy, including isolated water conveyance that was assumed to cost only $4.9 billion.

- Water exports account for only 20% of the economic costs from a large earthquake event that would flood between 10 and 30 Delta islands.

- Water exports account for less than 2% of the economic costs of more-common flood events due to high water and storms.

- Water exports account for 0% of the loss of life from any type of flood hazard event.

These findings have enormous implications for risk management in the Delta. Both the preliminary and final draft of DRMS Phase 2 found improving levees has the highest economic benefit per dollar invested and lowest total cost. Levee upgrades perform well in cost-benefit analysis of Delta options, because they reduce risk in all areas including water conveyance, other infrastructure, and in-Delta property. In contrast, isolated conveyance only protects water exports which DRMS clearly identifies as a minority of the economic risks.

This study concludes that most lowland Delta levees and selected other levees can be made robust under seismic loadings for a base engineering and construction cost of $1-2 billion. Even if the total program cost were $4 billion as suggested by PPIC (2007), a true "improved levees" scenario would have much lower costs than the version in DRMS and would perform much better in reducing the costs of in-Delta flood losses as well as out-of-Delta losses from water supply reliability and therefore have higher benefits. Although it is impossible to draw conclusions without a complete analysis, a true "improved levees" scenario would likely have a much higher benefit-cost ratio than the other scenarios considered in DRMS phase 2.

5.3.3.4 Delta Islands and Levees Feasibility Study

Meanwhile, the successor to the Bulletin 192-82 and CALFED studies is the USACE Delta Islands and Levees Feasibility Study, which is an on-going effort in collaboration with DWR.[77] The official description of the study is:

> *This feasibility study is USACE's mechanism to participate in a cost-shared solution to a variety of water resources needs for which we have the authority. Results of state planning efforts will be used to help define problems, opportunities, and specific planning objectives. The feasibility study will address ecosystem restoration and flood risk management, and may also investigate related issues such as water quality and water supply. USACE and DWR signed a Feasibility Cost Sharing Agreement (FCSA) in May 2006.*

The initial public findings and outreach are not expected until later this year. Thus, three joint state-federal efforts over the last 30 years have had significant positive impact in that they have generated the concept of improving Delta levees to the PL 84-99 standard and have supported

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that "Statewide Costs" are 38% of the total cost of a Delta earthquake, and water export disruption is 51.5% of statewide costs, thus both water exports and state highway damage are about 20% of total costs from the largest earthquake. The same table shows that water export interruptions are virtually none of the cost from smaller, more common flood events.

[77] http://www.spk.usace.army.mil/projects/civil/Delta/News.html

the continuation of the funding that is provided under the subventions program and the additional funding that was authorized under Propositions 84 and 1E and the CALFED Levee Stability program. However, they have not yet led to a strategy which will make the Delta sustainable longer-term facing the hazards due to floods, earthquakes, and possible sea-level rise.

This study is an element of the broader USACE CALFED Levee Stability Program created by the CALFED Bay-Delta Authorization Act of 2004. This program includes several short-term projects to be implemented by the Corps pending completion of the long-term feasibility study. A report to Congress issued in May 2006 identified 54 projects in the Delta for implementation as funding is available under the Corps Small Flood Control Projects authority. These projects included reconstruction of levees to the PL84-99 standard, enhancement of the stability of levees of particular importance to the system, and projects to protect critical infrastructure. Some of these projects have been initiated with funding provided in years subsequent to the completion of the report.

The CALFED Levee Stability Program also included short-term goals of developing best management practices to control subsidence, developing a Delta Levee Emergency Management and Response Plan, and developing a strategy for assessing the consequences of Delta levee failure from floods, seepage, subsidence, and earthquakes. Initial funding for the USACE response plan was used in 2010-11 to attempt to duplicate San Joaquin County flood contingency maps throughout the Delta.

5.4 Risk Reduction Strategies

There are three basic approaches to addressing the risks posed to the Delta levees by floods and earthquakes. One is to simply make the up-front investment to improve the existing levees so that they are more robust; a second is to make the preparations in advance for improved flood-fighting and/or emergency repairs after an earthquake so that breaches do not occur; the third is to make preparations in advance for minimizing the extent and depth of flood waters if breaches do occur, and rapid repair of breaches and draining of any flooded islands so that the consequences are minimized. These three approaches are discussed in more detail in the following sections, and are followed by a discussion of economic justification for investing in risk reduction strategies.

5.4.1 Improve the robustness of the existing levees

This is the standard approach to reducing risk: invest up-front in making everything more robust. As discussed earlier, a series of reports over three decades have concluded that Delta levees should be improved to the Delta-specific PL 84-99 standard. However, the Department of Water Resources has released a draft "Framework for DWR Investments in Delta Integrated Flood Management,"[78] a document that was only released for public comment on July 15, 2011, but had already been forwarded to the Delta Stewardship Council, that states or implies that the HMP "standard" provides an adequate basic level of protection against floods and earthquakes for Delta levees. The exact language of the draft Framework is:

> *As funding is available, DWR intends to cooperate with local public agencies to develop local plans to improve levees within the Delta levee network to at least the HMP standard. Some levees may warrant additional investment to provide a level of*

[78] California Department of Water Resources, DRAFT V3 DHF and SMB, "A Framework for Department of Water Resources Investments in Delta Integrated Flood Management," February 14, 2011.

protection beyond the HMP standard, but these projects likely would need to be justified based on one of the other categories of benefit described in this section.

Apparently on the basis of this language, the 5th staff draft of the Delta Plan, in Table 7-1, indicates that levees built only to the HMP "standard" are acceptable for protection of agricultural lands. However, the HMP "standard" is not an engineering standard. It is a minimum configuration agreed to by the state and federal governments for the purpose of defining a serious levee in order to protect the federal government from facing possible exposure to the cost of repairing levees that are height limited or not seriously being maintained. Since 1982, the minimum standard for engineered levees in the Delta has been the Delta-specific standard that was recommended in Bulletin 192-82 and subsequently adopted by the Corps of Engineers as the PL 84-99 standard for Delta levees. This Delta-specific PL 84-99 standard was also adopted in the CALFED Levee System Integrity Program Plan as the minimum standard for Delta levees. That plan specifically said:

> *The CALFED Levee program will institute a program that is cost-shared among the beneficial users to reconstruct Delta levees to the Corps' PL 84-99 Delta Specific Standard. This action will increase levee reliability and reduce emergency repair costs. In addition, levee districts meeting this standard are eligible for federal emergency assistance under PL 84-99*.

The 2006 USACE CALFED Levee Stability Program Report to Congress also identifies the PL 84-99 standard as the "primary emphasis of the short-term strategy and the authorized $90 million Federal funds" in reference to the 54 projects identified for immediate action pending completion of the long-term plan. The draft Framework and the draft Delta Plan would roll back 30 years of joint state-federal co-operation without sufficient justification. The draft Framework is inconsistent with DWR's own draft Technical Memorandum (2011) that is cited in the Framework document, not to mention CALFED and Bulletin 192-82. Given that it is possible, even likely, that FEMA will raise the minimum levee standard required for reimbursement after a disaster from the HMP standard to the PL 84-99 or some higher standard, the proposed policy change means the state would be forgoing the opportunity for significant federal financial assistance to sustain and enhance the Delta. As discussed in more detail below in Section 5.4.4, the call in the draft Framework for economic justification for improvements to levees from HMP to PL 84-99 standards can easily be economically justified for most, and possibly all, Delta levees. Thus, implementing the DWR Framework could delay necessary investments and increase administrative costs that reduce available resources and increase risk.

In stark contrast to the DWR proposal for a lower Delta levee standard, this Plan argues that many Delta levees should be improved beyond PL 84-99 levels to a higher Delta levee standard described in Section 5.3.2. The argument for making this additional investment is pretty straight-forward: even the Delta-specific PL 84-99 standard does not provide adequate protection from more extreme floods and earthquakes and does not provide a basis for adaption should sea level rise at an enhanced rate. Assuming a cost of $2–3 million per mile for 300 to 600 miles of levees, the $1–2 billion minimum investment that would be required to improve most lowland levees and selected other levees to this higher standard is small compared to the value of the land that they protect, the recreational benefits that they provide, the value of the infrastructure that crosses the Delta, and the increased reliability of water conveyance through the Delta. Furthermore, the cost is substantially lower than improving water supply reliability with isolated conveyance.

5.4.2 Improve inspections, maintenance, and emergency preparedness and response to prevent failures

As discussed above and in Appendix E, very few levee failures have actually occurred without warning. There is normally a few days to a few weeks warning of high water and/or wind events that pose increased threats to levee stability in the Delta. Even in the case of the uncontrolled Consumnes River there is a thirty-six hour window between occurrence of the precipitation event and the arrival of flood waters in the Delta. Earthquakes occur without warning, but the consequences of even a moderate-to-large earthquake that affects the Delta are more likely to be some slumping rather than immediate breaches. Even sunny-day failures may be preceded by signs of trouble that provide reaction time. The history and characteristics of flood fighting operations makes it clearly cost-effective to invest in emergency preparedness and modern investigative techniques to head off failures before they occur. In this regard, emergency flood-fight operations have been traditionally treated as something outside of the standard descriptions of the elements of the flood control system and as something secondary at best. However, emergency flood fighting operations aimed at preventing levee failure, or reducing the flood extent, depth and/or duration should be considered as an integral part of the flood control system along with physical infrastructure.

Below are some of the measures that might improve this kind of emergency preparedness.

- Complete flood contingency maps and preliminary engineering designs for the entire Delta that would both improve response to threats to levee stability and pre-identify specific options for reducing the extent, depth, and/or duration of flood waters in the event of a breach. This pre-planning would serve as the basis for more intelligent placement and composition of flood fight stockpiles with not only generally needed resources but also resources needed to implement specific, pre-identified, engineering actions to contain flood waters for that part of the Delta.
- Include in the stockpile system newer types of temporary means for raising levees, such as “Aquatubes” or “Aquafences,” and materials for controlling excessive seepage, blocking highway underpasses or gaps in secondary levees, and placing emergency berms. Aquatubes, and similar new devices, allow for temporary increases in the levee height when a particularly severe flood threatens or after an earthquake. These devices can quickly raise the crest of a levee, or secondary berm, over much greater lengths than can be accomplished with conventional sandbags. Other examples of new products include the “rapid repair of levee breaches” bladders developed and tested by USACE to seal incipient breaches or underpasses, and sheet pile which has been studied recently as a substitute to rock and fill for repairing breaches. These new products and techniques should be explored and added to the final Delta stockpile depot system developed out of the flood contingency mapping process.
- Set in place plans and procedures for improvised emergency repairs to levees following an earthquake. This might include borrowing from landside toe-berms as suggested above. This would reduce current reliance on the limited dredge resources in the Delta and allow more rapid response to multiple, simultaneous, threats to levee stability.
- Use newer technology, such as that developed at the University of Texas at Austin by Professor Kenneth Stokoe for monitoring highway and airfield pavements, to conduct periodic inspections of the levees. This technique senses small changes in the levee, such as those caused by rodent burrowing, and thus flags locations that require more detailed inspection.

- Install simple fiber-optic cables at the toes of levees as suggest by Professor Jason de Jong of UC Davis in order to sense deformations. Again, this technique flags locations that require more detailed inspection and, in the event of an earthquake or terrorist activity, would immediately identify trouble spots for emergency managers and national security personnel.
- Implement the recommendations of the SB27 Task Force report when released.

Improved federal, state, county, and community coordination is equally important in preventing failures. Notwithstanding improvements in coordination that are currently being worked on, the suggestion made elsewhere that responsibility for maintenance of emergency-response plans, protocols, and systems jointly developed by Delta jurisdictions responsible for flood response be turned over to a Delta-region authority with an appropriate funding base appears to have great merit.

5.4.3 Improve both immediate response and longer-term recovery after failures

In general, emergency response following a breach involves two elements. The first of these is very immediate and involves controlling the spread of flood waters, evacuating threatened people and livestock, and minimizing damage. In the riverine environment this might involve blocking freeway underpasses or otherwise reinforcing secondary levees and making relief cuts through levees to drain floodwaters back into the river system at a lower point on the river. To be effective, these actions require detailed emergency planning and preparation as exemplified in the flood contingency mapping concept (see www.sjmap.org/oesmg for a description of this concept with examples).

However, while this kind of planning and preparation should be made for all the Delta islands and tracts, the emphasis for islands with deep subsidence should be on planning for efficient dewatering and protection of interior levees since it is impossible in these cases to reduce or stop the flow of water until the island is flooded and water levels equalize. Once that has happened, the breach can be repaired and the island more efficiently pumped out and restored to a stable condition. As illustrated by the repair of the 2004 Upper Jones Tract failure, unnecessary delays and expense can occur unless the repair of the breach is planned and executed properly. In that case larger rocks were used to initially plug the breach but there were insufficient fines to limit continuing seepage to an acceptable rate. That resulted in construction of a waterside berm with provision for the planting vegetation on a bench in part as mitigation for encroachment into the channel, as may be seen in Figure C7 in Appendix C. Thus forward planning and stockpiling of suitable materials for repair of levee breaches is very desirable. In the absence of a one-stop permitting mechanism, it also seems very desirable that this forward planning includes establishment of a fast-track procedure for acquiring any necessary permits or authorizations. Speedy repair of breaches and pumping out of flooded islands not only minimizes damage and losses on the island in question but also the losses that occur as a result of enhanced seepage into adjacent islands.

5.4.4 Current planning efforts

5.4.4.1 High-Level Coordination

In response to the passage of Senate Bill (SB) 27 in 2009, the California Emergency Management Agency, Cal EMA, organized a Delta Multi-Hazard Coordination Task Force. Since funding was never provided by the legislature, this task force operated on limited funding to develop a draft report that outlines a strategy for improving Delta flood response and creating more effective regional response systems. This strategy includes the establishment of a permanent emergency response protocol to ensure that response to threats to levee integrity is

promptly initiated without the delayed response occasioned by budgetary or bureaucratic issues seen in past floods. This planning effort appears to overlap with DWR-USACE activities that are already under way, but it is the only report developed jointly by the emergency managers of Delta counties and State agencies actually responsible for directing emergency response. The final Task Force report has not yet been released but is expected early in 2012.

An important concept arising from the SB27 discussions is the need to treat the Sacramento-San Joaquin Delta as a single integrated area of operations for purposes of emergency planning and actual response and coordination rather than as the fragmented background to the current reliance on political and administrative boundaries to define distinct areas of operations.

5.4.4.2 DWR Emergency Planning

The current DWR studies were initiated by the Metropolitan Water District of Southern California (MWD) which, commencing in February 2006, undertook a study of two options for minimizing the interruption of exports resulting from a hypothetical 50 levee breaches/20 flooded islands scenario. The pre-event scenario involved advance construction of levee and river-flow barriers to block saltwater from entering the south Delta in a major emergency. It was estimated to cost $330-485 million. The post-event strategy allowed saltwater to enter the entire Delta, followed by the creation of an emergency freshwater pathway to the export pumps. The cost estimate for this strategy was about $50 million for pre-positioning of materials, with an ultimate cost of perhaps $200 million. MWD then elected in April 2007 to pursue the second alternative in association with the State Water Contractors and DWR using funds from propositions 84 and 1E to the maximum extent possible.

By January 2008 DWR was reporting on progress on the adopted strategy. At that time, contracts had been signed for the delivery of 240,000 tons of rock to three stockpiles in Rio Vista, Hood, and the Port of Stockton by June 2008. A planned second phase would have increased the quantity of rock at each location and added additional "breach closure materials."

That work has now apparently been subsumed into the development of a broader program which is intended to guide DWR's activities during an emergency.[79] This program includes three components:

1. Development of a plan for flood emergency preparedness response and recovery in the Delta. This plan consists of three elements:

    A. In association with USACE, development of a GIS-based flood contingency maps and associated data.

    B. Development of strategies for minimizing the delay in restoring fresh water to the export pumps. This includes advanced modeling of salinity intrusion and risk assessments. Although no results have been officially reported, it is understood that these studies suggest that the Delta flushes out more rapidly than had previously been expected, and that exports could be resumed in a maximum of six months, but more likely in a shorter period, even if multiple islands have been flooded. These studies are expected to produce tools that can be used to guide short-term water conveyance and upstream reservoir operations and prioritization of possible placement of emergency rock barriers and levee repairs.

[79] Delta Flood Emergency Preparedness, Response and Recovery Program, An Overview, DWR Brochure, June 2011, and presentation to Delta Stewardship Council, September 23, 2011.

C. Definition of the roles and responsibilities of DWR emergency response personnel and coordination with other agencies.

2. Coordination and integration of DWR's plan with the plans of other Delta flood response agencies.

3. Development and implementation of flood emergency response facilities in the Delta. Implementation of this item requires additional legislation to allow redirection of bond funding for this purpose.

5.4.4.3 County-Level Planning

Work is continuing on various county emergency response plans but these are more oriented to immediate response and public safety than to repair of levee breaches and de-watering of flooded islands, except in the case of San Joaquin County where flood contingency mapping has been undertaken since 1998 where flood fight operations have been addressed in detail. There are many elements of these different county plans, such as the flood maps and guide developed by San Joaquin County[80] that could be usefully extended to cover the entire Delta within the more integrated, regional, approach to planning advocated by the SB27 Task Force. It would be desirable to have a single integrated Delta-wide emergency response plan that identifies the actions that need to be taken by the individual counties only as sub-sets of a coordinated regional response.

5.4.5 Discussion of Alternate Risk Reduction Strategies

In summary, while some progress is being made on all three approaches to risk reduction, much of the DWR effort appears to be directed to the third approach, responding to failures after they have happened, instead of preventing them. The current round of DWR studies should certainly be completed, but going forward much more emphasis should be given to the issues raised by Baldwin (2011)[81], most notably that a regional emergency response agency is required to ensure that improved emergency response plans and systems are adequately maintained into the future, and that the regional emergency response agency should place much more emphasis on preparation for flood-fighting and emergency response following earthquakes, as discussed herein in Section 5.4.2. Such a regional agency would not have direct response responsibilities in order to not disrupt the existing system established under the California Standardized Emergency Management System (SEMS).

5.4.6 Economics of Risk Reduction Strategies

Figure 16 indicates that there are few, if any, islands in the Delta that are in purely agricultural use. However, even the discussions of agricultural value focus only on property value or net profits to farmers, ignoring all the other income and economic activity created by farm employees, suppliers, and related enterprises. For many islands, the energy and transportation infrastructure, homes and businesses far exceed the agricultural value. Even if a flooded island were purely agricultural, permanent flooding would have adverse impacts on the levees of adjacent islands through wave action and enhanced seepage. In addition to the agricultural and infrastructure losses and stress on adjacent levees, though Delta conveyance of water is impacted in the short term, and if islands were to be left in a flooded condition, both in-Delta and out-of-Delta uses of water would be impacted by other water quality issues such as increases in

[80] http://sjmap.org/oesmg/gfcm/Flood_Map_Guide_Final_6-1-10.pdf
[81] Baldwin, R., San Joaquin County Comments on the First Staff Draft of the Delta Plan, 2011, http://deltacouncil.ca.gov/public-comments/read/143?page=1

organic carbon. As noted by both Healey and Mount (2007)[82] and Suddeth (2011),[83] the ecological benefits of additional flooded islands are uncertain, whereas many agricultural islands (particularly those with low-value crops that are said to be not worth saving) provide critical habitat to migrating birds along the Pacific flyway. According to the draft DWR Technical Memorandum, the Delta levees presently provide a home for as many as 500 species, including several rare and endangered species, in its current configuration. Thus, although the current Delta is not as productive and valuable an ecosystem as the historic Delta, it still has considerable ecological value. As discussed elsewhere in this report, creating large open water areas would impact recreation and tourism because most Delta boaters are attracted to the Delta for its meandering, wind-protected channels. Finally, flooded islands also have much higher evaporation rates than agricultural lands so that there is a net loss of water from the system.[84] The following is a summary list of the economic assets and values protected by Delta levees:

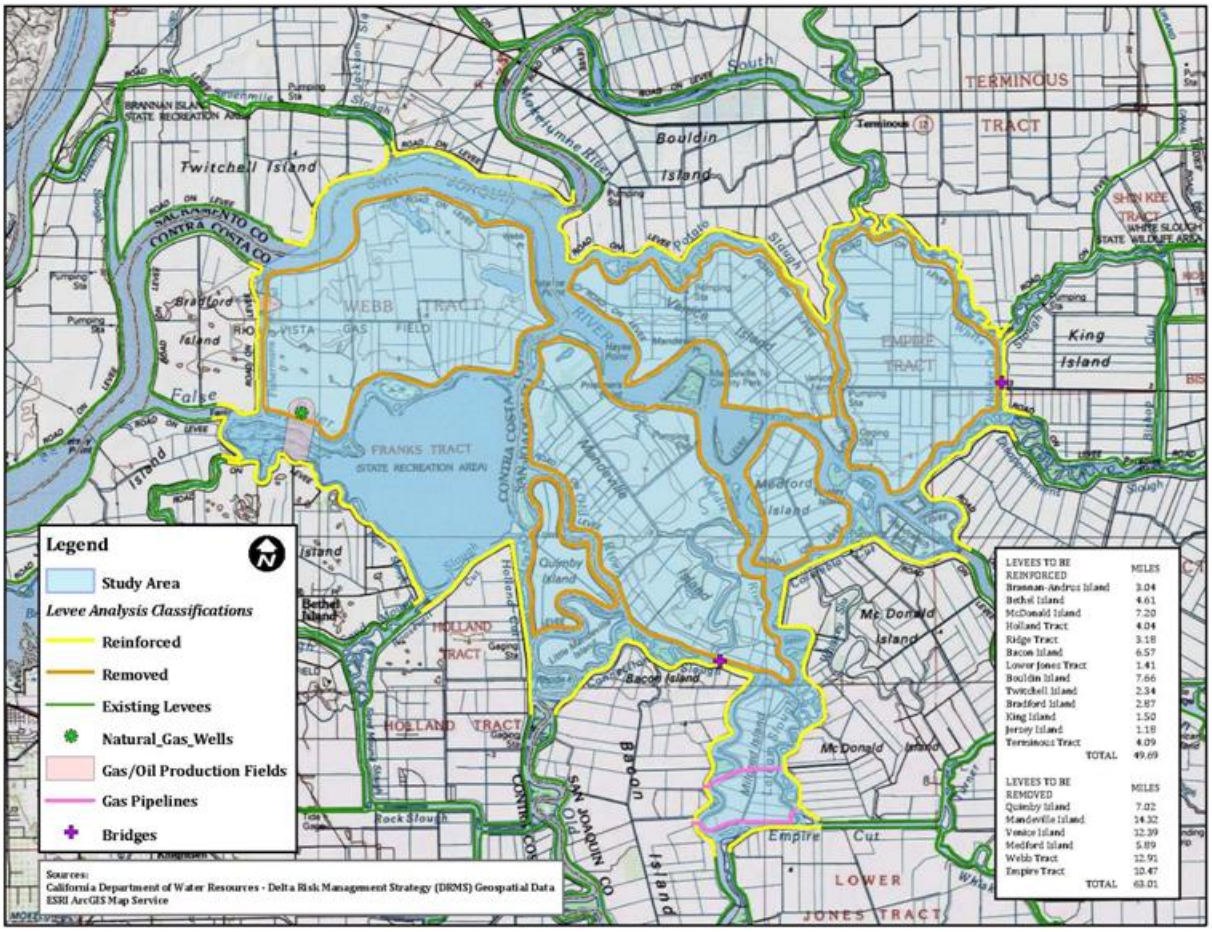
- Net farm profits (capitalized into farmland values)
- Residential and commercial structures
- Flood protection of nearby islands/levees (reduced flood-control costs)
- Critical infrastructure such as fuel pipelines, natural gas wells and storage, electricity transmission lines, highways and roads, railroads, deep-water shipping channels, communications infrastructure (TV/radio/phone towers)
- Other income generated by agriculture production (ripple effects)
- Water quality for municipal and industrial users in and outside the Delta
- Wildlife habitat
- Water conveyance
- Water supply (reduced freshwater consumption)
- Recreational values (primarily boating channels and hunting areas)
- Public safety, and prevention of loss of life
- Lost opportunity for future beneficial uses

A start on a more comprehensive assessment of the economics of levee upgrades, repairing breaches and draining flooded islands was made by Suddeth et al. (2008) and refined in Suddeth et al. (2010). In this very influential study, Suddeth et al. calculated the net expected costs for 34 subsided Delta islands and three scenarios using levee failure probabilities estimated in DRMS Phase 1: no upgrades from the 2005 conditions estimated by DRMS; upgrades to the Delta-specific PL 84-99 standard; and upgrades to that standard plus an additional 1 foot of freeboard. In addition to an estimate of agricultural land value for each island, the analysis included the value of structures on the islands. The analysis considered the estimated costs of repairing breaches and draining flooded islands and the costs of not repairing islands, which included the cost of rebuilding or re-locating roads and the cost of fortifying nearby islands, in order to make decisions on whether or not to recover flooded islands. In terms of the bullet list above, Suddeth et al. account for most of the first four value categories, but their model does not address the more difficult to measure impacts in the rest of the list including the potential loss of life.

