Ecosystem Work Group Recommendations Strategic Plan for Restoring the Delta's Ecosystem

Delta Vision

Developing Draft
4/24/2008

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1 Introduction

The purpose of the Delta Ecosystem Restoration Strategic Plan is to chart a specific suite of strategies that when followed are intended to reverse the changes in Delta ecology such that desirable ecological communities, including native species, their natural habitats, and the ecological processes necessary for their support are all returned to a level that can be resilient in the longer term. This document represents the recommendations as currently being formulated by the Delta Vision Ecosystem Work Group for the Ecosystem Restoration component of the Delta Vision Strategic Plan.

The Ecosystem Work Group has used the following steps to develop its recommendations; Fig 1 illustrates the linkages between these steps:

Step 1: Define the problems and their underlying drivers (Section 2)
Step 2: Define the desired ecosystem characteristics that represent the Delta as part of a healthy estuarine ecosystem and that represent solutions to the problems (Section 3)
Step 3: Define indicators of each desired ecosystem characteristic and establish performance targets for each indicator, quantitative wherever possible (Section 3)
Step 4: Develop strategies for achieving the desired ecosystem characteristics, based on understandings of forcing functions of the defined problems and factors affecting their solutions (Section 4)
Step 5: Recommend actions to implement these strategies (Section 5)
Step 6: Suggested performance measures to evaluate effectiveness of strategies and actions (Section 6)

Figure 1. Developing Ecosystem Recommendations

This draft of April 24, 2008 represents ~75% completion of steps 1 through 3. Steps 4 and beyond will be undertaken imminently.

All of this work is presented in the context of the overarching ecosystem goals for Delta Vision:

1) For the Delta to function as part of a healthy estuarine ecosystem
2) For ecosystem and water supply reliability to be co-equal

Each element of this document follows the "restoration recipe" presented in Figure 2. It provides very clear guidance for articulating problems, desired futures, performance targets, and the strategies and actions necessary to meet targets.

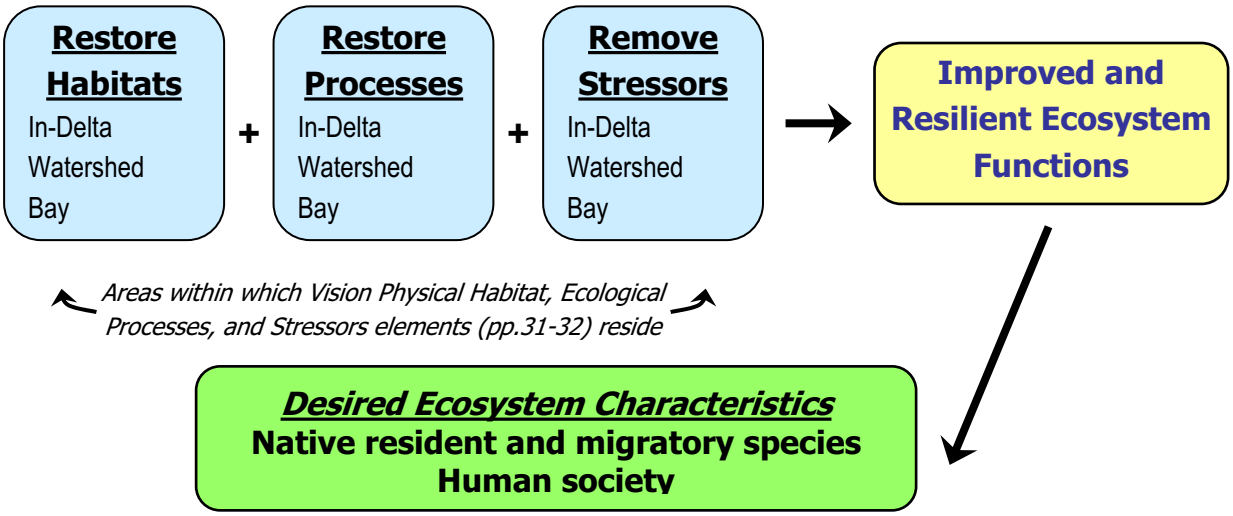

Figure 2. Ecosystem Restoration "Recipe"

These recommendations complement work being undertaken by the CALFED Ecosystem Restoration Program (ERP) Conservation Strategy, the ERP Delta Regional Ecosystem Restoration Implementation Plan (DRERIP), the Bay Delta Conservation Plan (BDCP), the Interagency Ecological Program (IEP), the Operating Criteria and Plan (OCAP), the Suisun Marsh Plan (SMP), and resource agency recovery plans.

2 Problem Statement

What are the measures or indicators of today's poor Delta ecosystem function? What underlying causes drive that poor function? By defining these indicators and the range of possible underlying causes, we can begin to identify strategies for their resolution. The information presented here comes from primary technical efforts that have been seeking to identify underlying causes and/or to develop strategies to improve the Delta. These problems and their underlying drivers are addressed

in Section 4 via strategies to improve the Delta as a functioning component of a healthy estuarine ecosystem.

Problem Indicators

The Delta is changed from abundant populations of fish and wildlife species, highly productive, variable conditions, extensive diverse habitats, good migration corridors, and free of contaminants to many listed species, impaired primary and secondary production, homogenous conditions, minimal and uniform habitats, poor transit corridor, and contaminant-affected water and sediment quality. Specifically:

1. **Population declines of native resident and migratory fish species:** Across a broad range of functional groups of native resident and migratory fish species that utilize the Delta, there have been major recent population declines – Delta smelt, longfin smelt, splittail, salmon, sturgeon. Their past declines already lead to their protected status and, with the recent declines, provide clear indication of the Delta's degraded ecological functions.
2. **Impaired primary and secondary production:** Reduced primary production, shift in phytoplankton assemblages away from diatoms, and loss of productivity to invasive species result in greatly reduced capacity to support higher trophic level native aquatic organisms
3. **Low variability in the aquatic environment:** Low intra- and inter-annual variability in inflows and outflows, environmental water quality, residence time, and channel geometry result in greatly reduced ability to support life history requirements of native species that utilize or depend on the Delta at different locations and times of year
4. **Minimal and uniform habitat with poor connectivity:** Major loss of natural habitats and reduced diversity and connectivity of remaining habitat types results in greatly reduced capacity to meet life history requirements of native species that utilize or depend on the Delta at different locations and times of year
5. **Poor transit corridor for migratory fish:** Altered flow regimes, diversions, predators, and poor water quality adversely affect juvenile and adult migration success leading to declines in abundance and fitness
6. **Poor water quality:** Exposure to contaminants in the water column and sediments generate lethal and sublethal toxicity effects in fish and wildlife populations and impairments of temperature, salinity, and dissolved oxygen reduce environmental water quality, both leading to declines in abundance and fitness

Problem Drivers

These problems derive from a number of factors:

- Physical habitat loss
- Flow-related habitat loss

- Loss of connectivity and extensive interfaces between different elements of the terrestrial and aquatic environments
- Dominance by aquatic invasive species; competition and predation by invasive species
- Altered flow regimes: reduced Delta inflow, reduced long-term Delta outflow, increased exports within and from the Delta, reversed river flows from through-Delta conveyance
- Altered geometry of Delta waterways in planform and cross section
- Low variability in surface water residence times throughout Delta waterways
- Entrainment
- Contaminant loadings

Relationships between Drivers and Indicators

Strategies and actions to achieve the desired ecosystem characteristics (Sections 4 and 5) are aimed at those underlying drivers of the problems that can be manipulated with direct human intervention, recognizing that some interventions may be difficult to implement.

Table 