[82] Healey, M., and J. Mount, Delta Levees and Ecosystem Function, Memorandum to John Kirlin, Executive Director of Delta Vision, November 2007.
[83] Suddeth. R., Policy Implications of Permanently Flooded Islands in the Sacramento-San Joaquin Delta, UC Davis Center for Watershed Sciences, 2011, http://watershed.ucdavis.edu/pdf/.
[84] Sacramento Valley Water Use Survey 1977, DWR Bulletin 168, October 1978.

The independent review panel for the ESP expressed concerns about the island by island cost-benefit approach utilized by Suddeth et. al. because Delta levees work as a system as described in this report. In addition, it should be noted that the Department of Water Resources itself has warned against utilizing the DRMS data in the manner employed by Suddeth et. al. For example, the January 2008 progress report to the legislature made these statements regarding the quantification of risks in the DRMS report "Results should be considered on a regional basis rather than for any individual island or levee reach," and "The results should be used for a broad understanding of the condition of the entire Delta, and should not be used as a basis for design for any specific location."[85] Because of the influence of the Suddeth et. al. paper, we ignore these general warnings about the approach and consider the details of the island-by-island cost-benefit approach.

Figure 18 The Suddeth et al. (2010) Inland Sea[86]



In their initial analysis, Suddeth et al. find that it is not "economically optimal" to upgrade levees to the PL 84-99 standard, and only cost-effective to repair 18 to 23 of the 34 islands if they fail. However, this result is very dependent on the assumed costs, values, and failure probabilities,

[85] See the last two bullet points on page 13 of "Risks and Options to Reduce Risks to Fishery and Water Supply Uses of the Sacramento/San Joaquin Delta." A Report Pursuant to Requirements of Assembly Bill 1200, Laird. Department of Water Resources & Department of Fish and Game. January 2008.
http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/docs/AB1200_Report_to_Legislature.pdf

[86] For high resolution image see http://forecast.pacific.edu/desp-figs.html

and sensitivity analysis in the article show significant changes when assumptions are adjusted to more realistic values. For example, the initial analysis assumes most agricultural land is worth $2,500 per acre based on a simulation of net profits, when current appraisals for Delta farmland are $6,000 per acre and nearby cropland without Delta flood risk is valued at $10-12,000 per acre. In addition, estimated probabilities of levee failure were taken from DRMS which a previous section explains are thought to err significantly on the conservative side. While the cost estimates that were used for levee upgrades to PL 84-99 were reasonable, it was assumed that each upgrade only reduced the probability of failure by 10 percent. In contrast, DRMS phase 2 report estimated a 24 percent decline in failure probabilities from PL 84-99 upgrade, and improvements might well be even greater, especially if the levee system is upgraded to uniform compliance with the PL 84-99 standard. In addition, the estimated cost of reinforcing the surrounding islands (and thus limiting the propagation of failures) is low, and other costs associated with leaving islands flooded (including the adverse effects on recreation and water quality) were neglected.

Fortunately, the most recent version (2010) of the paper includes some much needed sensitivity analysis to the study assumptions. In the most interesting scenario, the authors tripled their assumed property values and “Do Not Repair” costs in what they call an “extreme case.” In our view, this scenario is not extreme at all, but uses far more accurate values for two key variables. The results show nine islands that are not repaired, including six contiguous islands in the Central Delta and three small islands scattered in other areas. The results are displayed in Figure 9 of Suddeth et al. and the six central Delta islands are displayed in Figure 18 above.

These six islands in the Central Delta are the most likely candidates for conversion to open water, because they are relatively free of people, property and infrastructure and support mostly low-value crops. Thus, we have included this open water scenario as a policy scenario in subsequent chapters to more fully assess the potential effects to areas not considered by Suddeth et al. such as recreation and several categories of infrastructure. More details are found in subsequent chapters but we preview the results here to complete the present discussion.

The total length of the levees around the six islands is 63 miles, and the total length of the surrounding levees that would have to be improved to a higher standard to deal with higher wave heights and seepage is approximately 50 miles. If Webb Tract, which is one of the eight western islands called out for their importance to protecting against salinity intrusion, and Empire Tract, which houses the new City of Stockton water intake, were to be omitted from the list, the length of the levees removed would drop to 43 miles. The length of levees that would need to be improved, however, would only drop to approximately 45 miles. In our judgment, the cost of reinforcing the surrounding levees to cope with higher wave height and seepage forces would likely be much greater than the $1-2 million per mile cost of improving the levees on the existing islands, thus on the basis of the cost of improving and maintaining levees alone, the creation of this inland sea cannot be economically justified. But there are also additional factors that must be considered. First, Suddeth et al. did not account for major new water supply facilities for the City of Stockton that are being completed on Empire Tract. Accounting for this facility, Empire Tract would surely be excluded from the “do not repair” list, and the water quality problems from permanent flooding of nearby Medford, Venice, and Mandeville Islands would increase due to the nearby intake. Second, this open-water area is in the heart of the Delta’s most popular area for boating recreation and is surrounded by about half of the Delta’s marinas. The recreation experts on our study team, and numerous interviews with Delta recreationists unanimously agreed that this large open-water area would have a large negative effect on the Delta boating economy, for the boating attraction is the Delta’s unique meandering channels

protected from wind and waves. Third, although these islands are free of major highways and railroads, almost all of them border the Stockton Deep-water Shipping Channel, and their permanent flooding would create several problems for the Port including the need for increased dredging that is already constrained by a tight time window for environmental reasons. As discussed in the infrastructure chapter, expanding the Port of Stockton is at the center of the region's economic development, transportation, and air pollution reduction plans.

Taking into account these additional costs, Quimby Island is the only one of these six that might reasonably be considered for a "do not repair" list and eventual conversion to open water. Using this framework, the other three small islands that might be considered for "do not repair" status are Coney, Fay, and Dead Horse. The levee lengths on these islands range from 1.6 miles on Fay to 7 miles on Quimby for a grand total of 16.7 levee miles on the four candidate islands that may be expendable among the hundreds of miles of Delta levees. Even if upgrading and repairing these islands were not technically cost-effective, there would still be some benefits from the investment so that the net savings from letting the 16.7 miles of levees go would be relatively small. In our view, these very small potential savings are not worth the cost, delays, risk, and complexity created by requiring island-by-island, project-by-project justification of every upgrade from the HMP to the PL 84-99 standard as proposed in the DWR Draft Framework.

Given that federal assistance for costly repairs to islands is linked to achieving the Delta-specific PL 84-99 standard, the decision of whether to repair islands in the case of a breach is parallel and virtually the equivalent of whether the levees should be upgraded to the Delta-specific PL 84-99 standard. Thus, the above discussion summarizes the economic argument for our recommendation to upgrade all Delta levees to the Delta-specific PL 84-99 standard.

A second question is whether upgrading Delta lowland levees to a new higher Delta standard is economically justified. The primary economic justification for this additional upgrade is that it is a cost-effective and more financially feasible alternative to other proposals that address the coequal goals of water supply reliability and ecosystem restoration. A robust, seismically-resistant levee system would make a large improvement to water supply reliability. According to this study, $1–2 billion would be sufficient to achieve this higher standard with costs potentially increasing to $4 billion to allow for program management costs and ecosystem enhancements. This is much less expensive than the $12 billion cost estimate of isolated or dual conveyance, although dual conveyance would result in somewhat higher water exports. Water exporters have expressed concerns about whether the $12 billion isolated conveyance is cost-effective and have yet to develop a viable finance plan. Not only are upgraded levees less costly, but they provide a much broader set of benefits. While water exporters would have to pay all the costs of isolated conveyance, they could share the much lower costs of levee upgrades with others.

Water supply is not the only major infrastructure in the Delta that requires protection from seismic risk. Although they were not the focus of the 2009 Delta Reform Act, transportation, energy, and in-Delta water supplies are also critical infrastructure vulnerable to a seismic event. Upgraded levees are a cost-effective joint solution to the problem, rather than a more costly system by system approach. The infeasibility and extreme cost of the system-by-system approach is evidenced by the earlier discussion of the DRMS Phase 2 trial scenarios. Individually protecting Delta highways by building on piers cost $6 billion, individually protecting energy and aqueducts in a south Delta infrastructure corridor cost $4 billion, and individually protecting water exports costs $12 billion. The total cost of individualized solution approach is in excess of $20 billion, and some systems, not to mention in-Delta lives and property, have received no additional protection with the system-by-system approach.

This proposal to make the Delta levees more resistant to earthquake loadings is a logical extension of other seismic retrofit work that has been conducted in the Bay-Delta region since the 1989 Loma Prieta earthquake. These upgrades have already been performed for highways and bridges, dams, water supply systems, and the BART system. The Delta levees are the last major infrastructure element in the Bay-Delta region that needs to be upgraded to modern seismic standards. In order to put the proposed spending of a further $1-4 billion on Delta levees in perspective, it is noted that the Water System Improvement Program of the San Francisco Public Utilities Commission, which is basically a seismic upgrade of the Hetch-Hetchy aqueduct system, is costing $4.6 billion.[87]

Improvement of lowland levees to this standard means that they might also meet the Urban Levee Design Standard but that does not mean that it would be appropriate to construct higher-density housing behind them. It would not. The argument advanced by some that improvement of the Delta levees to a higher standard would lead to urbanization assumes a set of other regulatory controls would disappear and that a market would suddenly appear for an urbanized Delta. The Delta Protection Commission, Stewardship Council, and five county general plans are all highly protective of a rural, agricultural Delta and have regulatory authority that would limit significant urbanization. It is true that the additional flood protection would support some reinvestment and revitalization of Legacy Communities, and might facilitate the construction of some limited new recreation and tourism facilities to support enhanced recreation. However, this is a benefit to improved levees, not a cost. Existing law requires that the Delta be protected and enhanced, albeit as an evolving place, and our professional assessment is that most lowland levees need to be improved to this higher standard in order to accomplish this and that it is economically realistic to do so.

Although the details and reasoning is a little different, the recommendation of improved levees in this study is similar to the “Fortress Delta” alternative in the 2007 PPIC report, “Envisioning Futures for the Sacramento-San Joaquin Delta.[88] Although the PPIC evaluation showed that the “Fortress Delta” was the best of the “freshwater Delta” solutions, it was rejected from further consideration in the screening analysis due to “extreme costs.” The alternatives that passed the initial PPIC screening for further consideration either involved a peripheral canal estimated to cost $2–3 billion and ecosystem alternatives that do not satisfy the coequal goal of water supply reliability. Given that isolated conveyance is now estimated to cost $12-15 billion, and water supply reliability state law, our proposal for enhancing Delta levees is little more than suggesting that the 2007 PPIC rejection of the “Fortress Delta” alternative should be reconsidered in light of new information and developments.

5.5 Levee Improvement Strategies and Funding

Commencing in 1973, funding has been provided by the State of California to assist the Delta reclamation districts under two programs.

The Delta Levees Maintenance Subventions Program provides financial assistance to local levee-maintaining agencies for the maintenance and repair of levees in the Delta. It is authorized in the California Water Code, Sections 12980 through 12995. It has been in effect since passage of the Way Bill in 1973, which has since been modified periodically by legislation. One of these modifications provides for the inclusion of project levees in the program as long as more than 50 percent of the island is in the Primary Zone of the Delta, CWC 12980(f). Project

[87] http://sfwater.org/index.aspx?page=115
[88] http://www.ppic.org/main/publication.asp?i=671

levees in the Secondary Zone are not eligible for subventions funding. The intent of the legislation, as stated in the Water Code, is to preserve the Delta as it exists at the present time. A summary of expenditures under the subventions program is included as Table 3.[89] Through FY 2009-2010 the state has provided $147 million against a local share of $118 million for a total of $265 million. Details of the current procedures for prioritizing subvention funding and the required local cost shares are provided in the draft DWR Technical Memorandum (2011).

Table 3 Delta Levee Subventions Maintenance Program State & Local Cost Share 1973-2010

	STATE						
Fiscal	Maintenance	Priority 1	Priority2	Priority 3	Total	Local	**Sub-**
Years	Reimburs.				Reimburs.	Share	**Total**
	(1)	(2)	(3)	(3)			
	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	**$1,000**
1973-74	200				200	272	472
1974-75	175				175	483	658
1975-76	-				-	-	-
1976-77	190				190	395	585
1977-78	175				175	486	661
1978-79	175				175	323	498
1979-80	-				-	-	-
1980-81	-				-	-	-
1981-82	1,421				1,421	2,091	3512
1982-83	1,334				1,334	1,929	3263
1983-84	1,384				1,384	3,803	5187
1984-85	1,817				1,817	2,279	4096
1985-86	1,335				1,335	1,628	2963
1986-87	1,736				1,736	2,097	3833
1987-88	1,882				1,882	1,501	3383
1988-89	1,295	3,705			5,000	4,371	9371
1989-90	1,913	3,407			5,320	8,668	13988
1990-91	1,610	3,689			5,299	8,404	13703
1991-92	2,266	159			2,425	10,449	12874
1992-93	1,823				1,823	4,244	6067
1993-94	1,774	2,916	376	15	5,081	2,070	7151
1994-95	2,371	2,770			5,141	2,233	7374
1995-96	1,449	2,097			3,546	1,602	5148
1996-97	1,758	1,790			3,548	2,158	5706
1997-98	4,432	2,647			7,079	2,974	10053
1998-99	3,412	1,738			5,150	2,341	7491
1999-00	3,085	3,194	58		6,337	2,715	9052
2000-01	4,954	3,053	55		8,062	3,371	11433
2001-02	3,777	1,784			5,561	2,515	8076
2002-03	3,554	1,446			5,000	4,666	9666
2003-04	4,029	1,996			6,025	6,102	12127
2004-05	4,698	1,227			5,925	6,476	12401
2005-06	5,364	358			5,722	4,220	9942
2006-07	4,485	1,505			5,990	6,647	12637
2007-08	5,645	8,503	2,148		16,296	6,210	22506
2008-09	6,810	4,515	545		11,870	4,799	16669
2009-10	7,254	2,131	41		9,426	3880	13306
	89,582	**54,630**	**3,223**	**15**	**147,450**	**118,402**	**265,852**

(1) Excess maintenance over the maintenance cap and DFG costs are included in the maintenance.
(2) Priority 1 includes HMP and Bulletin 192-82 work.
(3) Priority 2 is priority 1 excess cost over $100,000 per mile cap. Priority 3 is land use changes

The Delta Levees Special Flood Control Projects provides financial assistance to local levee-maintaining agencies for rehabilitation of levees in the Delta. The program was established by the California Legislature under SB 34, SB 1065, and AB 360. The special projects program is authorized in the California Water Code, Sections 12300 through 12314. This program initially focused on flood-control projects and related habitat projects for eight western Delta Islands—

[89] Provided by DWR and also included in the DWR Technical Memorandum.

Bethel, Bradford, Holland, Hotchkiss, Jersey, Sherman, Twitchell, and Webb Islands—and for the Towns of Thornton and Walnut Grove; in 1996 it was extended to the rest of the Delta. Details regarding the current prioritization of special projects funding and the required local cost shares are also provided in the draft DWR Technical Memorandum. Also, special project bond funding has been authorized for the protection of the Mokelumne Aqueduct, for those levees whose failure would jeopardize water conveyance through the Delta, and projects that reduce subsidence and assist in restoring the ecosystem of the Delta.

Table 4 Delta Levee Program Special Projects State Expenditure 1989-2010

Fiscal Year	Planning & Engineering	Levee Construction	Habitat Enhancement	Total Expenditures
1989-1990	$15,000	$0	$0	$15,000
1990-1991	$5,210,000	$810,000	$0	$6,020,000
1991-1992	$709,400	$4,085,000	$0	$4,794,400
1992-1993	$668,500	$4,148,000	$0	$4,816,500
1993-1994	$140,000	$6,318,054	$0	$6,458,054
1994-1995	$300,505	$1,896,518	$0	$2,197,023
1995-1996	$30,000	$1,419,370	$0	$1,449,370
1996-1997	$513,618	$4,117,720	$0	$4,631,338
1997-1998	$609	$3,201,434	$0	$3,202,043
1998-1999	$0	$2,233,787	$4,035,000	$6,268,787
1999-2000	$80,555	$1,994,673	$4,009,134	$6,084,362
2000-2001	$199,613	$4,183,526	$3,837,381	$8,220,520
2001-2002	$0	$1,333,548	$1,138,797	$2,472,345
2002-2003	$800,985	$6,645,234	$6,961,843	$14,408,062
2003-2004	$95,979	$704,381	$1,118,243	$1,918,603
2004-2005	$188,044	$2,408,507	$972,500	$3,569,051
2005-2006	$553,989	$8,510,163	$446,193	$9,510,345
2006-2007	$922,127	$8,209,557	$59,500	$9,191,184
2007-2008	$1,606,681	$18,449,127	$144,000	$20,199,808
2008-2009	$4,115,986	$18,608,588	$0	$22,724,574
2009-2010	$2,346,311	$91,274,764	$6,117,538	$99,738,613
Totals:	**$18,497,902**	**$190,551,951**	**$28,840,129**	**$237,889,982**

Note: Funds for projects in FY 2008-2009 and FY 2009-2010 have been encumbered but in most cases have yet to be released due to recent, state-wide budgetary uncertainty.

A summary of expenditures under the special projects program is included as Table 4.[90] The figure for FY 2009-10 includes $35 million specially designated by the legislature for improvements to the five islands that protect the Mokelumne Aqueduct, $32 million for HMP projects, and about $26 million for Delta-specific PL 84-99 projects. The expenditures for FY 2007-8, 2008-9, and 2009-10 are larger than in previous years because of bond funding approved by the voters in Propositions 84[91] and 1E.[92] Through FY 2009-10, a total of $237 million will have been expended through the special projects program.

[90] Provided by DWR and also included the DWR Technical Memorandum.

[91] The Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84) authorizes $5.388 billion in general obligation bonds to fund safe drinking water, water quality and supply, flood control, waterway and natural resource protection, water pollution and contamination control, state and local park improvements, public access to natural resources, and water conservation efforts.

An additional $195 million is currently available from USACE through the CALFED Levee Stability Program. The USACE funding was authorized by the CALFED Bay Delta Authorization Act of 2004 which provided for USACE participation in the then CALFED program. These funds are specifically for raising levees to the Delta-specific PL 84-99 standard which was the goal of that program. Fifty-four specific projects were identified for the short-term plan of action which includes not only work on existing levees but projects to protect critical infrastructure such as the Stockton regional waste water facility.

The total investment in Delta levees since the inception of these programs will be $698 million plus the local shares for the special projects and the CALFED Levee Stability Program once the funding in the pipeline is expended. The fact that over $351 million of this has already been spent is reflected in the generally improved condition of the levees. Also, because levees tend to fail at their weakest point, such as where they were constructed over old sloughs, many levees have already failed and then been repaired and improved at their weakest point, with the result that the present levee system is more robust than it was before the breaches. Also, concurrent with the cessation of dredging, there has been increased placement of rock riprap on the water side of the levees. Taken together, these three observations mean that historic data on the rate of levee breaches is no longer relevant, and out-of-date data compiled on the previously weaker system should not be repeated in current reports and discussions.

Table 4-1 of the DWR Technical Memorandum provides a breakdown of the funds appropriated for expenditure in the Delta from Propositions 84 and 1E. These funds total $615 million. Table 4-2 of the DWR Technical memorandum provides a breakdown of both the funds committed and the funds expended to February 2010. A total of $293 million had been committed to the subventions and special projects programs and $70 million had actually been expended at that point. The total funds committed amounted to $492 million and the total funds expended amount to $166 million, so that significant funds have been committed or expended for other purposes which include contracts, program delivery, emergency, the urban and non-urban levee evaluation programs, the Sacramento bank restoration program, and bond servicing costs. Approximately $123 million remain uncommitted. $135 million was also allocated in Proposition 84 for improving flood emergency response of which approximately $40 million has been expended by DWR. The State is just beginning to issue bond funds to other local and State agencies with responsibility for flood response in the Central Valley through grants. Priority of this new grant series is to the Delta and local efforts through the Delta Protection Commission are underway to develop a regional, joint, approach for application of funds and subsequent implementation of approved projects.

Improvement of Delta levees from at or about the HMP standard to the Delta-specific PL 84-99 standard costs in the order of $1-2 million per mile,[93] the biggest variable being whether suitable borrow material is available on-island or whether it has to be trucked or barged from adjacent islands. With the funds that are in the immediate pipeline plus the remaining bond funds, all the lowland Delta levees and most other Delta levees should be improved so that they are at or about the Delta-specific PL 84-99 standard. Indeed, if expenditure of the bond funds had not

[92] The Disaster Preparedness and Flood Protection Bond Act of 2006 (Proposition 1E) authorizes $4.09 billion in general obligation bonds to rebuild and repair California's most vulnerable flood-control structures to protect homes and prevent loss of life from flood-related disasters, including levee failures, flash floods, and mudslides and to protect California's drinking water supply system by rebuilding Delta levees that are vulnerable to earthquakes and storms. Proposition 84 enhances these efforts with an additional $800 million for flood-control projects.

[93] Based on discussions with reclamation district engineers and DRMS Phase 2 report.

been delayed by state spending freezes and other issues, this standard could have been generally met already. Even after all Delta levees have been brought up to the PL 84-99 standard, some continuing funding will still be necessary to take care of unexpected settlements and other maintenance, but this funding might be at a reduced level. For budget purposes it is suggested that a sum in the order of $20 million per year should be allocated for this purpose, but, as discussed subsequently, the year-to-year spending might vary and should be balanced against funding for continuing emergency preparedness activities, maintenance of current and improved emergency response plans, protocols, and systems, and the setting aside of funds for to ensure prompt future emergency response to threats to levee stability and recovery of impacted areas.

As noted above, both the subventions program and the special projects program make provision for the enhancement of fish and wildlife habitat in conjunction with levee improvements. Several alternatives for accomplishing this are illustrated in Figure 6 of the CALFED Levee System Integrity Program Plan including the construction of new waterside berms and the widening or rolling back of the existing levees. These improvements cost much less than the kind of setback levees discussed in the DRMS Phase 2 report, which involves construction of entirely new levees on virgin ground, and might typically cost in the order of an additional $1-2 million per mile. The existing funding provides for a certain amount of this kind of enhancement but if the Delta Conservancy Strategic Plan and the Delta Plan call for more extensive enhancements of this kind, additional funding will be needed.

The cost of improvement of most lowland levees and selected additional levees to a higher Delta-specific standard that will provide 200-year plus protection for floods, earthquakes and sea-level rise and that will incorporate ecologically friendly vegetation on the water side is more difficult to estimate precisely. After improvement to the Delta-specific PL 84-99 standard, levees that do not contain saturated, loose sands may come close to meeting this standard although they would still benefit from wider crowns. Additional width also makes planting on the water side, which is desirable for a number of reasons and may be required by the Delta Plan, much more feasible. Determination of which levees do require additional improvement will require more detailed studies, but prioritization of further improvements is relatively straightforward and does not necessarily require risk analyses or cost-benefit studies. Regardless of whether or not they contain sands susceptible to liquefaction, most lowland levees should be improved to this higher standard because they face the most immediate threat from possible sea-level rise and help prevent salinity intrusion. Certain other levees which are judged to be critical to protecting infrastructure might also be improved to this higher standard if they are shown to contain sands that are susceptible to liquefaction. Figure 16 provides an initial indication of which islands and tracts might be considered to have relatively high priority for further improvements. These further improvements might cost in the order of an additional $2-3 million per mile. If it is assumed that this improvement is required over 300–600 miles of non-project, non-urban levees, the total cost might be as low as $1 billion. However, for general planning and budgeting purposes, it might be desirable to use a higher number like $2 billion. The biggest variable in these estimates is whether or not suitable fill is available on the same island or has to be trucked or barged in. That in turn is both a function of the availability of the materials and the cooperation of the landowners, for on-island borrowing may take some land out of agricultural production. The above estimates assume a combination of on- and off-island borrow sources. If only on-island borrow is used, these cost might be reduced by as much as 50 percent. Alternately, if the regulatory impediments to dredging in the Delta are resolved, good-quality fill material could be obtained for a cost comparable to that of on-island borrow. While there are other potential uses for the dredge spoils that will result from either deepening of the deep-water ship channels or from maintenance dredging, their use for levee improvements would provide a

means to keep down the cost of those improvements. These figures also assume that design and construction are executed by the local reclamation districts. If managed directly by DWR or USACE, these costs should be multiplied by a factor of as much as 2 or 3. Costs for non-urban and non-project levee improvements are much lower than costs for improvements to urban levees, which have to factor in encroachments and penetrations and where there is often no land available for widening the levees. This has resulted in the widespread use of deep-cutoff walls that are installed through the existing levees. In addition, there are significant bureaucratic issues which add to the cost, especially when there are many landowners involved. This results in the "soft costs" being as much as 50 percent of the actual construction costs on these projects. Although the possible need to take a strip of agricultural land on the Delta islands and the need to move existing drainage channels, siphons, and pumps are still issues, the cost implications are much smaller for Delta levees and only a relatively small number of landowners have to be accommodated.

The estimated cost of $1-2 billion for improving Delta levees beyond the PL 84-99 standard that is given above not only assumes that the work would be executed by the reclamation districts but also that engineering and permitting costs are no greater than they are at present. This figure also provides only for basic levee construction on existing alignments, not for planting and other environmentally-friendly enhancements. While planting vegetation on the water side of widened levees would add little to this cost, the creation of waterside berms or rolling the levee back as previously discussed in connection with improvements to the PL 84-99 standard might add 50 to 100 percent to the cost. Construction of setback levees on a new alignment would involve land acquisition issues and add significantly to the cost, especially where the setback levee is constructed over peat that has not previously been consolidated.

There are special considerations for levees that protect Legacy Communities in the Delta. Detailed estimation of the likely cost of improving those levees awaits policy decisions that have not yet been made. However, if the levees on the relevant islands are upgraded to the proposed new Delta standard, the Legacy Communities, and also industrial/commercial facilities that serve Delta agriculture such as wineries, crush-pads, and cold storage facilities, would automatically be afforded superior flood protection and special "ring levees" should not be required. In many cases superior flood protection is in fact already provided to these communities and facilities by the existing project levees. For instance, the project levee that borders the Sacramento River in Walnut Creek East already has a wide crown, exceeding 50 feet at some locations, in order to accommodate a two-lane highway with parking on either side. While some additional improvements might be required elsewhere to protect legacy communities, the issue is more one of non-compliance with vegetation and encroachment and calculated seepage gradient requirements that are included in various USACE and FEMA guidelines and policies, rather than real flood risk. This issue could be addressed much more cost-effectively by granting variations from national policies rather than requiring unnecessary construction which might destroy the communities that are trying to be protected.

There are three potential sources of funding from within the Delta for maintenance, improvements, and emergency response: (1) the traditional funding from the landowners, who also make in-kind contributions to inspection and maintenance; (2) the owners of the infrastructure that passes through the Delta; and (3) the agencies that convey water through the Delta. The Delta Stewardship Council has proposed the creation of a new agency, the Delta Flood Risk Management Assessment District, with fee assessment authority. Local government officials in the Delta have expressed concerns about this proposal, and have expressed a preference for a joint powers authority (JPA) of the five counties or the Delta Protection Commission take on this role. Regardless of the entity, and leaving politics aside and just

looking at this as an engineering management and risk reduction issue, it would be beneficial for a Delta region-centric entity to allocate the funding of Delta levee improvements once the present bond funding is exhausted, or even sooner. This entity should also be the entity that is responsible for maintaining emergency preparedness and response plans, protocols, and systems jointly put in place by Delta jurisdictions responsible under the SEMS for flood response because of the trade-off that has been previously discussed of investments in levee improvements and the need to effectively maintain improved regional emergency preparedness and response systems and protocols. Only if funding of both levee improvements and emergency preparedness response and recovery is controlled by a single entity whose prime concern is the protection and enhancement of the Delta in addition to consistency with the coequal goals, will it be possible to make a rational and efficient allocation of the available funds.

In addition to the funding of the improvement of selected levees to the higher Delta-specific standard, continuing funding will be required for maintenance of the existing levees and for emergency preparedness response and recovery. It has been suggested above that $20 million per year might be an appropriate sum for continuing maintenance of all Delta levees, but this figure might vary from year to year as more or less money is put into emergency preparedness response and recovery. A total sum in the order of $50 million per year might be appropriate to cover both maintenance and inspection and emergency preparedness. Some fraction of this sum should be set aside each year to provide for emergency response to threats to levee stability, response to reduce the extent, depth, and/or duration of flood waters in the event of a breach, and recovery of impacted areas to supplement any funding protocol or fund that the state has established for that purpose or to replenish such a fund following its use in an emergency. To put this sum into perspective, although the total cost should not be borne by either highway users or water conveyance alone, if it were borne by highway users, there would need to be a toll of $2 on each use of the state highways in the Delta and if it were borne by the state and federal water contractors, there would need to be an additional charge of $10 per acre-foot, assuming average exports of 5 maf. It would also be entirely reasonable that the state and federal governments contribute funding to this entity. If it is the policy of the state to protect and enhance the Delta because that is judged to be of benefit to the region and the state, then it becomes the state's responsibility to provide funding that could, for instance, be directed primarily to widening levees so that they can accommodate vegetation on the water side and allow construction of improved recreational and tourism facilities that benefit the entire region and beyond. Outside its operation of the Central Valley Project, the federal government has interests and obligations that include the continuing downstream effects of hydraulic mining on federal lands, navigable waterways, and national economic security.

Implementation of the necessary improvements to Delta levees would be greatly helped by reducing or eliminating regulatory impediments to action by the creation of a one-stop permitting system for selected activities within the Delta including dredging, levee construction, and ecosystem restoration.

5.6 Periodic Update of the Flood Management Plan for the Delta

One of the four specific directives regarding the Economic Sustainability Plan that was given in the 2009 legislation is to include "comments and recommendations to the Department of Water Resources concerning its periodic update of the flood management plan for the Delta." These recommendations are:

1. Update the expected maximum water surface elevations in the Delta taking into account both the findings and the recommendations of the Central Valley Flood Protection Plan and climate change considerations. This should be done as soon as possible without waiting for the 2017 update of the Central Valley Flood Protection Plan.

2. Make provision in the Central Valley Flood Protection Plan and otherwise for re-activation of historic flood plains upstream from the Delta and by additional flood bypasses, such as the proposed Lower San Joaquin River Flood Bypass, in order to reduce peak water surface elevations in the Delta.

3. Reaffirm that it is the policy of the state to improve and maintain all non-project levees to at least the Delta-specific PL 84-99 standard.

4. Establish an additional policy to improve most "lowland" levees and selected other levees to a higher Delta-specific standard that more fully addresses the risks due to earthquakes, extreme floods, and sea-level rise, allows for improved flood fighting and emergency response, provides improved protection for legacy communities, and allows for growth of vegetation on the water side of levees to improve habitat. Define this standard in more detail as necessary.

5. Cooperate with other state and federal agencies to facilitate the renewed use of appropriate dredging in the Delta.

6. Establish as state policy that in the future any flooded islands will be recovered and that existing flooded islands should be restored as tidal habitat in order to reduce the loadings on adjacent islands in addition to providing ecosystem benefits.

7. In regard to emergency response, establish the Sacramento-San Joaquin Delta as a single, integrated, geographical area of operations for purposes of emergency planning and actual response to include establishing a regional mechanism for effective maintenance of Delta regional plans, protocols, and systems developed jointly by Delta jurisdictions.

8. Integrate the strategy and recommendations of the SB27 Task Force into appropriate State policy documents and establish funding mechanisms for implementing those recommendations through specific emergency preparedness projects designed to address the overall preparedness strategy of that report.

9. Identify emergency flood-fight operations as an integral part of the flood control system to ensure that appropriate attention and resources are maintained for this important element of loss reduction into the future.

10. Support the plan of action for improving Delta emergency response included as an appendix, Appendix M, to this report which includes measures to improve evacuation and public safety response as well as flood fight operations.

5.7 Responses to Independent Review Panel

The Independent Review Panel organized by the Delta Science Program on behalf of the Delta Stewardship Council and the Delta Protection Commission made a total of 8 suggestions to the authors for further improving the Economic Sustainability Plan of which 5 related to levees. These suggestions and brief responses are provided below.

1. In terms of the public safety aspects of the Plan, we recommend that the authors provide guidance for evacuation planning and effective communication/education about the risk of flooding.

The treatment of evacuation planning and communication/education was admittedly brief in the previous version of the report but that was because the emphasis of the report was on economic sustainability, not life safety. Reference was made, however, to continuing planning studies in these areas and that discussion has been expanded this version. An appendix, Appendix M, has also been added as noted in Item 10 of the recommendations to DWR.

2. We recommend that the authors expand their discussion regarding the consequences of levee failure and clearly identify which areas have the highest potential and which areas have the lowest or no potential for life loss. This information would be helpful in for prioritizing levee upgrades and developing appropriate standards for upgrades.

Clearly the legacy communities in the Delta have the highest potential for loss of life in the event of levee breaches and flooding but the levees that immediately protect these communities are mostly, if not all, project levees that are in relatively good condition. It is true that levees elsewhere on the islands that contain legacy communities may not be in such good condition but in addition to the fact that there would be time for warnings and evacuations, the legacy communities tend to be located on the higher parts of the islands involved so that flood waters might not in fact reach these communities even if no special actions are taken. If necessary relief cuts can be made to ensure that the legacy communities are not flooded. Further definition of the details of the exposure of the legacy communities and detailed plans for emergency response are part of the ongoing work on emergency preparedness and response that is noted above.

3. We recommend that the authors investigate and evaluate what the Department of Water Resources (DWR) is doing with regard to both riverine and Delta levees. We are referring to what DWR calls their Urban Levee Evaluations (ULE), and the Non-Urban Levee Evaluations (NULE). If levees in the California Delta provide for public safety, as opposed to only agriculture, we further recommend the authors discuss and justify why Delta levees should be designed to a lower standard that ULE or NULE levees in the Sacramento-San Joaquin Valley.

The authors are fully aware of the ULE and NULE programs being conducted by the Department of Water Resources (DWR). These are, however, only evaluation programs and do not involve the setting of standards or detailed remedial design. The ULE and NULE programs are intended to provide input to the development of the Central Valley Flood Protection Plan which may go further on levee standards and prioritization of the needed improvements. In a separate but related effort, DWR is close to completing the Urban Levee Design Criteria (ULDC) which was called for by SB 5. Dr Pyke has been an active participant on the committee that is developing the ULDC. However, these criteria apply only to “urban” levees, that is, levees protecting a population of more than 10,000 people or “urbanizing” levees, expected to protect more than 10,000 people by the year 2025. There are some urban levees in the secondary zone of the Delta and these levees either already meet the ULDC standard or are currently being improved to that standard. There are no urban or urbanizing levees in the primary zone of the Delta but our report suggests that many of the “lowland” levees in the primary zone of the Delta do need to be improved with a widened section in order to address the risks posed by more extreme floods, earthquakes and possible sea-level rise. These “fat levees” would meet or exceed the ULDC requirements. Thus, we are proposing that the key Delta levees be improved to a standard that meets or exceeds the ULDC requirements although the primary driver of this need is somewhat different, being for economic sustainability reasons rather than life safety reasons. But Delta “lowland” levees improved in order to protect vital infrastructure,

existing and expanded agriculture, recreation and tourism, and the unique historic and cultural values of the Delta, which includes the legacy communities, will also provide superior life safety protection for residents both in the legacy communities and elsewhere on the Delta islands and tracts.

4. We recommend that the cost estimate of a "fat levee" concept be better substantiated as in our opinion the current estimate of the cost of design and construction is overly optimistic. At a minimum, we recommend that a realistic upper bound be presented, assuming that the federal government is a partner and that right-of-way and borrow material acquisition are involved.

Additional data on our cost estimates was provided to the review panel and is included in this revised report. We are confident that the overall program cost estimate makes adequate provision for some federal government involvement and right-of-way and borrow material acquisition. We do not pretend that our costs estimates would be applicable if the program of improvement was totally managed by either the state or federal governments. Costs elsewhere are simply not applicable to the Delta "lowland" levees. In particular post-Katrina levee re-construction or improvements in New Orleans are not applicable for reasons that include but are not limited to:

1. Management of the program by the US Army Corps of Engineers (USACE);
2. The tight deadline imposed by Congress which placed unreasonable demands on USACE;
3. Severely restricted right-of-ways in many locations;
4. Foundations conditions consisting or swamp and marsh deposits which are worse than the Delta peats; and
5. The almost complete lack of locally available materials.

None of these conditions apply in the Delta lowland. It is true that some of these conditions are faced by the urban levees in the secondary zone of the Delta and the project levees in the North and South Delta but those improvements have or will have separate sources of funding and are not included in our estimate of the cost of improving "lowland" levees in order to provide for the preservation of and the economic sustainability of the Delta. Examples of program cost escalation such as the post-Katrina improvements in New Orleans, the Boston Central Artery / Tunnel, or closer to home, the New East Bay Bridge, are also not applicable to the improvement of lowland levees which is a relatively straight-forward design and construction challenge that should neither be schedule-driven nor subject to multiple design changes.

5. We suggest that the authors provide a discussion of how the lack of formal inclusion of risk and uncertainty in the analyses impacts their findings. We are not suggesting that the authors attempt a formal risk-based analysis at this time, given the availability of the DRMS analysis. However, the authors may wish to provide qualitative information relative to areas of greatest uncertainty in their estimates.

The two areas of greatest uncertainty relative to levees have already been addressed *quantitatively* in the report. One of these is the number of miles of "lowland" levees that need to be improved beyond the Delta-specific PL 84-99 standard. Existing levees that do not contain liquefiable materials likely need to be improved only to what is called the "PL 84-99 plus" standard in the report, with a 22-foot crown and 3 feet freeboard over the 100-year water surface elevation. However, that determination cannot be made without more detailed site investigation. Thus we have based our cost estimates on a range of 300-600 miles of upgrades to the "fat levee" standard. The second area of uncertainty involves the cost per mile of

upgrades to the “fat levee” standard. Based on the work cited in the report by Hultgren-Tillis Engineers (HTE), we have used a figure of $2-3 million per mile for basic engineering and construction costs, applying a 50 percent contingency to HTE’s estimate of $2 million per mile. Extension of the range of miles and the range of cost per mile gives a basic engineering and construction cost of $0.6-1.8 billion and we have rounded that up to $1-2 billion. Because of concerns that these costs might be inflated by some state and federal government involvement and the attribution of the cost of some environmental restoration measures to the levee program, we have doubled the upper limit of this range to suggest a total program cost of $4 billion. That doubling attempts to account for the greatest single uncertainty in this work – how such improvements would be funded and managed. We do not deny that costs could be even higher if the program is totally mismanaged but we assert that it could be comfortably completed for less than $4 billion if it is managed even somewhat less than optimally. In responding in this way we are not ignoring the uncertainties in design loadings, variable foundation conditions, variable composition of the existing levees and the possibility of construction imperfections, but we believe that these can be accommodated by using a robust design, namely a very broad levee section, and that these uncertainties are covered in the estimated $1-2 billion for basic engineering and construction costs. We note that the greatest uncertainties are not in engineering design and construction but in program management and politics.

Part Two: Analysis of Key Economic Sectors in the Delta

Chapter 6: Framework for Analysis

This chapter describes a framework of policy scenarios that will be considered in chapters 7– 9 which contain detailed analyses of key components of the Delta economy: agriculture; recreation and tourism; and infrastructure including energy, transportation and water systems. The first two areas were called out in Delta Protection Commission's Framework Study as the key drivers of the Delta economy. Additional research for chapter 2 of this report identified Transportation, Warehousing, and Utilities as an additional economic driver for the Legal Delta, and this sector is closely tied to energy, transportation and water infrastructure. In addition, infrastructure by definition underlies all parts of the Delta economy. The research and outreach for this report has revealed the importance of the Delta as a regional and state infrastructure hub and Delta policies currently under development have significant implications for a broad range of infrastructure. This chapter discusses the framework that will be utilized for the detailed analysis of the key sectors, and defines the scenarios for policy choices that will be made in the Delta in four important areas: water conveyance, habitat enhancement, levee and flood control investment, and land-use regulation.

Each of the following three chapters follows a common framework. First is a data-driven description of the current baseline and trends for the sector, which may include reference to other significant reports on the sector. Second is discussion of the likely outcomes for the economic sector under the baseline policy scenario, followed by recommendations that might improve economic sustainability under the baseline scenario. Third, each chapter includes an evaluation of the positive and negative impacts of alternative policy choices on economic sustainability in each area. Some topics, such as taking land out of agricultural production, are suited for a detailed quantitative analysis. Other topics, such as how the creation of tidal marsh could affect Delta tourism and recreation, will necessarily rely on more qualitative analysis and expert opinion. Finally, each chapter will include discussion of additional issues or proposals as appropriate, including relevant strategies outlined in the Delta Vision strategic plan. In some chapters, there will be discussion of additional issues or proposals. For example, the recreation chapter will discuss a recent recreation plan developed by California State Parks.

6.1 Baseline Scenario

The baseline analytical scenario is the vision that includes few major policy changes. However, it is not a "status quo" scenario as some significant human and environmental changes are likely in the Delta between now and 2050. Population growth will continue in the Delta counties, some agricultural land will be developed in the secondary zone within city boundaries, sea level is expected to increase by a foot, tertiary treatment will become operational at most municipal wastewater plants discharging into the Delta and improve water quality, and significant investment in levees will occur.

As discussed in Chapter 2, the population of the region surrounding the Delta is growing. The 2010 Census found the population in the five Delta counties was 3,767,312 and grew at a 1.4 percent annual rate over the decade, slightly faster than the 1 percent annual growth rate for the state of California. Based on the 2010 Census results, the forecasting firm Global Insight projects the five-county population will reach 5.57 million in 2040, a growth rate that projects to 6.1 million in 2050. Higher projections from the California Department of Finance, most recently updated in 2007, put the 2050 population at 6.9 million. Despite this growth, the population of the Primary Zone of the Delta has remained steady, and is projected to remain constant in the baseline scenario. In contrast, the Secondary Zone will continue to experience significant growth within the boundaries of its incorporated cities.

For the four policy choices, the baseline scenario is as follows. The baseline scenarios are not recommended policy choices, but simply represent the most logical starting place for the analysis. Baseline conditions could be recommended for some policy choices, but not others.

- *Baseline Water Conveyance*: Through-Delta Conveyance. Under this scenario, water would continue to be conveyed to the south Delta pumps through Delta channels. The level of water diversions would be constrained to less than 5 million acre feet per year in compliance with the current biological opinions.
- *Baseline Habitat Conservation Measures*: None. None of the habitat conservation measures outlined in the BDCP drafts would be implemented in the baseline scenario. The positive and negative impacts of each of the major conservation measures will be assessed individually in the other scenarios.
- *Baseline Flood Control*: All levees upgraded to PL 84-99. As discussed in Chapter 5, the upgrade of most Delta levees to PL 84-99 standards is a reasonable expectation with currently identified resources and on-going maintenance. Most levee breaks would be repaired to original conditions and islands restored. Unincorporated towns in the Primary Zone would remain in the 100-year flood plain, significantly constraining development. Urban areas in the Secondary Zone such as West Sacramento would successfully achieve 200-year flood protection status in accordance with current plans.
- *Baseline Land Use Policy*: Current Policy. Delta Protection Commission guidelines remain in place over the Primary Zone, and land-use planning and regulation would remain under the jurisdiction of local governments. The Delta Stewardship Council does not take an active regulatory role in regards to Delta land use.

6.2 Isolated Conveyance Scenario

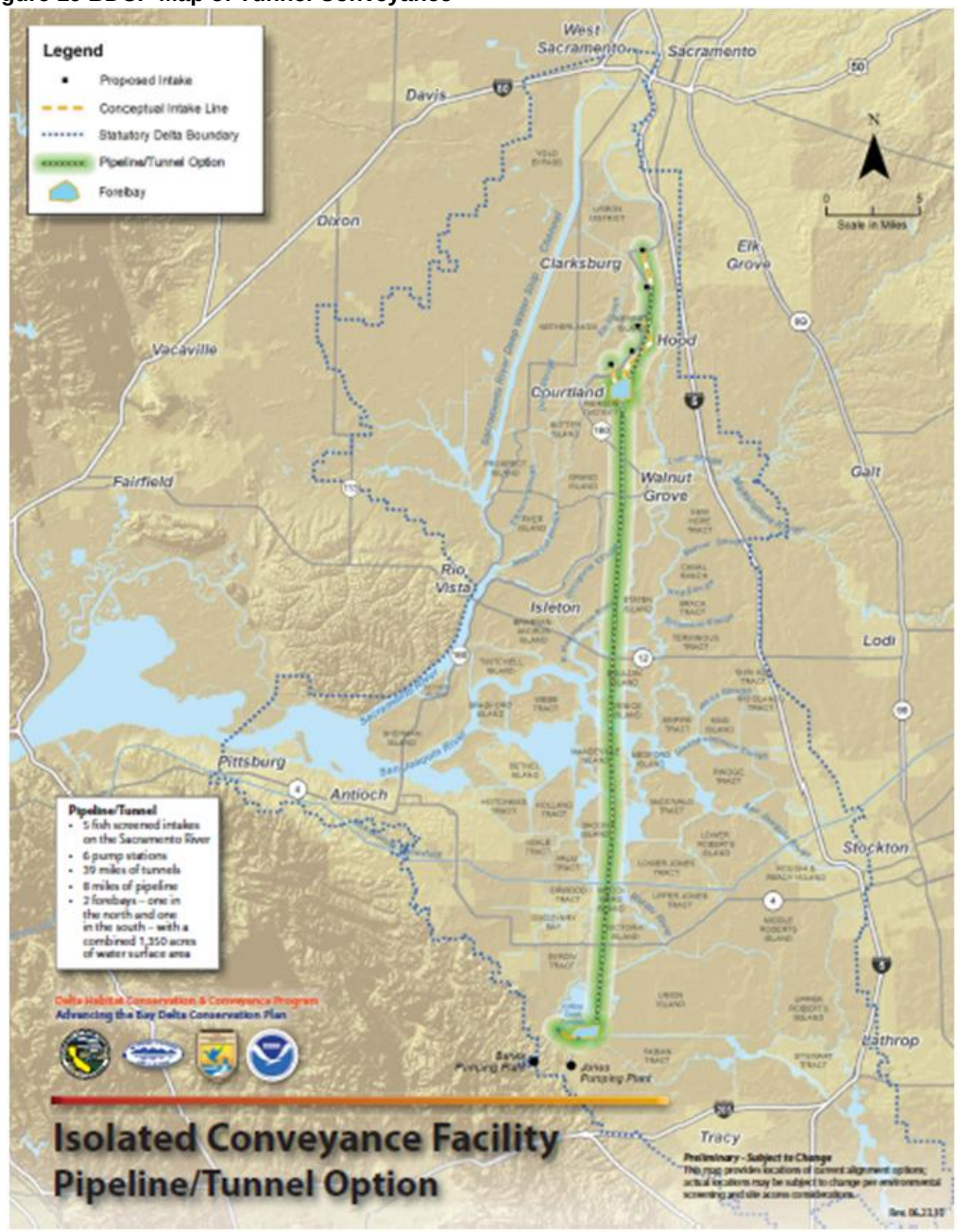
The leading proposal for new water conveyance facilities in the Delta is a 15,000 cfs (cubic feet per second) tunnel extending from the Sacramento River near Hood to the CVP and SWP pumps near Tracy. The facility would include a pair of 34-mile long, 33 ft. diameter tunnels running between a new intermediate forebay near Courtland to a new forebay adjacent to the existing Clifton Court Forebay near Tracy. Five new water intakes would be built along the Sacramento River between Clarksburg and Courtland, and another 13 miles of pipeline would be required to convey water from the five intakes to the intermediate forebay. Each of the five intakes and the intermediate forebay would have pumping plants with a combined 210 MW electrical load.

According to the operational criteria described in the latest BDCP documents, the new conveyance would increase average water exports from the Delta in 2025 from 4.7 maf with through-Delta conveyance under the existing biological opinions to 5.4 to 5.9 maf. The footprint of a tunnel is significantly less than a surface canal, it will still consume roughly 8,000 acres, mostly agricultural land in Sacramento and San Joaquin counties. The new intake facilities will significantly alter the shoreline of the Sacramento River between Clarksburg and Courtland.

The goals for in-Delta agricultural, municipal, and industrial water quality are among the most important provisions for the Delta economy. Both the November 2010 draft BDCP and a May 2011 revised operation documents state that existing D-1641 water quality standards will be met in the north and west Delta with the measuring point moved slightly upstream in the Sacramento River. Notably, none of the BDCP operations descriptions make any commitments to water quality in the central or southern Delta, the areas at most risk from increasing salinity impacts from isolated conveyance. The uncertainty surrounding Delta water quality impacts and the

importance of the issue to the Delta economy makes it one of the most difficult issues to assess in the economic sustainability plan.

Figure 19 BDCP Map of Tunnel Conveyance[94]



While alternative sizing and other options for water conveyance are under development and consideration, none of these options has been described in sufficient detail at this time to be included in this analysis. Thus, the tunnel conveyance described in the most recent BDCP is the only alternative to through-Delta conveyance that will be considered in this report. As alternatives—such as a smaller 3,000 cfs isolated conveyance facility—are developed in more detail, additional analysis would be warranted.

[94] For a better resolution image see http://forecast.pacific.edu/desp-figs.html

Box 1 Financing Isolated Conveyance: Potential Risks for Delta Communities and Taxpayers

While the impacts on the state and federal water projects is generally beyond the scope of this plan, the financial feasibility of water contractors' plans to pay for the proposed isolated conveyance is of critical importance to economic sustainability in the Delta. There are significant questions as to whether isolated conveyance is financially feasible, especially if operated under the proposed operating criteria that would not significantly increase water exports. Despite years of work on the BDCP, there is still no finance plan while the cost estimates continue to rise.

Inadequate financing could create serious problems such as 1) pressure to increase water exports from the Delta beyond agreed upon environmental and in-Delta water quality protections, 2) pressure to divert funds from Delta mitigation, habitat improvement, and flood control programs, 3) subsidies that divert general tax revenues from other public needs, 4) increased pressure for transfers of water from San Joaquin Valley agriculture to urban customers that could adversely affect the San Joaquin Valley agricultural economy over and above losses to Delta agriculture, and 5) the risk of a costly stranded asset that unnecessarily burdens water ratepayers for decades.

6.3 Habitat Conservation Scenarios

In addition to isolated water conveyance, the BDCP proposes 18 additional conservation measures. Similar conservation measures are under consideration by the Delta Stewardship Council for the Delta Plan, and some of these measures are also included in the Ecosystem Restoration Program proposed by the Department of Fish and Game. In this report, we use the draft BDCP descriptions of the conservation measures, because they are more detailed and thereby better suited to the analysis.

The individual conservation measures could have negative or positive impacts on different aspects of the Delta economy. Our analysis will not examine all 18 measures, but focus on four major proposals that would change the current use of 1,000 acres or more of Delta land. For simplicity, the measures will be considered individually rather than as a package at this initial stage. The four major conservation measures include:

- *Yolo Bypass Fisheries Enhancements*: Requires thousands of acres in new flowage easements. More frequent flooding and improved fish passage in the Yolo bypass will benefit fish and flood control, but will reduce agricultural production.
- *San Joaquin River Floodplain Restoration*: Creation of new seasonally-inundated floodplain habitat along the San Joaquin River between Vernalis and Stockton using setback levees. Approximately 10,000 acres of land would be in the new floodplain.
- *Tidal Habitat Restoration*: Up to 65,000 acres in agricultural land converted to tidal habitat in designated zones throughout the Delta. This scenario requires breaching levees and restoring subsided islands to shallow water habitat. If fully implemented, this strategy would affect the most agricultural land and have the highest capital costs. Preliminary cost estimates are $1.5 billion or more than $23,000 per acre of tidal marsh created.
- *Natural Communities Protection*: There are several elements to this conservation measure including the acquisition of 8,000 acres of rangeland for conversion to natural grasslands, acquiring agricultural easements or purchases on 32,000 acres that would be restricted to "wildlife friendly" agriculture, and the conversion of 700 acres of rangeland to vernal pools and alkali wetlands.

For all of these measures, it is important to note that there are alternatives to the BDCP proposals being developed, and that the BDCP proposals are continuing to be refined in work

groups. For example, there is an alternative to the San Joaquin River floodplain proposal in BDCP for an enhanced flood bypass at Paradise Cut. The alternative proposal has been negotiated between environmental groups and local landowners and reclamation districts. Another example is Yolo County's efforts to work with the BDCP's Yolo Fisheries Enhancement Working Group to reduce the agricultural impacts and develop mitigation measures.

6.4 Levee Scenarios

Investment in levees and other flood control measures could be more or less than described in the baseline scenario. Some have proposed creating large expanses of open water habitat in the Delta through the intentional flooding of Delta islands or an explicit policy of not repairing islands when and if they flood in the future. On the other hand, an increased level of levee investment within the Primary Zone could bring some areas to 100-year or 200-year levels of flood protection and allow increased opportunities for economic development.

Six Island Open Water Scenario

There have been proposals to transform large expanses of the Delta to open water. Proponents argue that open water could provide environmental benefits to native fishes, and that it isn't cost-effective to repair or upgrade levees around most Delta islands. The most expansive proposals would transform 20 or more Delta islands to open water, and are illustrated in the "eco-friendly" Delta map in a recent report from the Public Policy Institute of California. As discussed in detail in an appendix, the Suddeth, Mount and Lund (2010) analysis understates the benefits and overstates the costs of maintaining Delta islands. In addition, this strategy faces substantial legal and political hurdles that make the more expansive open water scenarios exceedingly unlikely. A very expansive open water scenario is clearly incompatible with economic sustainability in the Delta, and there is little point in evaluating it in detail.

However, a smaller open-water scenario is likely to be considered as a possible component of the Stewardship Council's Delta plan and is more economically, legally, and politically viable. A smaller scenario is illustrated in a recent letter from Jeff Mount to the Delta Stewardship Council, and in Figure 9 of the Suddeth, Mount and Lund (2010) paper.[95] The result comes from running the Suddeth, Mount, and Lund analysis with assumed property values that more closely match market values and a more accurate infrastructure costs, but still does not capture all of the economic benefits provided by the levees. Thus, this scenario can be considered a reasonable upper-bound on the extent of open water that could be economically justified in the Delta. Most notably, the figures illustrate six contiguous islands in the Central Delta as open water. These islands are the most attractive candidates for open-water habitat because they are very sparsely populated, mostly grow low-value agricultural crops, and are not crossed by completed major physical infrastructure such as highways, railroads, or natural gas pipelines.

While the lack of physical infrastructure and population substantially reduces the cost of permanent flooding compared to nearby islands like Bouldin and McDonald, eliminating these islands would still entail significant economic costs. These costs would include but are not limited to the elimination of about 10,000 acres of farmland and some recreational facilities, increased dredging costs for the Stockton Deepwater Ship Channel, and significant reinforcement of nearly 50 miles of adjacent levees that would be subject to increased pressure from waves and under seepage.

Increase to Higher Standard Levees in Targeted Areas

[95] http://watershed.ucdavis.edu/pdf/Suddeth-Mount-et-al-2010-SFEWS.pdf

In this scenario, areas surrounding strategically targeted areas would have levees upgraded beyond the PL 84-99 standard. As explained in Chapter 5, these could be upgrades to increase seismic resistance, or they could be targeted upgrades to support at least 100-year flood protection in and around Legacy Communities to allow development and investment consistent with the rural character of the Delta. This scenario would also further the statewide goal of increased water supply reliability, would allow the growth of natural vegetation on the water side of the levees as part of an overall ecosystem restoration plan, provide a basis for addressing possible sea-level rise, and would provide increased protection for the critical infrastructure that passes through the Delta.

6.5 Regulatory Scenarios

In the following chapters, we take an initial pass at envisioning how adjustments to the land-use regulatory framework could affect economic sustainability in the Delta. The draft Delta Plan under development by the Delta Stewardship Council envisions expanded land-use regulations in the Legal Delta to support the coequal goals of water supply reliability and ecosystem restoration. In contrast, some of the Delta counties are interested in reducing the restrictions in the current Delta Protection Commission guidelines in concert with increased flood control investments.

Increasing the regulatory power of the Delta Stewardship Council could affect economic sustainability in the Delta. As the Stewardship Council's fifth draft plan is written, most proposed investment in the Legal Delta outside the spheres of influence of incorporated cities could be regulated by the Delta Stewardship Council. In particular, any location that is a potential location for a conservation measure or water conveyance facility in the future is explicitly called out in the Delta Plan for increased regulation. Compared to the current regulatory framework, the proposal would increase the level of regulation in the Primary Zone and expand the regulatory reach of state agencies in the Delta into much of the Secondary Zone. The policy would restrict and increase the cost and risk of property improvements for many Delta residents, businesses, and local governments beyond that experienced in other areas of the state making the Delta a comparatively less attractive area for new investment. The new regulatory policies are described in Chapter 4 of the Delta Plan which is currently in its fifth draft with a sixth draft expected in a few weeks. These new regulations could have profound implications for the Delta economy, although implementation details and how they will work in practice are still uncertain.

While the trend is towards increasing regulation at the state level, some local governments around the Delta are interested in reducing regulation to promote economic development. The signs of stagnation within existing communities are thought by some to be caused by excessive regulation that discourages new investment. One mechanism proposed for reducing regulation is to shift some of the Delta Legacy Communities from the Primary to the Secondary Zone, an unlikely change since it would require an act of the state legislature which seems more inclined to expand the area within the Primary Zone rather than reduce it.

In addition to the Delta Protection Commission Plan and County General Plans, it is important to note that all of these areas have been remapped into the FEMA 100-year flood zone, or are in the process of being added to the 100-year flood zone. Thus, reduced regulation would have little impact unless it were combined with increased flood-control investments and technical evaluations to achieve designation for 100-year flood protection or potentially 200-year urban flood protection in the designated area. In some areas outside the Delta, development generates resources finance flood-control investments, but in the Delta Legacy Communities the scale of development required to finance levee upgrades would be inconsistent with the

rural character of the Delta, County General Plans, not to mention the plans of state agencies such as the Delta Protection Commission and Delta Stewardship Council. Thus, some of the analytical chapters consider the increased flood control and reduced land-use regulation scenarios as a package rather than individually.

6.6 Delta Vision Strategies

As discussed in Chapter 4, the October 2008 Delta Vision Strategic Plan provided a list of strategies and actions to support their second goal, "Recognize and enhance the unique cultural, recreational and agricultural values of the California Delta as an evolving place, an action critical to achieving the coequal goals." The specific actions were:

- Apply for designation of the Delta as a federally recognized National Heritage Area.
- Expand the State Park and Recreation Area network in the Delta.
- Establish special Delta designations within existing federal and state agricultural support programs, primarily regional labeling and marketing programs.
- Conduct research and development for agricultural sustainability in the Delta, focusing on developing agricultural practices consistent with habitat and ecosystem restoration.
- Establish new markets for innovative agricultural practices such as carbon sequestration credits and conservation easements.
- Charge the Delta Protection Commission with creating a regional economic development plan that addresses agriculture, recreation, tourism, and innovative land use.
- Establish enterprise zones that use tax incentives to spur investment at the major "gateways" to the Delta.
- Establish a Delta Investment Fund for regional economic development and adaptation. Initiate the fund with state funding, and structure it to accept revenues from federal, state, local, and private sources.
- Adopt land-use policies that enhance the Delta's unique values and that are compatible with the public safety, levee, and infrastructure strategies.

For some of the strategies, action is in progress or complete such as the feasibility study for Natural Heritage areas,[96] a recent report from the UC Agricultural Issues Center that assessed the viability of some alternative and innovative agricultural approaches in the Delta,[97] and the preparation of this Economic Sustainability Plan.

The state budget and larger fiscal trends have presented significant challenges for some of the other strategies. While State Parks has developed a plan for the Delta, fiscal pressures have put all the state parks and recreation areas in the Delta on the closure list, the opposite of expanding the network. Enterprise zones were initially targeted for elimination in the 2011-12 state budget. Although enterprise zones survived this year's budget cuts, actions continue to reduced and reform enterprise zones, and the prospect for approving significant new enterprise zones is low. Regardless, much of the Delta is already in Enterprise Zones, including virtually all of the Delta in San Joaquin County.

Other strategies are discussed when appropriate in the analytical chapters, and promising strategies will be reinforced in the final recommendations including specific priorities and strategies for the Delta Investment Fund.

[96] http://www.delta.ca.gov/heritage.htm
[97] http://aic.ucdavis.edu/publications/AIC_Delta_study_final.pdf

Chapter 7: Agriculture

7.1 Overview and Key findings

- Close to 80 percent of all farmland in the Delta is classified as Prime Farmland, the California Farmland Mapping and Monitoring Program's highest designated tier.
- Total cropped acreage in 2010 was 423,727 acres, not including approximately 38,000 acres of grazing land.
- The top five Delta crops in terms of acreage are: 1) Corn, 2) Alfalfa, 3) Processing Tomatoes, 4) Wheat, and 5) Wine Grapes.
- Total crop value in 2009 was approximately $702 million. Truck and vineyard crops account for 59 percent of crop revenues on 18 percent of acreage.
- The top five Delta crops in terms of value are: 1) Processing Tomatoes, 2) Wine Grapes, 3) Corn, 4) Alfalfa, and 5) Asparagus.
- The highest per-acre values in the Delta come from truck crops mainly situated in the southern Delta and deciduous crops principally located in the northern Delta.
- The approximately $702 million in Delta crop production and $93 million in Delta animal and animal product revenue has an economic impact of 9,681 jobs, $683 million in value added and $1.416 billion in output in the five Delta counties. Across all of California, the economic impact of Delta agriculture is 12,934 jobs, $819 million in value added, and $1.643 billion in output.
- When related value-added manufacturing such as wineries, canneries, and dairy products are included with the impact of Delta agriculture, the total economic impact of Delta agriculture is 13,179 jobs, $1.059 billion in value-added, and nearly $2.647 billion in economic output in the five Delta counties. Including value-added manufacturing, the statewide impact of Delta agriculture is 25,125 jobs, $2.135 billion in value-added, and $5.372 billion in economic output.
- The 10-year land allocation forecast in the baseline scenario predicts a future increase in vineyards, deciduous, and truck crops, and decreases in grain and pasture crops. Field crops will continue to account for 50 percent or more Delta agriculture acreage for the foreseeable future. This shift of 5 percent of land to higher value crops could lead to an approximately $111 million gain in crop revenues.
- The potential impact of policy changes on Delta salinity is highly uncertain at this time and depends on decisions on water quality standards and the effect of isolated conveyance. A preliminary estimate of losses from increased salinity is between $20 million and $80 million per year. The loss of farmland to construct the conveyance facility is estimated to generate an additional $10 to $15 million in crop losses per year.
- The agricultural impacts of most of the BDCP conservation measures are difficult to quantify due to the lack of precision in site specification and other details. Broad ranges of potential annual crop losses have been calculated from the land requirements and descriptions of easement costs in the draft BDCP.
    - Tidal habitat restoration losses range from $18 to $77 million annually with lower losses when restoration is targeted to Suisun Marsh.
    - Natural Communities Protection losses are estimated to range from $5 to $25 million annually.

- San Joaquin River Floodplain crop losses are estimated at $5 to $20 million annually, and could be reduced significantly by implementing an alternative proposal to expand an existing bypass at Paradise Cut.
- Yolo Bypass Fishery Enhancements could generate crop losses between $7 and $10 million annually..

7.2 Current Status and Trends

7.2.1 Mapping Delta Agriculture

Delta agriculture is part of a complex and constantly-changing landscape, and it presents many challenges to precise measurement. Over the past few years, studies and data-collection by a range of state and federal agencies have yielded results which provide a detailed overview of the Delta's diverse agricultural backdrop. The use of empirical techniques such as satellite imaging, digitization of farm records, field surveys, and public review have accumulated a wealth of information pertinent to policymaking. None of the data sources described below is complete in itself, but collectively leveraged they create the best available picture of Delta agriculture and its broad role in the Delta economy.

7.2.1.1 Land Use Data

Field Borders

California law requires full reporting of agricultural pesticide use. Each Delta county collects information from farmers on all crop fields in which pesticide applications are conducted. Through the use of geographic information system (GIS) software, four of the Delta counties digitally map that data to form a mosaic of agricultural fields within their borders. This data is extremely useful, as it provides recent data on fields intended for actual use and harvest, and includes specific information on the crops each land manager intends to grow in the coming year. This data enables analysis of Delta agriculture at an extremely granular level, that of the individual crop field. Approximately 90 percent of Delta acreage in this study is represented at this level. One challenge presented by this data is that though the vast majority of crop fields have some form of pesticide application, the small percentage that do not is not included and must be estimated by other means.

National Agricultural Statistics Service

For the two counties which do not digitally map their field borders, satellite remote sensing data captured and made available by the National Agricultural Statistics Service (NASS) provides good information. The data collected by this agency is applied in a wide range of agricultural applications, and the accuracy of the methods used to determine crop type is quantified in detail. Though less accurate than direct field borders reporting, this data shows agriculture not permitted for pesticide use, and provides a means to survey Delta land not covered by field borders.

Farmland Mapping and Monitoring Program

For estimates of total farmland acreage, GIS data collected by the California Farmland Mapping and Monitoring Program (FMMP) was employed. This state program uses a combination of satellite imagery, public review, and field surveys to produce a complete map of the state's agricultural lands. FMMP maps were leveraged by making use of their categorization of grazing land. Though grazing land is not actively farmed, it is sometimes incorrectly captured in the NASS data as active pastureland; close examination of areas marked by FMMP as grazing land eliminated such errors.

National Agriculture Imagery Program
Public aerial photography provided by the National Agriculture Imagery Program is used to resolve major inconsistencies between the previously described data sources. While it is impossible to eliminate the more minute discrepancies, for large acreage areas in which conflicts are noted, NAIP photos allow a direct look at the area in question in order to ascertain into what land use category a parcel should be attributed.

UC Berkeley Resilient and Sustainable Infrastructure Networks (RESIN)
The RESIN project at Berkeley mapped areas of the Delta region expected to undergo urbanization in the future. These were used to determine the extent of urbanization expected to occur on agricultural lands, and those effects are included in the long-term forecasts of agricultural land allocation presented in Section 7.5.

7.2.1.2 Revenues, Profits, and Costs Data

County Crop Reports
In order to determine aggregate revenues from Delta crop production, crop yield and price figures published in each county's 2009 crop report were used. These were the most recent figures available at the time the data was compiled. Though the values used in reporting are collected through a variety of sources and represent average yields for the entire county, they offer the most practical means of determining total revenues from Delta agriculture. Where possible, outside sources were consulted to obtain more accurate values for Delta-specific agriculture.

University of California Cost and Return Studies
The University of California Cooperative Extension prepares extremely detailed studies on the costs and returns associated with establishing and maintaining various crops in different regions of the state. Where available, this analysis drew from the UC Cooperative Extension studies conducted in Delta regions to calculate various costs and profits expected from different agricultural operations in the Delta region.

7.2.2 Crop Categories

In order to facilitate presentation and analysis of Delta agriculture, it is necessary to categorize crops into a limited number of discrete categories. In addition to enabling the use of econometric techniques for forecasting future land use, these categories allow for the broader overview of Delta agriculture presented in the tables and maps throughout this report. Examples of major Delta crops from each category are outlined in Table 5 below, and the full crop category table is included in Appendix G.[98]

[98] In response to a suggestion by the California Department of Food and Agriculture at both a DPC meeting and a comment letter on an earlier draft, alfalfa was moved from the pasture to field crop category in this draft. In addition to the significant change of reclassifying alfalfa, some additional adjustments were also made to low acreage crops so that the groups were more consistent across value, salt tolerance, and crop type.

Table 5 Crop Category Examples

Deciduous	*Almond, Cherry, Pear, Walnut*
Field	*Alfalfa, Corn, Rice*
Grain	*Barley, Oats, Wheat*
Pasture	*Pastureland, Clover*
Truck	*Tomato, Asparagus, Potato, Blueberry*
Vineyard	*Grapes*

7.2.3 Delta Agricultural Acreage

Total Farmland Acreage

All agricultural production in the Delta is dependent on high-quality farmland able to support it. Adequate soil quality, moisture, and temperatures are just a few of the characteristics necessary to support sustainable high yields. FMMP mapping uses a tiered system of farmland categories which provide a comprehensive view of agriculture suitability around the Delta. Since FMMP surveys are updated every two years, they also allow observation of the continuing effects of urban growth and expansion on agricultural farmland. The table and figure below offer a snapshot of Delta farmland in 2008, the most recent year from which FMMP maps are available. The total size of available farmland in the Delta is 500,383 acres, with almost 80 percent of the total acreage designated in the FMMP's top tier of Prime Farmland.

Table 6 Total Farmland Acreage, 2008

County		**Class**	
San Joaquin	267,741	Prime Farmland	396,554
Sacramento	71,722	Farmland of Statewide Importance	33,360
Yolo	54,644		
Solano	53,509	Unique Farmland	29,525
Contra Costa	49,685	Farmland of Local Importance	40,944
Alameda	3,082		
Total	**500,383**	**Total**	**500,383**

Harvested Acreage and Crop Allocation

This analysis places the total number of Delta acres in agricultural production in 2010 at 461,380 acres. Acreage includes all irrigated crops and pastureland, and grazing land. Table 7 depicts the total acreage of each crop category by county, as well as totals for the entire Delta. Table 8 depicts the largest crops by total acreage.

Table 7 Delta Agricultural Acreage, 2010

Crop Category	*San Joaquin*	*Sacramento*	*Yolo*[1]	*Solano*[1]	*Contra Costa*[2]	*Alameda*[2]	TOTAL
Deciduous	7,127	6,902	816	486	1,426	82	**16,839**
Field	127,912	33,178	13,082	16,097	22,591	789	**213,649**
Grain	21,222	7,589	9,141	14,295	14,196	2,262	**68,705**
Pasture	3,724	3,957	7,465	19,738	6,243	223	**41,350**
Truck	43,158	3,661	3,789	1,755	248	4	**52,615**
Vineyard	10,477	8,295	9,194	1,528	1,074	1	**30,569**
Grazing Land[3]	433	2,846	11,499	18,600	2,284	1,991	**37,653**
TOTAL	**214,053**	**66,428**	**54,986**	**72,499**	**48,062**	**5,352**	**461,380**

[1] Pasture acreage adjusted using NASS estimates.

[2] NASS data used due to lack of recorded field borders.

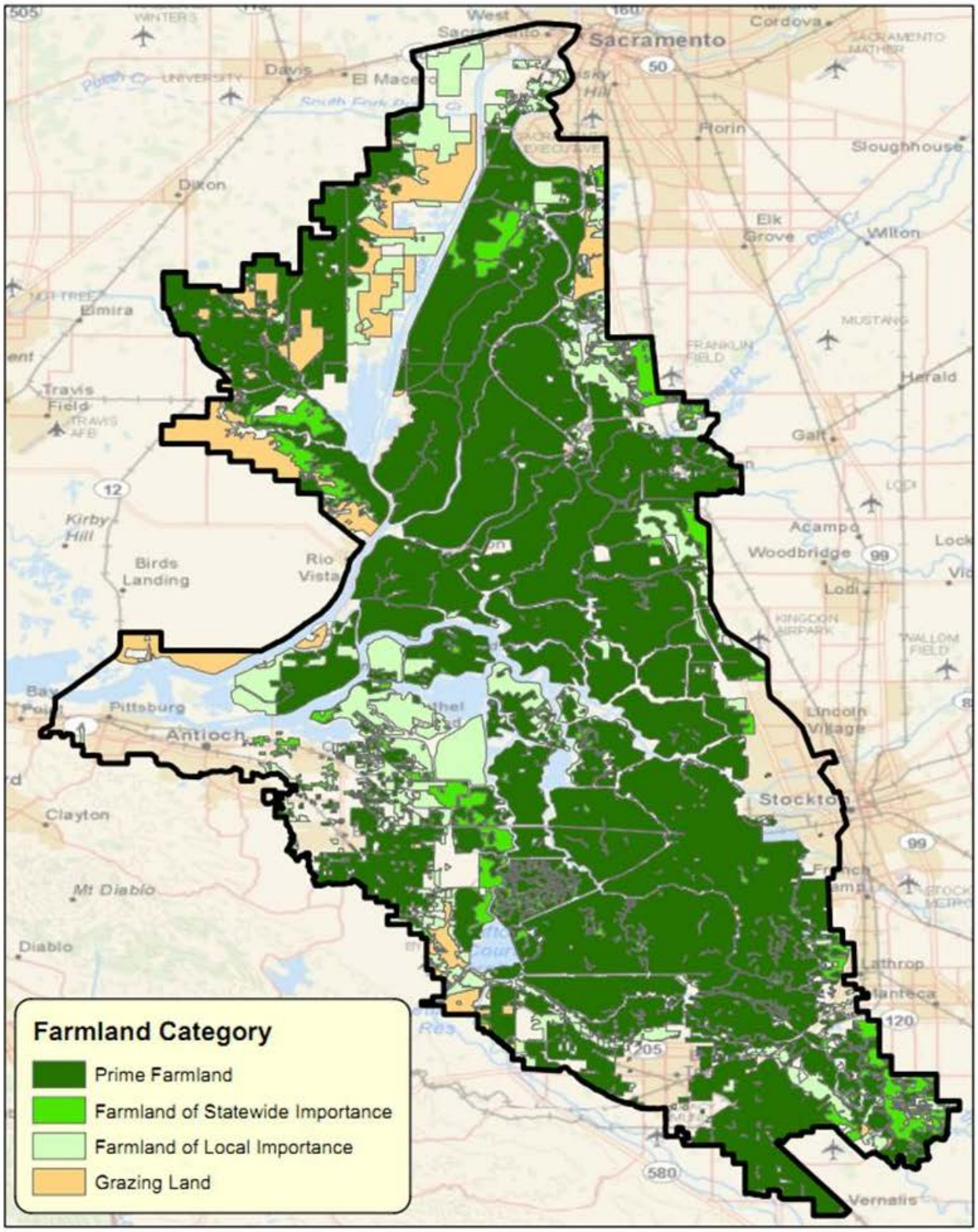
[3] Grazing land acreage estimated from FMMP data.

Table 8 Top 20 Delta Crops by Acreage, 2009

	Crop	Acreage	Value
1.	Corn	105,362	$92,975,715
2.	Alfalfa	91,978	$66,027,076
3.	Processing Tomatoes	38,123	$117,242,615
4.	Wheat	34,151	$17,549,215
5.	Wine Grapes	30,148	$104,990,142
6.	Oats	15,847	$4,195,540
7.	Safflower	8,874	$3,312,014
8.	Asparagus	7,217	$50,050,037
9.	Pear	5,912	$36,746,649
10.	Bean, Dried	5,493	$3,990,318
11.	Rice	4,874	$6,822,488
12.	Ryegrass	4,398	$1,061,436
13.	Cucumber	3,737	$7,866,553
14.	Turf	3,633	$31,643,344
15.	Potato	3,353	$28,605,465
16.	Almond	3,121	$8,776,101
17.	Sudangrass	3,025	$1,398,634
18.	Walnut	2,512	$9,453,874
19.	Pumpkin	2,103	$7,926,038
20.	Watermelon	1,717	$7,953,590

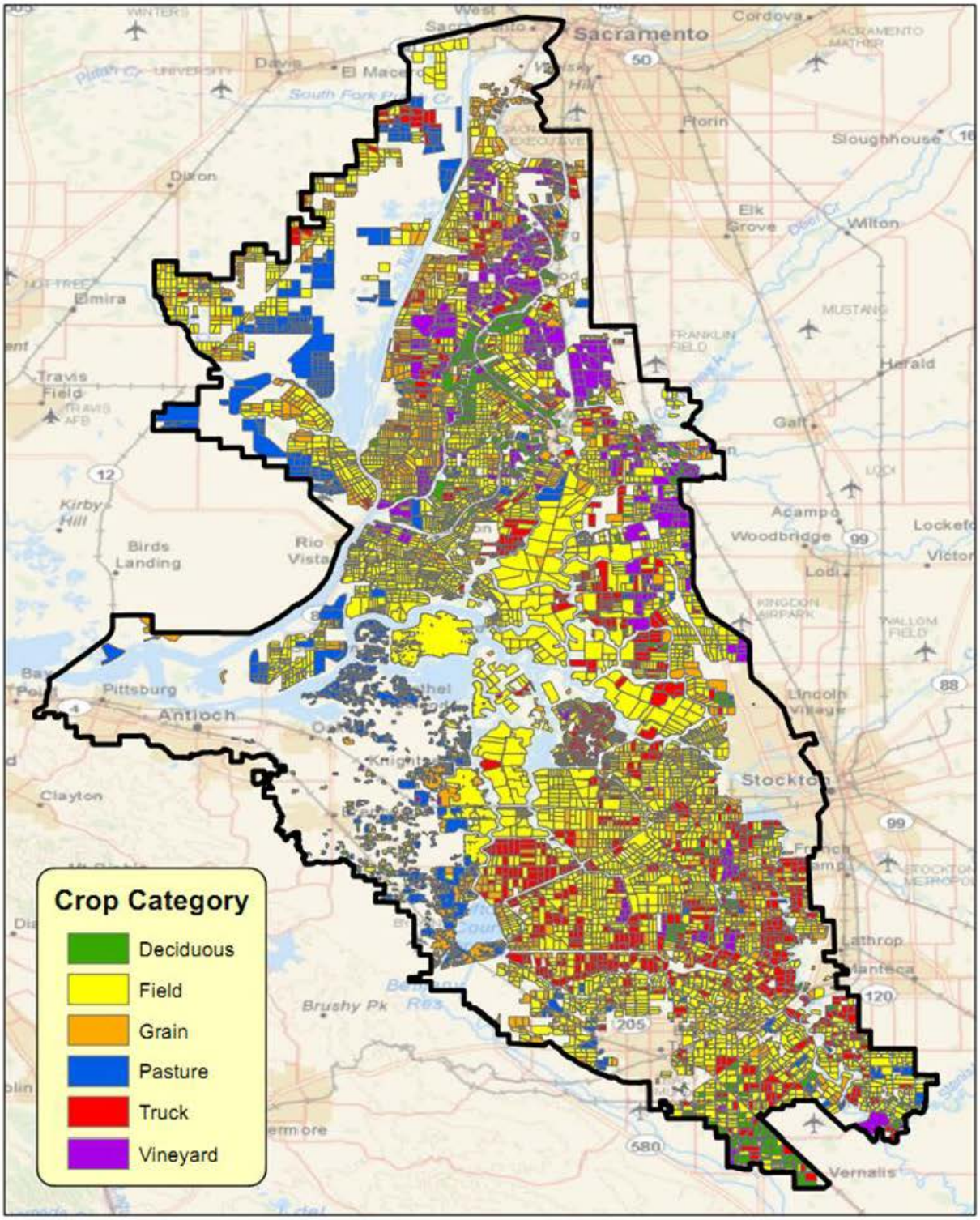
Note: 2009 acreages used in order to provide accompanying value estimates, which were not available for 2010.

Figure 20 FMMP Delta Farmland Coverage[99]



[99] For high resolution image see http://forecast.pacific.edu/desp-figs.html

Figure 21 Agricultural Land Cover, 2010[100]



[100] Note: Grazing Land indicated on previous figure. For high resolution image see http://forecast.pacific.edu/desp-figs.html

7.2.4 Delta Agricultural Revenues

Total Delta agriculture revenues can be calculated using the acreage analysis described above and multiplying the 2009 acreage of each individual crop by the yield and unit price reported in that year's county crop reports. This produces a total of $702 million in revenues from Delta agriculture in 2009. Tables 9 and 10 depict total revenue by crop category in each county and the top revenue-generating Delta crops.

Table 9 Delta Agricultural Revenues, 2009 (in $1000s)

Crop Category	*San Joaquin*	*Sacramento*	*Yolo*	*Solano*[1]	*Contra Costa*[2]	*Alameda*[3]	TOTAL
Deciduous	25,118	41,738	3,345	1,347	8,667	355	**80,570**
Field	107,001	22,071	9,341	12,418	21,398	398	**172,627**
Grain	15,535	3,276	2,587	7,512	288	1,059	**30,257**
Pasture	741	438	411	1,717	1,013	270	**4,590**
Truck	248,982	20,847	15,987	8,949	13,871	17	**308,653**
Vineyard	32,099	28,474	32,718	5,042	6,657	3	**104,993**
Grazing Land[4]	9	57	230	372	46	40	**754**
TOTAL	**429,485**	**116,901**	**64,619**	**37,357**	**51,940**	**2,142**	**702,444**

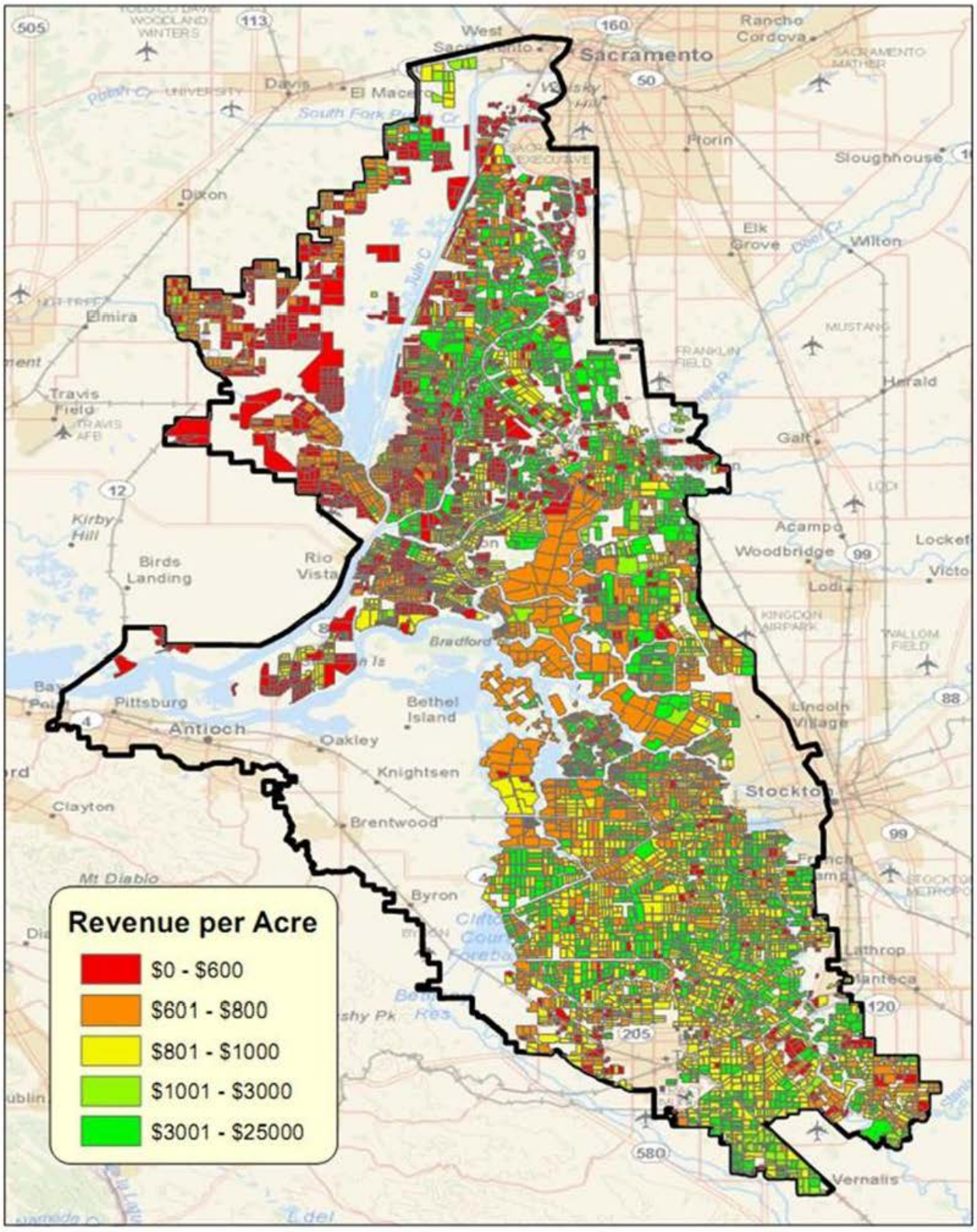
[1] Crop value calculations use 2010 field borders acreage.
[2] Values for non-grazing land include all reported county crop report acreage due to lack of reported field borders.
[3] Values computed using 2010 NASS acreage estimates and average crop category values.
[4] Grazing land acreage estimated from 2008 FMMP data and valued at $20 an acre.

Table 10 Top 20 Delta Crops by Value, 2009

	Crop	Value	Acreage
1.	Processing Tomatoes	$117,242,615	38,123
2.	Wine Grapes	$104,990,142	30,148
3.	Corn	$92,975,715	105,362
4.	Alfalfa	$66,027,076	91,978
5.	Asparagus	$50,050,037	7,217
6.	Pear	$36,746,649	5,912
7.	Turf	$31,643,344	3,633
8.	Potato	$28,605,465	3,353
9.	Blueberry	$25,255,917	1,097
10.	Wheat	$17,549,215	34,151
11.	Cherry	$11,490,843	1,855
12.	Almond	$8,776,101	3,121
13.	Walnut	$9,453,874	2,902
14.	Watermelon	$7,953,590	1,717
15.	Pumpkin	$7,926,038	2,104
16.	Cucumber	$7,866,553	3,529
17.	Rice	$6,822,488	4,874
18.	Pepper	$6,247,592	1,289
19.	Apple	$4,455,826	846
20.	Oat	$4,195,540	15,847

Note: Kern County crop report value used for turf value, as no Delta counties report turf separately from other nursery crops.

Figure 22 Average Revenues per Acre[101]



[101] Using Field Borders Data, Contra Costa County is not included in the figure because data was not available in this format. For high resolution image see http://forecast.pacific.edu/desp-figs.html

7.3 Economic Impact of Delta Agriculture

The previous sections focused on the value and composition of crop production in Delta agriculture. To calculate the economic impact of agriculture in the Delta, two additional areas needed to be considered: 1) the value of animal agriculture in the Delta, and 2) the output of local food and beverage manufacturing firms that are located in the region because of Delta crop output. The section concludes with a brief discussion of impact analysis and policy analysis and how to interpret the results, and a discussion and comparison with related estimates by the Department of Water Resources.

7.3.1 Animal Production in the Delta

Animal and animal product output in the Delta is more difficult to estimate than crop production. It is clear that the Delta is not as oriented towards crop production as many other areas in the Central Valley, although a significant amount of its crop production is alfalfa and field crops that are consumed by animal enterprises outside the Delta. Other reports by the Department of Water Resources and the Delta Stewardship Council White Papers have estimated animal-related output in the Delta at about $90 million per year, significantly less than crop production. Estimates produced for this study are very similar. Enterprise data from Dun and Bradstreet and NETS were used to identify dairy, cattle, and other animal production enterprises located within the legal Delta, and this figure was compared to the total number in the counties. The percentage of animal enterprises in each county located in the Delta was applied to the total animal production in the crop reports for each of the five Delta counties, resulting in an estimate of $93 million in animal output, shown in Table 11.

Table 11 Animal Output in the Delta

Animal Output	Value
Cattle	$24,097,110
Sheep, Poultry, other Livestock	$3,160,977
Milk	$64,322,406
Wool	$94,628
Apiculture	$1,712,879
Total Animal and Animal Products	**$93,388,000**

7.3.2 Value Added Processing: Food and Beverage Manufacturing

The value of farm production is typically measured as the revenue earned by farm operations for selling crops. “Farm gate” values are reported in County Crop Reports and are the measures of agricultural revenues used in this chapter and most other discussions of agricultural values. Some farm products are not transformed significantly, and therefore have little additional value added to them between the farm and when they are shipped out of the region, or received by retailers or food service providers for sale to local consumers. Tree nuts such as almonds and walnuts, cotton, and many fresh fruits and vegetables are examples of high-value agricultural crops that have little additional value added to them before they are exported from the state or region. In contrast, wine grapes, processing tomatoes and milk are examples of farm products that have significant processing and value added by local food and beverage manufacturers.

Food and beverage manufacturing is an important economic sector in California and the five Delta Counties. Some of that manufacturing only exists in the region because of local farm

output, whereas many food and beverage manufacturing enterprises such as bakeries are located in a region to serve the local market or for other reasons. Wineries, most fruit and vegetable canneries such as tomato paste, and most dairy product manufacturing such as cheese, butter, and fluid milk in California is closely linked to local farm production.[102] Wine grapes also have a large associated tourist economy. Thus, valuing wine grapes to the California economy at the "farm gate" significantly understates their true value to the economy.

Comparing data for food and beverage manufacturing from the 2007 Economic Census to 2007 farm production in California for the associated farm products illustrates the point.[103] The value of wine grape production at the farm gate in 2007 was $1.855 billion according to the California Department of Food and Agriculture, but the value of shipments from California wineries was $10.764 billion, 5.8 times the agricultural value of the wine grapes harvested on 480,000 acres in California in 2007 (or $22,400 of output per acre). The Delta is about 5 percent of California's wine grape production. Milk was the highest value California farm product in 2007 at $7.33 billion in agricultural production. Virtually all of that milk was used by various segments of California's dairy product manufacturing industry (NAICS 3115, includes fluid milk, cheese, ice cream, etc.) which recorded a value of shipments of $12.467 billion in 2007, 1.7 times the value of raw milk in agricultural reports. Roughly 2 million acres of irrigated crops in California supported the dairy industry, about 10 percent of which is in the Delta, although a significant amount of feed is also imported from other states. Disaggregated data on processing tomatoes is unavailable as it is combined in NAICS code with all fruit and vegetable canning, but data from major tomato processor Morning Star suggests that the value of shipments in the tomato paste production is roughly 2 times the value of processing tomatoes purchased from local farms.[104] Thus, the $849 million in processing tomatoes produced in 2007 would be conservatively supporting about $1.7 billion in canned tomato products production,[105] from about 300,000 acres of production of which a little more than 10 percent is in the Delta.

The point is that all of the four most significant crops in the Delta—alfalfa, corn, processing tomatoes, and wine grapes—are supporting a significant value-added chain in the region and state. In contrast, crops such as nuts, cotton, and even produce such as lettuce, melons, and broccoli may have higher farm gate values and agricultural revenue per acre, but less economic value is added to the crop in the region or state between the farm and consumers. Almonds have slightly higher agricultural receipts than wine grapes in California, but wine grapes generate more than five times the income of almonds. Processing tomatoes and cotton have similar agricultural receipts, but processing tomatoes generate more than double the income for the state. Thus, when measuring and comparing the contribution of various regions to the state's economy, an approach that focuses solely on agricultural receipts is easy to calculate but is too narrow and will significantly undervalue the Delta's contribution relative to areas further south in the Valley that receive water exported from the Delta.

To be conservative in the modeling, only food and beverage manufacturing where a clear link to regional production could be identified and reasonably estimated are used in the economic

[102] It should be noted that relatively "low value" alfalfa and corn silage production in California is an important part of the dairy product value chain as well.
[103] 2007 is the most recent year for which the value of shipments data is available at the 5-digit NAICS level that identifies wineries as a separate manufacturing category, NAICS 31213.
[104] See exhibit 2 and exhibit 8 in this presentation, http://www.morningstarco.com/statdocs/2010%20Exhibits%20Brochure.pdf
[105] Morning Star is known for low cost tomato paste production; other higher valued canned tomato products are likely adding more value than bulk tomato paste production, which absorbs roughly 75 percent of California's processing tomato production, according to Morning Star.

impact analysis, and all analysis is presented with and without the related manufacturing component. Although Delta crops are definitely consumed in large quantities by dairies outside the Delta, these dairies also use grain and alfalfa transported significant distances and could increase the use of these imported feeds if necessary, although at higher cost. Thus, dairy production outside the Legal Delta is not attributed to Delta agriculture in proportion to the Delta's contribution to dairy cattle feed. Some additional value-added processing to cattle production and fruits and vegetables other than tomatoes and cattle are excluded due to measurement difficulties. The complexity of the industry and limited data makes it difficult to precisely estimate the entire value-chain and linkages, but this analysis is important to capture the overall scale and contribution of agricultural production to the region.

As discussed above, our estimate of value-added manufacturing focuses on three industries: wineries, tomato canning, and dairy product manufacturing. Delta wine grapes are roughly 5 percent of California production by both weight and value. The prices are similar to state averages, much higher than other areas of the Central Valley but much lower than premier growing areas such as Napa and Sonoma. Winery capacity in the Delta and the five Delta counties is small relative to local production, but Napa and Modesto winery capacity is very high relative to local production. The data and interviews with local producers support that most Delta wine grape production is contracted to large Napa County wineries or Modesto-based Gallo. Using state and regional shares of wine grape production from the Delta, and county winery output estimates from IMPLAN, we estimate that $181 million of winery output in the five Delta counties is dependent on Delta wine grapes, and $541 million of winery output in adjacent counties (Napa and Stanislaus) is sourced from the Delta. The $117 million in processing tomato output is estimated to support $234 million in cannery output based on the Morning Star input data.

Delta farms produce less than 1 percent of California's milk, but produce roughly 10 percent of the state's alfalfa and forage crops, critical and increasingly scarce and costly inputs to the dairy industry. Although there are few dairies in the Delta, maps of dairy cow concentration in the San Joaquin Valley indicate large nearby clusters between Highway 99 and I-5 between Manteca and Merced, and in southeast San Joaquin County near Escalon.[106] Clearly the Delta is more critical to the state's industry than the milk production data shows, but quantifying its importance is difficult since Dairy producers can import feed and adjust the mix of feeds in cow rations in response to scarce local feed sources. One could argue Delta agriculture supports anywhere from 1 percent ($137 million) to 10 percent ($1.37 billion) of California's dairy product industry. As a rough estimate in this range, we link 5 percent ($687 million) of California dairy product manufacturing to Delta agriculture, a similar contribution as winery production, and attribute half of this total ($344 million) to dairy products produced in the five Delta counties, which is a little less than half of all dairy product manufacturing in the Delta counties.[107]

7.3.3 Economic Impact Estimates

The IMPLAN 3 model calibrated to 2008 regional and statewide economic data was used to estimate the overall economic impact of Delta agriculture. See Appendix F for a description of the IMPLAN model and formal definitions of terms such as direct, indirect, and induced effects. Following a methodology initially proposed by UC-Davis agricultural economists, the default

[106] EPA Dairy Cow Concentration Map. http://www.epa.gov/region9/ag/dairy/images/CED0601309_2.gif
[107] There is one very large cheese manufacturer of note in the legal Delta, Leprino Foods in Tracy.

IMPLAN production functions were adjusted to account for the unusually high use of contract labor in California agriculture.[108]

Table 12 Agriculture Related Output Used for the IMPLAN model

Industry	Output Value (millions $)
1 Oilseed farming	3.3
2 Grain farming	135.9
3 Vegetable and melon farming	250.1
4 Fruit farming	191.7
5 Tree nut farming	20.1
10 All other crop farming	101.5
11 Cattle ranching and farming	27.2
12 Dairy cattle and milk production	64.3
14 Animal production, except cattle and poultry and eggs	1.8
Food/Beverage Manufacturing in expanded analysis	
54 Fruit and vegetable canning, pickling, and drying	234 in Delta counties & statewide
55-58 Dairy Products Manufacturing	344 in Delta counties 687 statewide
72 Wineries	180.5 in Delta counties 722 statewide

For the five-county economic impact model, Delta agricultural production and Delta-dependent food processing and winery production was distributed across IMPLAN production sectors according to Table 12. In the initial model, only the impacts of the $795 million in direct agricultural production were modeled. As shown in Table 13 (A), the approximately $702 million in Delta crop production and $93 million in Delta animal and animal product revenue has an economic impact of 9,681 jobs, $683 million in value added and $1.416 billion in output in the five Delta counties. Table 14 (A) shows that across all of California, the economic impact of Delta agriculture is 12,934 jobs, $819 million in value added, and $1.642 billion in output. This equates to an employment multiplier of 12.2 jobs per million dollars in output in the five Delta Counties and 16.2 jobs per million dollars in output when evaluated statewide. These multipliers are very consistent, if not low, compared to other studies. In a recent essay published by UC-Davis, Howitt et al. (2011) states that agricultural employment multipliers typically range from 16 to 27 jobs per million dollars.[109]

To get a more complete picture of the full economic impact of Delta agriculture, the impact of linked food and beverage manufacturing for wineries, tomato canning and dairy products were included as described in the previous section. These upward linkages must be estimated separately, because the indirect effects of the IMPLAN model only includes backwards linkages from purchased inputs. To avoid double counting impacts from the initial stage, the indirect effects attributed to the purchase of crops as inputs were netted out of the results. For example,

[108] The production functions were adjusted to ensure that virtually all (97 percent) of the output of the agricultural service sector was utilized by the regional agriculture industry, a common sense adjustment and a methodology that recently yielded good predictions of the employment effects of the 2009 drought in the San Joaquin Valley.

[109] Howitt, R.E., D. MacEwan and J Medellin-Azuara, "Drought, Jobs, and Controversy: Revisiting 2009," *ARE Update*, 14 (6) (2011): 1-4.

for wineries, the indirect effects associated with purchasing wine grapes were estimated and removed from the total to avoid double counting the impact of growing wine grapes. The total five-county economic impacts are displayed in Table 13 (C). Delta agriculture supported 13,179 jobs, $1.059 billion in value-added, and $2.647 billion in output in the five Delta counties. For the California economic impact model, the additional $541 million of Delta dependent winery production and $344 million in dairy product production from adjacent counties and was added to the totals. The economic impact rises from this extra production, and also because the indirect and induced effects grow when considered on a statewide rather than five-county basis. Table 14 (C) shows that across the State of California, Delta agriculture supports nearly 25,125 jobs, over $2.135 billion in value added, and over $5.372 billion in output.[110] Even when using this more expansive view of impacts, the employment multipliers are 16 to 32 jobs per million dollars of agricultural production, similar to the range described as typical by Howitt et al. (2011).

Caution is advised before using the more expansive multipliers to estimate the potential long-range socio-economic impacts of the policy changes described in this chapter. These are current economic impact estimates for Delta agriculture, and do not take into account potential substitution or adjustment strategies that may be employed. For example, wineries or canneries could purchase inputs from different sources if Delta tomatoes or wine grapes became unavailable, so the multipliers from the broader scenario including food processing would be too large for analyzing long-range policy impacts, particularly at the statewide level.

Table 13 Economic Impact of Delta Agriculture on Five Delta Counties

Impact Type	Employment	Labor Income	Value Added	Output
(A) Delta Crop and Animal Production Impacts				
Direct Effect	4,132	$146,710,832	$361,683,700	$815,797,504
Indirect Effect	4,051	$155,957,376	$192,082,400	$380,246,048
Induced Effect	1,499	$69,450,720	$129,108,300	$219,740,912
Total Effect	9,681	$372,118,912	$682,874,400	$1,415,784,448
(B) Delta Agriculture Processing Impacts				
Direct Effect	609	$82,201,128	$109,578,400	$665,876,520
Indirect Effect	2,000	$98,387,163	$190,347,240	$434,962,236
Induced Effect	888	$41,268,532	$76,653,590	$130,501,340
Total Effect	3,498	$221,856,824	$376,579,120	$1,231,340,096
(C) Total Delta Agriculture Impacts				
Direct Effect	4,741	$228,911,960	$471,262,100	$1,481,674,024
Indirect Effect	6,051	$254,344,539	$382,429,640	$815,208,284
Induced Effect	2,387	$110,719,252	$205,761,890	$350,242,252
Total Effect	13,179	$593,975,736	$1,059,453,520	$2,647,124,544

[110] The Department of Water Resources has called these estimates inflated and inflammatory in comments, including to the Delta Stewardship Council. The accusation is strange since DWR's own estimate of Delta agricultural production of $817.6 million is higher than in this study. Interestingly, DWR has not estimated any employment impacts of Delta agriculture, but used employment multipliers of 50-60 jobs per million dollars of agricultural output in the San Joaquin Valley in their highly publicized 2009 drought reports. If DWR were to apply similar multipliers to their estimate of Delta agricultural output, they would estimate that Delta agriculture creates 41,000 to 49,000 jobs, far higher than the estimates in this report.

Table 14 Economic Impact of Delta Agriculture on California

Impact Type	Employment	Labor Income	Value Added	Output
(A) Delta Crop and Animal Production Impacts				
Direct Effect	5,104	$158,528,784	$361,683,600	$815,797,504
Indirect Effect	5,502	$207,782,128	$241,993,300	$447,518,752
Induced Effect	2,328	$119,379,712	$215,517,800	$379,519,392
Total Effect	12,934	$485,690,624	$819,194,800	$1,642,835,712
(B) Delta Agriculture Processing Impacts				
Direct Effect	1,457	$188,053,130	$273,482,330	$1,506,051,552
Indirect Effect	7,066	$389,934,316	$702,163,970	$1,623,701,672
Induced Effect	3,669	$188,538,768	$340,253,880	$599,425,808
Total Effect	12,191	$766,526,200	$1,315,900,600	$3,729,179,040
(C) Total Delta Agriculture Impacts				
Direct Effect	6,561	$346,581,914	$635,165,930	$2,321,849,056
Indirect Effect	12,568	$597,716,444	$944,157,270	$2,071,220,424
Induced Effect	5,997	$307,918,480	$555,771,680	$978,945,200
Total Effect	25,125	$1,252,216,824	$2,135,095,400	$5,372,014,752

7.4 Other Agriculture Issues

There has been significant interest in alternative forms of agriculture in the Delta, as well as new approaches to increase agricultural revenue. Many of the ideas have been proposed in Delta Vision and other Delta related plans and reports. Ideas include increased agritourism, regional branding and marketing of Delta crops, growing crops for biofuels, subsidence-reversal agriculture, and growing crops for carbon sequestration purposes and the marketing of carbon credits. Some of the ideas are promoted for the dual benefits of ecosystem restoration and reducing flood risks, whereas others are primarily seen as a way to enhance local agricultural income.

Most of these options were evaluated in a recent report by the UC Davis Agricultural Issues Center (AIC) developed for the California Department of Food and Agriculture and presented to the Delta Stewardship Council. In virtually all cases, the AIC report determined that the ideas have very limited potential to develop a significant market in the Delta. For example, most Delta crops are commodities such as corn and processing tomatoes for which branding is not effective.

Agritourism, defined as recreational, educational, and other visits to working farms, is a small but fast growing source of income for farms in the region. As discussed in the Appendix of the recreation and tourism chapter,[111] agritourism was estimated by USDA to generate $4 million in income for farms in the five Delta counties in 2007. Assuming agritourism in the Delta is proportional to overall agriculture in the county, a roughly 25 percent share, agritourism generated roughly $1 million in revenue in 2007. An inventory of agritourism enterprises in California maintained by UC cooperative extension (http://www.calagtour.org/) identifies 91 agritourism operations in the five Delta counties, and 12 (13 percent) of these are located in the Delta. Over half of the Delta agritourism enterprises were in Contra Costa County where there is a cluster of U-pick orchards and other farms open to tourists around Brentwood. Only one of the

[111] Appendix H

20 agritourism locations in San Joaquin County was in the Delta, but it was a very large attraction at Dell'Osso Family Farm adjacent to Interstate 5 near Lathrop that is estimated to draw over 100,000 visitors each fall to its corn maze and other attractions. Currently, it appears that agritourism is only significant in the suburban edges of the Delta secondary zone, and it is probably best suited to these areas. Agritourism is discussed in more detail as a potential growth strategy for tourism and Legacy Communities in subsequent chapter.

A January 2011 report prepared for the Nature Conservancy examines the potential of carbon capture wetland farms and low carbon agriculture in the Delta.[112] Although carbon capture wetland farms could generate environmental benefits and potentially reverse subsidence on Delta islands, the report casts doubt on whether carbon capture farming is economically viable, although the authors encourage large-scale demonstration projects to further research the potential. Specifically, the authors state:

> "Our analysis illustrates that Carbon Capture Wetland Farms are unlikely to provide a clear incentive to both landowners and investors without either fairly high carbon prices or some type of grant or payment scheme to subsidize some of the costs of conversion and annual management." (p. 106)

The report also details other problems including increased methylmercury, organic carbon, and mosquitos that could have negative impacts on various aspects of the Delta economy. The report discusses other low carbon changes to agriculture including conversion to rice growing and reduced tillage practices that may be more economically feasible. The authors encourage large-scale demonstration projects to more fully research the potential of carbon capture wetland farms.

7.5 Modeling Crop Choice in the Delta

A multinomial logit model is used to estimate farmers crop choice at the field level in the Delta. Since its development in the early 1970s, the multinomial logit model has been extensively used to statistically model choices between multiple options, and has been applied to myriad settings including occupational choice, health care choices, and crop choices among others.[113] Professor Daniel McFadden of UC Berkeley was a significant contributor to the development of the multinomial logit and related models for which he was awarded the Nobel Prize in Economic Sciences in 2000. In addition to crop choice, the approach has been used to study a variety of problems in agriculture over the past three decades including studies of irrigation technology choices (Caswell and Zilberman, 1985), and crop management practices (Wu, Adams, Kling, and Tanaka, 2004; Wu and Babcock 1998).[114]

[112] A. Merrill, S. Siegel, B. Morris, A. Ferguson, G. Young, C. Ingram, P. Bachand, Holly Shepley, Maia Singer, Noah Hume, "Greenhouse Gas Reduction and Environmental Benefits in the Sacramento-San Joaquin Delta: Advancing Carbon Capture Wetland Farms and Exploring Potential for Low Carbon Agriculture," prepared for The Nature Conservancy, Sacramento, California, 2010. Available at: http://www.stillwatersci.com/

[113] Maddala, G.S., *Limited Dependent and Qualitative Variables in Econometrics.* Cambridge University Press, 1993.

[114] Caswell, M.F. and D. Zilberman, "The choice of irrigation technologies in California," *American Journal of Agricultural Economics* (1985), 67: 224-34.
Wu, J. and B. A. Babcock, "The choice of tillage, rotation, and soil testing practices: Economic and environmental implications," *American Journal of Agricultural Economics* (1998), 80: 494-511.

The multinomial logit model is used to predict agricultural land allocation, conditional on its current land use and other exogenous variables, including soil quality, a multi-year average of irrigation water salinity, temperature, slope, elevation, field size, and dummy variables for year and conservation zone to capture fixed effects. The model generates estimates of the probability of observing a given crop type in each specified field over a long-term time horizon. It was trained on a dataset of over 6,000 individual crop fields for which annual crop data was tabulated for each year from 2002 through 2010, excluding 2005 for which reliable data was not available. All of the explanatory variables were statistically significant and of the expected signs. More details on the model input data and output results are provided in Appendix G. The impact on Delta crop allocations under various scenarios is described in tables on the following pages.

There is significant urbanization pressure in the Secondary Zone of the Delta, so the model was run with and without the inclusion of land that is expected to be developed by 2050. We determined this area using the urbanization probability maps generated by the UC Berkeley RESIN project with some minor adjustments to the high and very high probability categories to conform to the sphere of influence of cities in the Secondary Zone and discussions with city officials and local developers with knowledge of land development plans. Table 15 depicts the agricultural crop acreage expected to convert to urbanized land, while Figure 23 displays the affected fields. All of these fields are excluded in the forecast with urbanization effects.

Overall, urbanization will reduce agricultural production in the Delta due to the loss of land. However, it should be noted that the Delta's location in the heart of the growing Northern California megaregion surrounded by growing cities creates opportunity for the majority of farmland that remains in production. Wu, Fisher, and Pasqual (2011) find that the revenue opportunities created by urbanization could outweigh the negative impacts on farm infrastructure and production costs due to growing market opportunities for higher-value crops such as vineyards, fresh vegetables, and nursery products.[115] In a later section of this report, we also discuss the presence and growth of agritourism around the urban fringe.

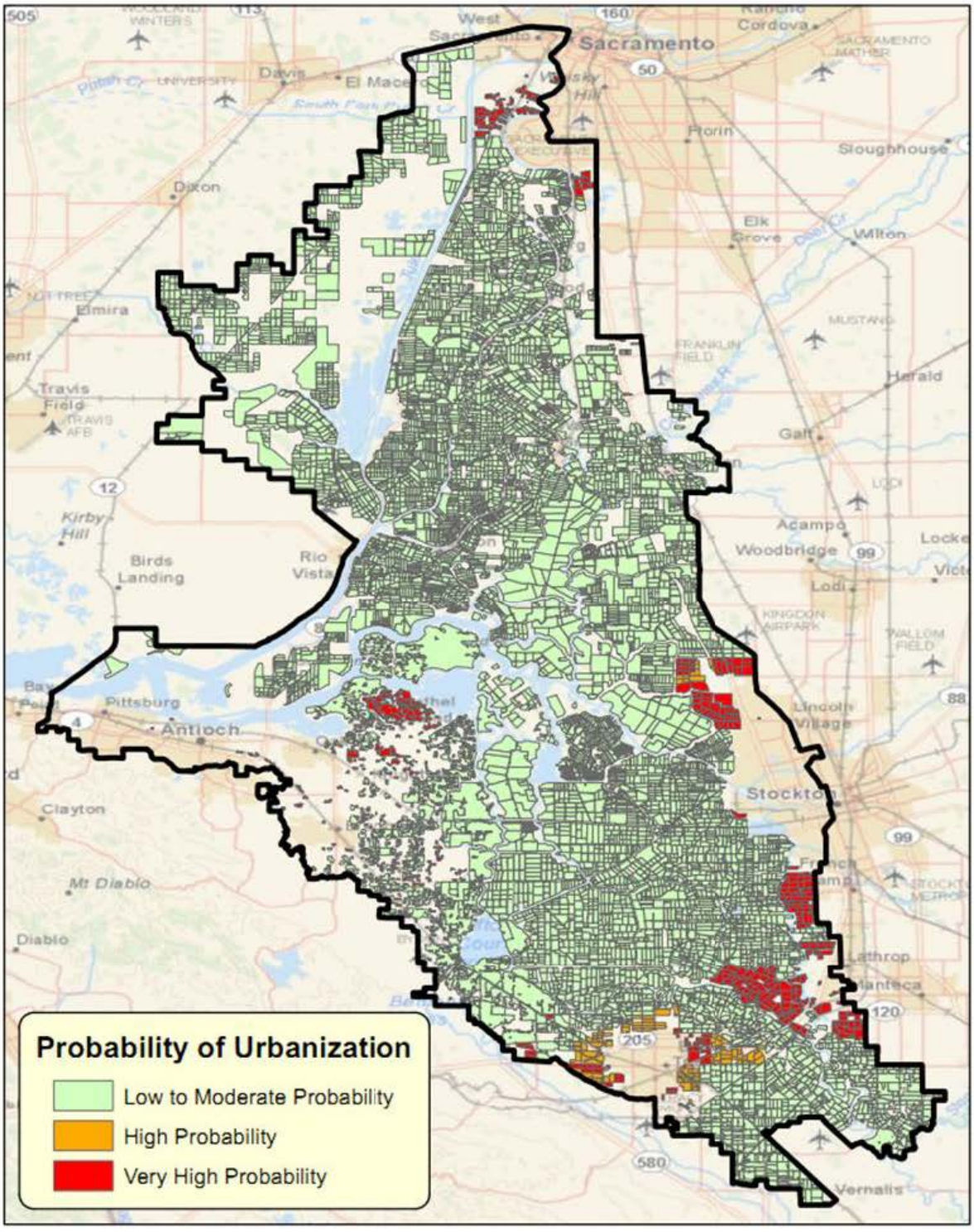
Table 15 Crop Acreage with High or Very High Probability of Urbanization

Crop Category	High Probability	Very High Probability	Total
Deciduous	72	588	660
Field	3,598	8,210	11,808
Grain	597	6,095	6,692
Pasture	531	703	1,234
Truck	604	5,111	5,715
Vineyard	1	515	516
All Crops	**5,403**	**21,222**	**26,625**

Wu, J., R.M. Adams, C.L. Kling, and K. Tanaka, "From micro-level decisions to landscape changes: An assessment of agricultural conservation policies," *American Journal of Agricultural Economics* (2004), 86: 26-41.

[115] Wu, J., M. Fisher, and U. Pasqual, "Urbanization and the Viability of Local Agricultural Economies," *Land Economics* (2011), 87: 109-125.

Figure 23 Crop Fields with High or Very High Probability of Urbanization[116]



[116] For high resolution image see http://forecast.pacific.edu/desp-figs.html

Table 16 Long-run Land Allocation Forecast

Scenario	*Deciduous*	*Field*	*Grain*	*Pasture*	*Truck*	*Vineyard*
Current Land Allocation	3.97%	50.42%	16.21%	9.76%	12.42%	7.21%
Baseline Forecast	5.12%	51.11%	11.46%	6.80%	17.74%	7.76%
Forecast with Urbanization Effects	5.26%	51.13%	11.02%	7.08%	17.24%	8.26%
Forecast with Urbanization Effects vs. Current Allocation						
Land Allocation Change	1.29%	0.71%	-5.19%	-2.68%	4.83%	1.04%
Relative Crop Allocation Change	32.34%	1.41%	-32.01%	-27.45%	38.87%	14.46%
Forecast with Urbanization Effects vs. Baseline Forecast						
Land Allocation Change	0.14%	0.02%	-0.44%	0.28%	-0.50%	0.50%
Relative Crop Allocation Change	2.66%	0.05%	-3.81%	4.10%	-2.81%	6.41%

The results of the long-run land allocation forecast are contained in Table 16 above. Significant growth is predicted in truck, deciduous, and vineyard crops, with the largest decline among grain and pasture crops. Forecasted revenue changes are illustrated in Table 17 below. It indicates a trend towards increased planting of high-value crops, which would lead to an estimated $111 million increase in total agriculture revenue assuming current crop acreage and average crop class revenue using 2009 prices. Taking into account the 26,625 acres expected to undergo urbanization, annual revenues are expected to increase by $68 million, a decline of $43 million per year compared to the baseline.

Table 17 Long-run Agricultural Revenue Forecast

Crop Category	Average Revenue per Acre	Forecasted Acreage Change			Forecasted Revenue Change		
		Baseline	*Urbanization*	*Urbanization vs. Baseline*	*Baseline*	*Urbanization*	*Urbanization vs. Baseline*
Deciduous	$4,612	4,869	4,046	-823	$22,455,695	$18,660,853	-$3,794,841
Field	$780	2,921	-10,595	-13,516	$2,278,075	-$8,264,247	-$10,542,321
Grain	$426	-20,138	-24,926	-4,788	-$8,578,785	-$10,618,569	-$2,039,784
Pasture	$116	-12,532	-13,236	-704	-$1,453,712	-$1,535,376	-$81,664
Truck	$3,903	22,566	15,862	-6,704	$88,076,852	$61,909,659	-$26,167,192
Vineyard	$3,566	2,314	2,222	-91	$8,251,441	$7,925,330	-$326,111
			Total Revenue Change		**$111,029,565**	**$68,077,651**	**-$42,951,914**

Many future crop allocations are possible, and these results depict the most likely allocation calculated by the model. It predicts a modest (approximately 5 percent) shift towards higher-value crops over several decades, with field crops holding steady at over 50 percent of Delta cropland over time. Some comments have pointed to a decline in higher-value truck crops in the Delta to cast doubt on the model results. However, that recent decline is due to the rapid loss of tens of thousands of acres in the Delta's signature asparagus crop which has declined to a mere 7,000 acres from reported levels near 70,000 acres in the 1960s. The California Asparagus Board reports acreage was relatively stable during the 1990s, then dropped from 37,000 acres statewide in 2000 to a mere 12,000 acres in 2010, with a little over half of the acreage in the Delta. Asparagus is a labor-intensive crop, and increased competition from the growth of lower-cost producers in Peru and Mexico has impacted California producers.

However, other truck crops including tomatoes, peppers, cucumbers, pumpkins and blueberries have shown modest growth in recent years, and it is hard to see asparagus production in the Delta dropping all the way to zero given its iconic status at local festivals, growing consumption,

and the demand for the fresh market. Even in the unlikely prospect that asparagus were to completely disappear from the Delta, the lower bound of zero production would soon stop the downward trend.

Thus, the 16,000 acre increase in truck crops predicted by the model is plausible, certainly over the 2050 planning horizon of this study. In contrast, other comments and recent trends suggest the prediction for 2,000 acres of additional vineyards is too small given current trends. In comments received from Delta farmers, most expected the most rapid growth in vineyards, as much as another 20,000 acres over the next one to two decades. Current trends and the 64,000 acres of available land in the growing Clarksburg American Viticultural Area suggest this is possible, if not probable. Overall, the 5 percent shift from lower-value crops such as grains to higher-value crops is a reasonable, if not conservative, forecast through 2050. Markets will change and projections are, of course, uncertain and could be more or less than predicted. Nevertheless, the trend towards higher-value crops is consistent with broad trends throughout the Central Valley, although the shift to higher-value crops in other areas has been dominated by growth in tree nuts. However, the shift towards permanent crops in the rest of the Valley and growing urbanization around the Delta creates a market opportunity for increased specialization in truck and vineyard crops in the Delta. In spite of this, truck crops and vineyards, with the notable exception of asparagus, are sensitive to salinity.

7.6 Impact of Policy Scenarios

7.6.1 Background on Salinity and Delta Agriculture

The impact of salinity and potential salinity changes on Delta agriculture is a contentious topic.[117] There are two current proposals that could affect salinity in the Delta:

A proposal to increase the salinity levels allowed in the south Delta from 700 ec to 1000 ec during the growing season, and from 1000 ec to 1400 ec at other times, a 40-42 percent increase. This is known as the D-1641 standard, and the proposed change is currently being considered by the State Water Resources Control Board (SWRCB). The Department of Water Resources and State and Federal Water Contractors support the change, whereas the Central and South Delta Water Agencies oppose the change.

A proposal to shift from through-Delta conveyance to "dual conveyance" utilizing an isolated conveyance facility as proposed in the draft BDCP. The operation of dual conveyance is the subject of continued modeling, but the intention would be to use the isolated conveyance as much as possible while still maintaining south Delta water quality standards. Under the current through-Delta conveyance, salinity levels in the south Delta vary substantially from year to year, and are often much lower than the current 700 ec standard while running at or above the standard in dry years. Thus, under dual conveyance that diverts more water around the Delta in wet years, it is expected that south Delta salinity will run close to the D-1641 standard most of the time, making "every year a drought" in the words of a Delta farmer. The effect could be an increase in the average level of salinity of 25-50 percent even if the 700 ec standard is always met, and a potential doubling in average salinity levels if dual conveyance were combined with an increase of the D-1641 standard to 1000 ec.[118]

[117] In the report, for consistency among databases, salinity is measured by electroconductivity (ec) in units of micro Siemens per centimeter.

[118] Modeling by William Fleenor reported in the 2007 PPIC report indicates that ec would rarely if ever exceed 1000 ec with a dual conveyance system.

In addition to the current proposals, concerns have been expressed by Delta agriculture interests that isolated conveyance could lead to future increases in salinity that would exceed the levels discussed above. They point to emergency declarations by the Governor during periods of drought that temporarily suspend water quality standards and current efforts to weaken environmental and water quality protections through legislation and the courts. The pressures on water quality standards could increase if a $12 billion isolated conveyance facility is built as water exporters attempt to maximize the value of the isolated facility they are financing, and the commitment to maintaining Delta levees could decrease.

The 2007 PPIC "Envisioning Futures" report estimated the potential impacts of a peripheral canal on Delta agriculture by modeling a tenfold and twentyfold increase in Delta salinity, far greater than the salinity increases contemplated in this chapter. In contrast, the same PPIC report estimates a similar isolated facility operated in a dual conveyance system would rarely if ever exceed 1000 ec as discussed above.

Perhaps the most contentious issue isn't the level of salinity changes, but whether salinity will have significant impacts on Delta agriculture at proposed levels. In focus groups, Delta farmers have told us that they monitor salinity levels closely in their current operations, and that some already incur significant costs in chemicals and drainage systems to deal with current levels of salinity. In contrast, the Department of Water Resources and water contractors argue that there would be no loss to Delta agriculture, even if the SWRCB adopted a 1000 ec standard in the south Delta. For example, Department of Water Resources' comments to an earlier draft of this report state,

> *"The salinity objective established by the State Water Resources Control Board is determined by the most salt-sensitive crop grown in the Delta—beans. The EC value has been determined to provide full yields for these most salt-sensitive crops when best-management is practiced by farmers. If the SWP with the isolated facility is operated to meet this objective, then water quality conditions in the Delta would be adequate to allow full crops yields for all crops grown in the Delta and no loss of revenue would occur at all."*[119]

The position that there is no impact on Delta agriculture from proposed increases to Delta salinity levels is based on a report by Hoffman (2010).[120] Hoffman uses well-established yield functions for crops typically grown in the south Delta to estimate potential loss to Delta farmers from changes to salinity. The yield functions depend on the leaching fraction of the soil. Yield loss can occur at low levels of salinity when leaching fractions are low, and crops can tolerate higher salinity in irrigation water when leaching fractions are high. The Hoffman (2010) report states (p. 51),

> "The leaching fraction in the South Delta is difficult to estimate because measurements of soil salinity or salt concentration of drainage water are not measured routinely."

[119] See page 42 of comments at http://www.delta.ca.gov/res/docs/ESP%20Comments%20-%20DWR.pdf.
[120] "Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta," Final Report, January 5, 2010, by Glenn Hoffman. Prepared for the California EPA and the State Water Resource Control Board. http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/final_study_report.pdf

In his calculations, Hoffman generally assumes leaching fractions of 0.15 or above. This is supported by deriving leaching fractions from water samples collected from tile drains in an area in the southwest corner of the south Delta, and a 1976 study of soil salinity in nine locations of the south Delta by Meyer et al.[121] Hoffman's assumed leaching fractions are strongly contested by Delta water agencies.[122] Delta water agencies point out that Hoffman is using tile drains from an area in the southwest corner of the Delta characterized by clay soils and low water tables not typically found in the Delta, and that the sample points used by Meyer are also not broadly representative of the area. They contend that high water tables and soil permeability conditions in most of the south Delta produce low leaching fractions and high sensitivity to irrigation water salinity, and provided a report by Dr. G.T. Orlob that calculated yield loss for soils with a leaching fraction of .05 and estimates this soil type characterizes roughly 40 percent of south Delta cropland.[123] The Orlob report estimates the following percent yield decrements for crops in this soil type where applied water salinity is 1000 ec: beans, -68 percent; corn, -34 percent; alfalfa, -19 percent; tomatoes, -21 percent;, fruit and nuts, -61 percent; and grapes, -29 percent. Similar to Hoffman, Orlob estimates virtually no impact on yields if leaching fractions are 0.18.

A simple comparison of south Delta soil maps and the sampling locations utilized by Hoffman confirms that they are not a representative sample of the region. Thus, Hoffman's conclusion regarding the 1000 ec standard is based on an untested hypothesis about soil conditions in the south Delta. The hypothesis could be tested by conducting the appropriate soil tests on a truly representative sample of cropland in the south Delta, but that data is not available. The empirical analysis in this report can be seen as an alternative approach to testing the hypothesis with existing crop production data. If salinity below 1000 ec has no impact on crop yields in the Delta, then an empirical study should show no relationship between salinity and crop choice controlling for the environmental conditions of the field and other factors.

Incorporating measurements of salinity throughout the Delta as an exogenous variable in the multinomial logit model allows for capturing the marginal impacts on crop choice of changes in salinity. These observations can then be used to predict how the agricultural composition of the southern Delta would change if it were subjected to various scenarios of increasing salinity. The average revenues of the different crop classes are then used to estimate total impacts on the Delta's annual agricultural revenue. The model inputs and results are described in more depth in Appendix G.

To our knowledge, the only other economic study to model the impact of salinity on Delta agriculture is the 2007 PPIC report.[124] In contrast to the econometric approach of this report, they build a Delta Agricultural Production Model using the positive mathematical programming approach.[125] The Hoffman yield functions are built into the model, and the report states regarding current salinity levels, "most of the stations have an EC less than 1 mS/cm, which in

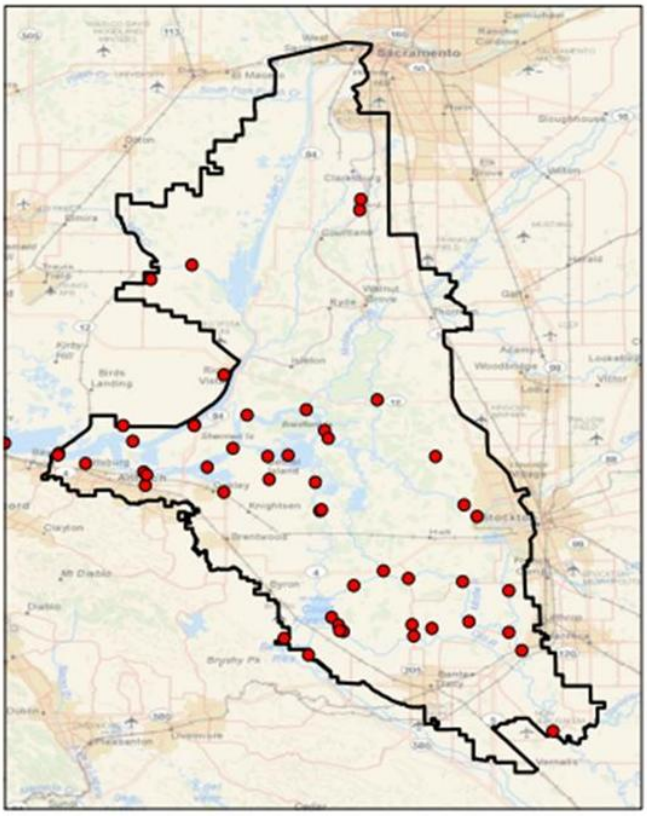
[121] Meyer, J. L., Carlton, A., Kegel, F., Ayers, R. S., "South Delta Salinity Status Report," University of California, Davis, CA, 1976, 16 p.
[122] Personal communication with John Herrick, July 5, 2011. See also a presentation to the State Water Board: http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/docs/060611wrkshp/sdwa.pdf, and comments on the Hoffman report to the State Board, http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/cmmnts052311/john_herrick.pdf.
[123] G.T. Orlob, *Impact of San Joaquin River Quality on Crop Yields in the South Delta,* 1987.
[124] Details of the model are in Appendix D, http://www.ppic.org/content/pubs/report/R_207JLR.pdf.
[125] Howitt, R.E. 1995. Positive Mathematical Programming. *American Journal of Agricultural Economics* 77: 329-342.

practice means no effect on agricultural production." Thus, the study is assuming leaching fractions above 0.15 as in the Hoffman report. Nevertheless, the study predicts potentially large impacts of salinity from a peripheral canal and other strategies to increase salinity, ranging from 25-60 percent declines in Delta agricultural revenue, and 8-40 percent declines in irrigated acreage as water quality in some areas could decline to levels unsuitable for any crop. If the same model were applied to dual conveyance that would keep salinity at or below the 1000 ec threshold, it would predict virtually no loss in agricultural output in parallel to the argument of the Department of Water Resources, because the Hoffman threshold functions for crop yield are built in.

7.6.1.1 Salinity Data

For the purposes of baseline salinity modeling, salinity data has been collected for over 50 sites in the Delta region. An analysis of salinity impacts required the creation of a variable representing average salinity on an annual basis. Based on information gained in a working group and further consultation with Delta farmers, a decision was made to use a value for the average salinity observed between May and August, when sensitive crops are most vulnerable to salinity changes in the Delta. Salinity is represented using measures of electroconductivity (ec), in units of micro Siemens per centimeter.

Figure 24 Salinity Observation Stations[126]



The modeling also required the ability to map salinity values to each individual crop field. In order to predict these values, salinity measurements were averaged across all observation sites in a three-mile radius of each crop field. The measurement value of the nearest station was used for fields without multiple monitoring stations within that radius. This generated

[126] For high resolution image see http://forecast.pacific.edu/desp-figs.html

standardized estimations of salinity for fields throughout the Delta using a replicable technique. A map of the salinity observation stations used as inputs is depicted in Figure 24, and the sources of the station data are described below.

Interagency Ecological Program (IEP)
The IEP samples discrete water-quality data at 19 sites throughout the Delta. The sites are chosen in an attempt to represent the major inflows and outflows of the Delta, with new data sampled monthly. All reported observations undergo a detailed quality assurance process prior to being made publicly available. Sampling sites are mapped in GIS using longitudinal and latitudinal coordinates provided by the IEP.

California Data Exchange Center (CDEC)
Additional salinity data is collected from 45 Delta water monitoring stations reported through the CDEC. The sites are maintained by a variety of organizations, including the California Department of Water Resources, the U.S. Bureau of Reclamation, and the U.S. Geological Survey. The sites are sampled daily, and the monthly average is taken based on reported daily values.

Tables in Appendix G provide more detail about how average salinity varies across space and years in the Delta. It is important to emphasize that the data is presented here as a season long average, and thus masks important spikes that often occur during years when the average is considerably lower. The ten-year sample for which detailed information is provided includes six dry years with very high salinity from 2001–2002, 2004, and 2007–2009. Salinity was significantly lower in other years. During 2008, average salinity levels in most of the Delta were 60 percent to 80 percent higher than in 2006. In the north Delta, average salinity is less than 200 ec in most years and there is relatively less variation between years. In contrast, the south Delta averaged 646 ec in 2008 and 408 ec in 2006, with some areas averaging 800 ec or more in 2008 and 2009. Thus, the south Delta experiences significantly higher levels of salinity and more variation than the north Delta. This reflects many factors, including the significant differences in water quality between the Sacramento and San Joaquin Rivers.

7.6.1.2 Salinity Modeling

As discussed earlier and shown in the model results in Appendix G, the multinomial logit model found salinity to have a statistically significant impact on crop choice in the Delta. Since virtually all of the fields in the sample have irrigation water supplies below the 1000 ec, the finding does not support the assumption that there are no agricultural impacts below 1000 ec as argued by the Department of Water Resources and others.

For preliminary calculations of impacts, scenarios were established for percentage increases in salinity for the southern Delta regions, comprising fields within BDCP conservation zones 6 through 9. In reality, salinity would not increase uniformly across the region, and future simulations of the model with more spatially precise estimates of salinity changes could generate more accurate and detailed results. However, the current predictions in Table 18 below are a good initial estimate of the magnitude of agricultural revenue impacts that could be generated by crop shifting from salinity changes.

Table 18 Forecasted Crop Revenue Impacts from Increasing Delta Salinity

		Forecast Acreage					Total Revenue				
Crop Category	**Crop Category Avg. Revenue per Acre**	**Baseline**	**25% Salinity Increase**	**50% Salinity Increase**	**100% Salinity Increase**	**200% Salinity Increase**	**Baseline**	**25% Salinity Increase**	**50% Salinity Increase**	**100% Salinity Increase**	**200% Salinity Increase**
	[a]	**[b]**	**[c]**	**[d]**	**[e]**	**[f]**	**[g]**	**[h]**	**[i]**	**[j]**	**[k]**
Deciduous	$4,612	6,954	5,971	5,051	3,486	1,499	$32,071,848	$27,538,252	$23,295,212	$16,077,432	$6,913,388
Field	$780	80,752	83,621	85,246	85,011	74,848	$62,986,560	$65,224,380	$66,491,880	$66,308,580	$58,381,440
Grain	$426	15,925	19,197	22,734	30,335	45,892	$6,784,050	$8,177,922	$9,684,684	$12,922,710	$19,549,992
Pasture	$116	2,963	3,757	4,667	6,810	12,056	$343,708	$435,812	$541,372	$789,960	$1,398,496
Truck	$3,903	29,804	24,460	19,843	12,741	5,029	$116,325,012	$95,467,380	$77,447,229	$49,728,123	$19,628,187
Vineyard	$3,566	3,519	2,911	2,376	1,534	594	$12,548,754	$10,380,626	$8,472,816	$5,470,244	$2,118,204
				Total Revenue			**$231,059,932**	**$207,224,372**	**$185,933,193**	**$151,297,049**	**$107,989,707**
				Scenario Revenue Losses				**-$23,835,560**	**-$45,126,739**	**-$79,762,883**	**-$123,070,225**

Notes:

Modeled regions include 2010 field borders acreage located within specified BDCP conservation zones.

[a] is the average crop class revenue per acre based on 2009 yield and price data from county crop reports.

[a] is the forecasted acreage of each crop class under the specified baseline salinity conditions.

[c]- [f] are the forecasted acreage of each crop class assuming a 25-200% increase in salinity levels

[g] = [a] * [b]

[h] = [a] * [c]

[i] = [a] * [d]

[j] = [a] * [e]

[k] = [a] * [f]

The model predicts a large shift from high-value truck and vineyard crops to lower-value grain and pasture crops should salinity levels rise in the south Delta. This shift would have significant revenue impacts on Delta agriculture. The forecasted shifts in crop distribution are intuitive, as they reflect the salt sensitivity of the dominant Delta crops in each crop category. Processing tomatoes, the dominant truck crop in the Delta, are salt-sensitive, as are wine grapes. Both are expected to decline, while salt-tolerant grain and low-value pasture crops are expected to increase in acreage. Deciduous crops are largely salt-sensitive and are also expected to face decreasing acreage in the south Delta under forecasted salinity increases.

As shown in Table 18, a 25 to 50 percent increase in south Delta salinity could cause a $24 million to $45 million reduction in crop revenue, and the roughly 40 percent proposed increase in south Delta salinity standards falls in this range. The model projects an $80 million revenue loss from a doubling of south Delta salinity, and the potential for larger losses if salinity were to increase further is illustrated by a $123 million loss.

It is important to note that the estimated revenue losses in Table 18 are solely due to crop shifts, and the model does not estimate any potential impacts from yield declines as salinity increases. Further, it does not move any land out of agricultural production as salinity increases, it merely assigns it to lower value categories, and does not account for accumulation of salinity over time. Thus, the losses could be even higher if accounting for these effects, especially for the higher levels of salinity increase. On the other hand, the losses in Table 18 probably include a few upland areas in the Delta that would be little impacted by increased salinity in Delta channels, and these could be areas with higher concentrations of high-value deciduous crops. As discussed earlier, as more spatially disaggregated data on potential salinity changes become available, the estimated effects could be adjusted to take advantage of that data.

7.6.1.3 Agricultural Revenue Impacts of Isolated Conveyance

As discussed above, the potential revenue impacts of introducing an isolated conveyance facility operated as dual conveyance in combination with continued through-Delta conveyance is closely linked to south Delta salinity standards. If south Delta salinity standards remain at their current levels, the water quality impacts of dual conveyance could be as low as $20 million per year. If an isolated conveyance is introduced and salinity standards are relaxed, the model predicts up to $80 million in lost agricultural revenue per year. There still is significant uncertainty regarding the exact impacts of isolated conveyance, but $20 million to $80 million in annual revenue impacts is a reasonable range based on this modeling. The $20 million to $80 million annual decline is significantly different than the estimates of no loss based on the threshold yield functions and untested assumptions regarding soil leaching fractions.

In addition to water quality impacts, the footprint of an isolated conveyance facility will also take a significant amount of land out of agricultural production, especially in the north Delta. The November 2010 draft BDCP estimates that roughly 8,000 acres will still be required for a tunnel conveyance system, even though the land requirements are much lower than a surface canal. Most of the affected acres are in relatively high-value agricultural lands in the north Delta that currently average about $2,000 per acre per year in revenue. Using detailed acreages allocated across crop classes in the draft BDCP, the land consumption of the isolated conveyance project would result in an additional $10 to $15 million annual loss to Delta agricultural revenues. A surface canal would impact roughly four times the amount of agricultural land.

7.6.2 Agricultural Revenue Impacts from Habitat Conservation Scenarios

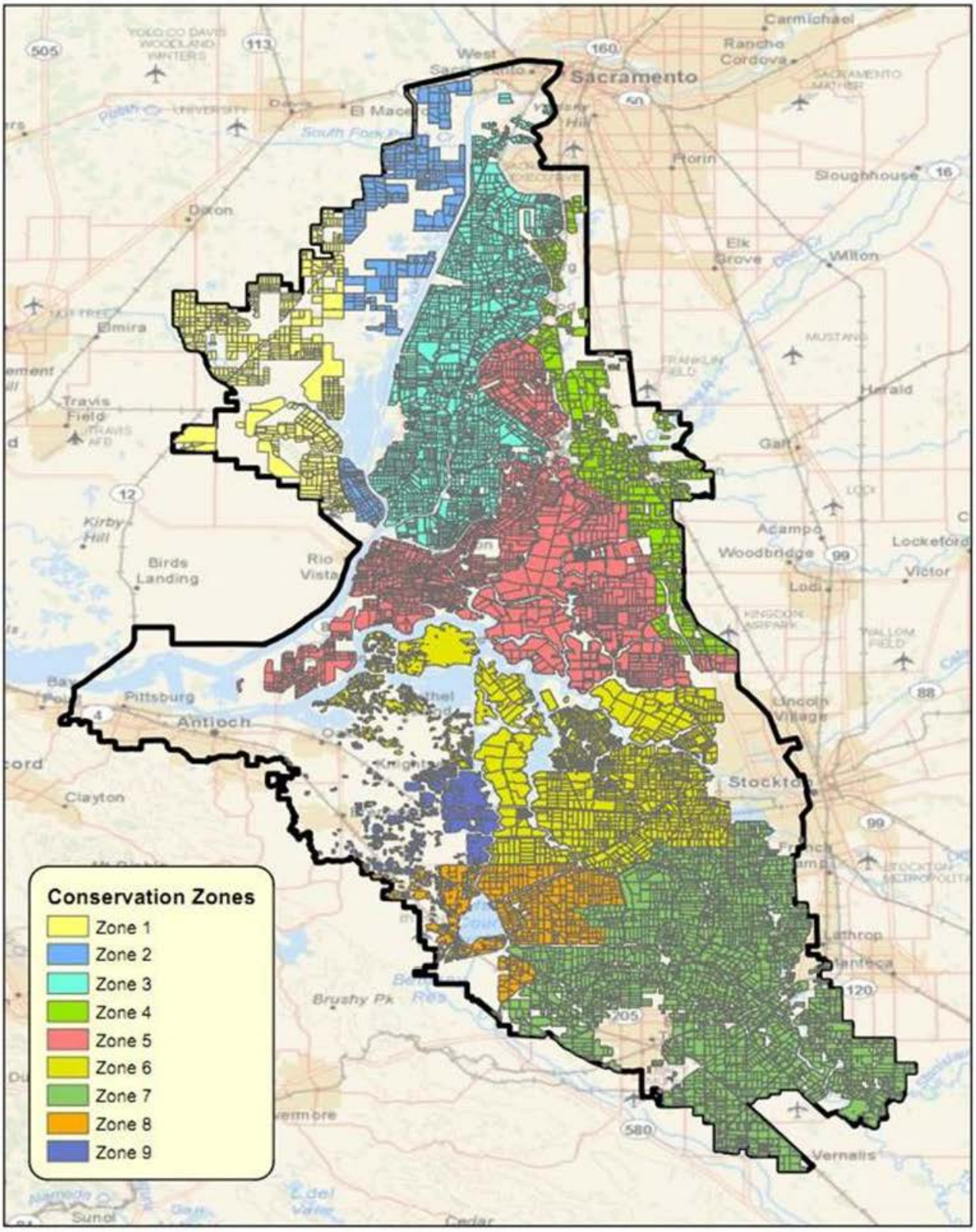
As outlined in Chapter 6, this report seeks to address impacts of four major conservation measures proposed by the BDCP. An extremely precise examination of agriculture impacts is not currently possible due to the lack of specificity provided in the BDCP as to where lands would potentially be conserved or restored. The best spatial approximation of targeted areas is provided by the BDCP's delineation of Conservation Zones and Restoration Opportunity Areas (ROAs) for which conservation investments are proposed. Replicating the spatial extent of these zones and analyzing the agricultural landscape of each gives an estimate of the impacts on agriculture that each conservation measure would entail.

Table 19 below illustrates the total agricultural acreage and average revenue generated by crops fields in each of the BDCP's conservation zones. In addition, a list of the conservation measures with significant impacts in each conservation zone is provided. A map of Delta crop fields and their associated conservation zone is included in Figure 25.

Table 19 Agricultural Composition of BDCP Conservation Zones

Conservation Zone	Agricultural Acreage (2010)	Revenue per Acre (2009)	Relevant Conservation Measures
1	31,030	$463	CM3, CM4
2	14,064	$802	CM2, CM3, CM4
3	59,011	$1,474	CM6
4	26,441	$2,075	CM3, CM4, CM6
5	75,239	$1,838	CM3, CM4, CM6
6	71,219	$1,885	
7	89,716	$1,823	CM3, CM4, CM6
8	27,595	NA	
9	15,809	NA	

Figure 25 BDCP Conservation Zones[127]



[127] For high resolution image see http://forecast.pacific.edu/desp-figs.html

7.6.2.1 Yolo Bypass Fisheries Enhancement

Major impacts on agriculture from Yolo Bypass Fisheries Enhancement will come from the potential acquisition of lands through fee-title or conservation and flood easements. The largest source of revenue in the affected conservation zone comes from rice fields located along the northern region of the Yolo Bypass, and the use of rangeland could also be impacted. Table 20 estimates current Yolo Bypass crop production excluding grazing land, which might add another $500,000 to the total of $27.1 million. Total agricultural revenue in the Legal Delta area is currently estimated at about $11 million. However, the majority of high-value rice fields is located in the area of the Yolo Bypass north of the Legal Delta, and is estimated to generate almost $16 million in annual revenue and could experience the most significant direct impacts. Given that it is impossible to enhance the Yolo Bypass fishery flows in the legal Delta without simultaneously affecting the area outside the legal Delta, we consider impacts beyond the legal Delta for this conservation measure.

The November 2010 draft BDCP estimates that new flowage easements would be required for 21,500 acres on the eastern bypass or as much as 48,000 acres assuming western tributary flows also flooded the central and western portions of the bypass. Current documents from the BDCP working group are focused on the Fremont Weir Gated Channel operations with an impact on 17,000 acres, and most important, would inundate 7,000 to 10,000 acres in most years after March 1, which gets into the time period where flooding interferes with agricultural planting.[128]

Yolo County is working with UC-Davis on an analysis of the agricultural impacts of more frequent flooding of the Yolo Bypass for fish habitat. The study has more detailed crop, yield and price data than is currently available.[129]

The November 2010 draft BDCP estimates new flowage easements would average 25 percent of property value on 21,500 acres in the bypass, using the current agricultural revenue that implies a roughly $7 million annual decline in crop revenue. If, as in the September 2011 discussion document, roughly 10,000 acres were flooded to preclude production in about 60 percent of years, average lost agricultural revenue could be as high as $10 million. Thus, our rough estimate of potential lost agricultural revenue from Yolo Bypass Fishery enhancements is $7 million to $10 million.

Yolo County is working with the BDCP Yolo Bypass Fishery Enhancement Working Group to develop a proposed project that minimizes or avoids impacts to existing land uses, and provides full mitigation for tax revenue and economic impacts. Like other preliminary cost estimates for habitat measures, the estimated impacts could change as plans change over time.

[128] Potential Operation Pattern for Fremont Weir Gated Channel, or "Notch," September 23, 2011 Draft for Discussion Purposes. Available at www.baydeltaconservationplan.com.

[129] Garnache, C. and R.E. Howitt. 2011 "Analyzing the Tradeoffs Between Agriculture and Native Species: The Case of the Yolo Bypass Floodplain." Selected Paper prepared for presentation at the AERE 2011 Summer Conference, Seatlle, June 9-10, 2011.

Table 20 Yolo Bypass Crop Acreage and Revenue, 2009[130]

	Inside Legal Delta		*Outside Legal Delta*	
Crop Category	**Acres**	**Value**	**Acres**	**Value**
Deciduous	73	$314,000	0	$0
Field	5,026	$3,961,837	7,760	$11,087,862
Grain	1,179	$394,461	370	$145,050
Pasture	4,415	$241,030	0	$0
Truck	1,875	$6,321,309	1,500	$4,634,129
Vineyard	0	$0	0	$0
Total	**12,568**	**$11,232,637**	**9,630**	**$15,867,041**
YOLO BYPASS TOTAL			**22,198**	**$27,099,678**

7.6.2.2 Natural Communities Protection

The Natural Communities Protection strategy has several elements. The most significant for agricultural production in the Delta would be the conversion of 8,000 acres of grazing land to native grasslands, and the creation of nearly 33,000 acres of agricultural habitat through fee-title purchases or easement acquisition. Since grazing lands crop value is roughly $20 per acre, the loss of 8,000 acres would amount to only $160,000 per year. However, that measure probably understates the total impact on cattle production in the region, as this would represent a roughly 30 percent loss in the current grazing land that supports cattle production estimated at $24 million per year. The increase in irrigated pasture that could be created through the 32,000 acres of "agricultural habitat" protection could offset this loss and thereby minimize any impact on the cattle industry.

The most significant part of this conservation strategy is the acquisition of nearly 33,000 acres in "wildlife friendly" agricultural easements. The draft BDCP does not give specific information about implementation, but offers some general guidelines that can be used to anticipate impacts. Pages 2-130-132 of the November 2010 draft BDCP identify alfalfa, irrigated pasture, and rice as crops that provide high habitat values, and orchards and vineyards as crops that provide little habitat value. Other cultivated annual crops such as corn, tomatoes, grains, and other truck crops are described as providing seasonal habitat value with high variation among crop types. The high habitat value crops generate average revenue of $100 to $1,400 per acre, whereas the low habitat value crop types generate average revenues of $3,500 to $4,500 per acre. The draft BDCP estimates the costs of land and easement acquisition of cultivated habitat at $8,000 per acre ($260 million for 32,600 acres) which suggests that at least some permanent crops will be targeted for acquisition given current land prices.

Roughly 13,000 acres of the "agricultural habitat" is targeted for Conservation Zones 1 and 2 which include most of the Cache Slough area in Solano County and the Yolo Bypass. These areas average less than $1,000 per acre in crop value and are already mostly planted in the preferred crop types for habitat. Thus, the creation of "agricultural habitat" in this area would presumably lock in current cropping patterns, and have little impact on agricultural revenue compared to current levels.

[130] Yolo bypass crop production varies widely from year to year and as explained earlier, our field level data does not include fields that did not have pesticide use filing (e.g. organic). Detailed studies in progress by UC-Davis will likely have more detailed and complete data.

Approximately 10,000 acres of agricultural habitat is targeted for Conservation Zone 4, in the northeast Delta, and Conservation Zone 7, the south Delta. These areas have average revenues of approximately $2,000 per acre, among the highest value croplands in the Delta. Vineyards are a significant part of CZ4, and there is much potential growth for this region. Presumably, the objective of this conservation measure would be to stop or reduce vineyards in this region in favor of pasture, alfalfa, or corn as grown by the Nature Conservancy on Staten Island. In the south Delta, there are some vineyards as well as significant numbers of truck crops that might be viewed as less wildlife friendly. The anticipated easement costs suggests a displacement of $300 to $400 per year in net profit, which might translate to roughly $1000 per year in net production.

Overall, the natural communities and agricultural habitat protection is among the most difficult to value the agricultural revenue impacts. Considering the discussion above, an agricultural revenue loss of $5 million to $25 million per year is a reasonable estimate at full implementation. The use of more limited term easements or a conservation reserve program model instead of fee-simple and permanent easement purchases might be considered. This would reduce the impact on the agricultural economy by allowing Delta agriculture more flexibility to respond to future market changes.

7.6.2.3 San Joaquin River Floodplain Restoration

The November 2010 draft BDCP calls for the restoration of 10,000 acres of seasonally-inundated floodplain habitat over a 40-year period, with 1,000 acres restored in the first 15 years. No specific regions are outlined, though the BDCP notes that "the most promising opportunities for large-scale restoration are in the south Delta along the San Joaquin River, Old River, and Middle River channels…" These areas fall almost entirely within conservation zone 7, which is largely occupied by high-value alfalfa and tomato crops and has an average per-acre revenue of $1,823. In addition, the identified areas are almost entirely in agricultural production, and a large proportion of the restored floodplain would almost certainly affect land currently in production. Based on current production, the San Joaquin River Floodplain Restoration could reduce annual agricultural revenue by $15 million to $20 million per year.

An alternative proposal focused on enhancing the flood bypass at Paradise Cut has been developed cooperatively between environmental groups and local Delta landowners. This proposal would generate significant flood control and ecosystem benefits while limiting agricultural impacts to 2,000 acres, thereby reducing agricultural impacts by up to 80 percent. The alternative proposal is recommended in the fourth draft of the Delta Stewardship Council's Delta Plan. The details of these plans are very uncertain at this time, and BDCP planning does not seem to be as well developed as it is for Yolo Bypass Fishery Enhancements at this point. Given the uncertainty, the estimate of potential lost agricultural revenue ranges between $3 million and $20 million per year depending on what plans are implemented.

7.6.2.4 Tidal Habitat Restoration

Of the major conservation measures addressed in this report, tidal habitat restoration has the most clearly defined geographic areas and restoration targets. Tidal habitat also has by far the largest potential economic impact on agriculture due to the high acreage targets and the fact that it eliminates all agricultural uses rather than limits agricultural activity with measures such as conservation easements. The agricultural fields contained in each Restoration Opportunity Area (ROA) are shown in Figure 26, with their acreage and value in each region depicted in Table 21 below. The BDCP outlines various restoration targets to be achieved over the next 40 years, with a final target of 65,000 restored acres in the Delta and Suisun Marsh. In addition,

there are minimum values for acreage in each of the four ROAs which must be restored, as shown in Table 21. A minimum of 7,000 acres is targeted for Suisun Marsh, which lowers the maximum target for tidal habitat in the Delta to 58,000 acres.

Table 21 Agricultural Composition of BDCP Restoration Opportunity Area

Restoration Opportunity Area (ROA)	Total Acreage	Agricultural Acreage (2010)*	Minimum Restoration Target (Acres)	Revenue per Acre (2009)
Cache Slough Complex	49,167	19,854	5,000	$491
Cosumnes/Mokelumne River	7,805	7,840	1,500	$2,175
South Delta	39,969	34,914	5,000	$2,151
West Delta	6,178	2,587	2,100	$1,279
TOTAL	**103,119**	**65,195**	**13,600**	**$2,014**

*Values may be slightly inflated due to large fields centered within the ROA which extend past its borders.

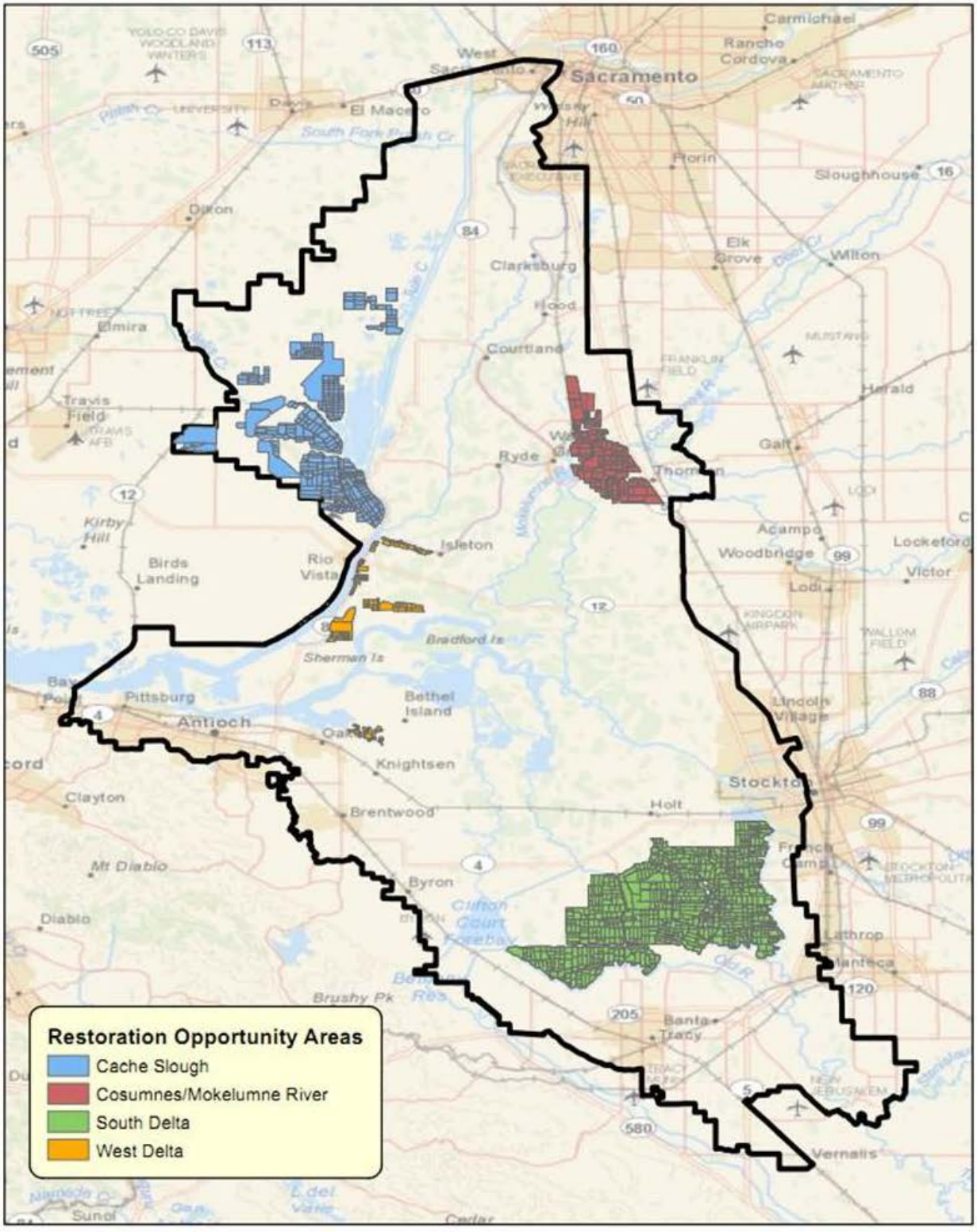
As can be seen in Table 21, in some regions even the minimum restoration targets will require the acquisition of land currently used in crop production. In addition, both the Cosumnes/Mokelumne River ROA and the South Delta ROA are centered in some of the highest revenue agricultural areas of the Delta. Even if over 50,000 acres were restored in Suisun Marsh so that only the minimum restoration targets were reached in the four Delta ROAs, total agricultural revenue loss would be about $18 million per year with nearly $11 million of the total loss occurring in the south Delta. If only the minimum were restored in Suisun Marsh and the remaining 58,000 acres were proportionally distributed across the Delta, the estimated revenue loss would reach $77 million per year with about a $46 million loss in the South Delta.

Tidal marsh restoration in Cache Slough has been discussed for decades because restoration in the area would have little impact on the current through-Delta conveyance of fresh water, and it has desirable environmental and elevation characteristics. Table 21 indicates that its lower revenue per acre might make it a target area for economic reasons, although representatives from Solano County have said that the low revenues per acre can be partially attributed to the regulatory and planning "cloud" that has been over the area for years and discouraged investment in higher-value crops. A March 2008 report by Kurt Richter of the University California Agricultural Issues Center[131] provides a detailed tract by tract analysis of the potential impacts of tidal habitat restoration proposals in Cache Slough and Suisun Marsh that go beyond the direct loss of agricultural production.

The report finds that the least costly way to attain the ecological restoration goals for Cache Slough area would be to convert Hastings Island, Egbert Tract and Little Egbert Tract to tidal habitat. These three areas "would provide over 17,000 acres of habitat and remove $9.6 million from the agricultural economy in Solano County (2006 dollars)." The report also notes that restoration of these three areas "will require that the levees around Ryer Island, North Ryer Island and Hass Slough be moved or redesigned since the new system will increase the threat of underseepage," and notes other concerns related to waterfowl habitat and water quality.

[131] Richter, K.R., "The Potential Impact of the Delta and Suisun Marsh Habitat Restoration Plans on Agricultural Production in Solano County," University of California Agricultural Issues Center, March 14, 2008.

Figure 26 BDCP Restoration Opportunity Areas[132]



[132] For high resolution image see http://forecast.pacific.edu/desp-figs.html

The wide range of potential agriculture losses ranging from $18 million to $77 million annually illustrate the risk and uncertainty this conservation strategy poses for Delta agriculture. Compared to the other conservation measures, the tidal marsh restoration strategy entails the largest necessary direct impacts on Delta agricultural production, and also has some of the highest direct implementation costs for BDCP. The BDCP currently states that the majority of these targeted lands will be determined "based on land availability, biological value, and practicability considerations." The absence of agricultural impacts from the described methodology is a notable omission considering the potential implications for the Delta economy. Targeting criteria that avoids high-value agriculture lands and reduced target acreages, particularly in the south Delta, should be considered.

7.6.2.5 Summary and Additional Concerns Regarding Habitat and Agriculture

Considered together, the four habitat conservation measures here could reduce agricultural output in the Delta between $33 million and $137 million per year. The wide range shows the importance of considering agricultural impacts when designing conservation measures. The $33 million revenue loss scenario shows that it is possible for significant habitat restoration to be compatible with economic sustainability of Delta agriculture if it is carefully planned to minimize impacts. However, the potential for $137 million in direct losses to agricultural output shows that habitat restoration could also have severe negative impacts on the Delta economy.

There are additional risks to Delta agriculture from habitat restoration measures in addition to the direct losses to agricultural production described in this section. The following list of additional concerns is taken from a letter from Deputy Natural Resources Secretary Jerry Meral inviting participants to a September 13, 2011 meeting on the potential impacts of the BDCP habitat projects on agriculture.

- Increased risk of levee failure due to changes in levee configurations with tidal habitat restoration actions
- Water quality and salinity issues for agricultural irrigation as a potential result of water facilities operations and tidal habitat restoration
- Water elevation changes at agricultural intakes as a result of water facilities operations
- Effects on agricultural land from adjacent restored tidal habitat, such as seepage
- Neighbor effects of increased endangered wildlife species on BDCP preserves next to agricultural lands
- Increased presence of listed fish species at agricultural diversions and potential regulatory effects where aquatic habitat restoration increases listed fish densities
- Weed control on habitat lands
- Mosquito and vector control issues

In addition to these impacts, participants in the meeting raised concerns about the potential for decreased property values even if land is not being restored, and increased crop loss from feeding and predation of wildlife such as birds attracted to nearby restored habitats.

7.6.3 Loss of Agricultural Value from Open Water Scenario

The central Delta open water scenario discussed in Chapter 6 would result in a loss of agricultural production on the flooded islands. The impacts can be quantified simply by looking at the agricultural farmland currently in production on each island. If the six islands were flooded, almost 13,000 acres would be lost, with a corresponding loss of around $11 million dollars in direct revenues per year. The islands are largely composed of low-value field crops, with average revenue per acre significantly below that of the Delta as a whole. A summary of the affected islands is depicted below in Table 22. As discussed in Chapters 4 and 6, it is highly unlikely that Empire Tract would be flooded due to new water supply infrastructure for the City of Stockton.

Table 22 Six Island Agricultural Composition

Island	Agricultural Acreage (2010)	Total Revenue (2009)	Revenue per Acre (2009)
Mandeville	2,345	$2,198,583	$1,117
Medford	365	$279,797	$715
Quimby	629	$487,720	$776
Venice	2,587	$2,008,844	$765
Webb	4,469	$3,467,869	$776
Empire	2,521	$2,539,318	$1,031
TOTAL	**12,916**	**$10,982,131**	**$981**

7.6.4 Impact of Land Use Regulatory Changes on Delta Agriculture

The “covered actions” provisions of 5th Draft of the Delta Plan have raised concerns about increased regulatory costs or constraints on Delta agriculture. For example, on page 54, the Delta Plan attempts to clarify what are “covered actions” regulated by the Delta Plan by saying, “Routine agricultural practices are unlikely to be considered a covered action unless they have a significant impact on the achievement of the coequal goals or flood risk.” The statement has created concerns that increased regulation could affect investment to supporting farm structures such as packing sheds or regulating the planting of permanent or crops that are deemed to be less wildlife friendly. There are also concerns about potential impacts on property values.

EXHIBIT B

Technical Memorandum:

Delta Risk Management Strategy (DRMS) Phase 1

Topical Area:

Impact to Infrastructure

Final

Prepared by:
URS Corporation/Jack R. Benjamin & Associates, Inc.

Prepared for:
California Department of Water Resources (DWR)

June 15, 2007

7.2 Summary

The total estimated replacement costs for infrastructure assets within the Delta are summarized in Table 7-8 for the current (2005) and 2050 conditions, for MHHW and 100 year inundation levels. This table accounts for infrastructure assets that could be damaged as a result of levee breaching and island flooding (see Section 1.2). The costs are based on the results presented in Tables 7-1, 7-2, 7-4 and 7-5.

Table 7-8 Comparison of Total Replacement Costs of Delta Infrastructure - Current and 2050[a]

Inundation Level	Current (2005)[c]	2050	Cost Ratio: 2050/Current
Within Mean Higher High Water (MHHW) Limits [b]	$6.7 billion	$8.5 billion [e]	1.3
Within 100-year Flood Limits [b,c]	$56.3 billion	$67.1 billion [e]	1.2

[a] Costs in this table are for infrastructure assets and their contents that could be damaged as a result of levee breaching and island flooding.
[b] See Section 4.1.2 and Figure 4-1 for limits of inundation.
[c] Flood plain limits were developed from FEMA Flood Insurance Rate Maps.
[d] Costs are in 2005 dollars.
[e] Costs are in 2005 dollars; not escalated to 2050.

As indicated in Table 7-8, the total replacement cost of assets within the 100-year flood limits significantly exceeds (about 8 times) these costs for assets within the MHHW limits. The reason for this large difference is explained by referring to Figure 4-1. This figure shows that the 100-year flood event has the potential to inundate major urban areas such as Sacramento and Stockton that have a large inventory of infrastructure assets. However, the MHHW limits do not extend to these large urban areas. Smaller towns and rural/agricultural areas mainly fall within the MHHW limits. The largest differences between damages for the 100-year flood event and other events would be for infrastructure that is located near the edge of the floodplain in urban areas (areas with topographic relief).

Table 7-8 also indicates that over the next 50 years, the total replacement cost of assets could increase by about 20 to 30 percent within the MHHW limits and the 100-year flood plain limits. Likewise, the overall damage repair costs of assets as a result of levee failure are also expected to increase over the next 50 years due to the (1) increase in the amount of infrastructure assets as a result of population growth, (2) Delta water level rise due to climate change, and corresponding increase in MHHW and 100-year flood levels, and (3) decrease in island elevation levels due to subsidence. The increase in water levels, coupled with the decreasing island elevations, would increase the amount of inundation of Delta assets in the future. The damage would therefore increase, resulting in greater future repair costs and repair times.

The repair costs for infrastructure assets will be based on the number of island failures and resulting inundation, and the repair costs will vary from island to island. For both current and 2050 conditions, the overall results of the repair and replacement costs presented in the asset tables indicate that the repair costs due to inundation could be on

the order of 30 percent (for MHHW) and 50 percent (for the 100-year food) of the asset replacement costs, considering all Delta islands and tracts.

7.3 Limitations

As stated in Section 1.2, we consider damage to infrastructure assets that could result from levee breaching and island flooding. Infrastructure assets that would not be damaged by levee failure (e.g., pumping plants and power plants) are beyond the scope of the TM.

As stated in Section 3, because some asset types lack attribute information, it was not always possible to estimate asset costs from the GIS data. In these cases, there is insufficient definition of quantitative attributes to evaluate reliable replacement and repair costs and assumptions had to be made so that damage loss could be estimated. Also, some assets were not available in the GIS database. Further characterization of the Delta infrastructure assets would reduce the uncertainty in the damage estimates.

Because of the lack of information on repair times (due to the absence of historic experience), especially for multi-island failures, judgment was used to estimate repair times.

8. References

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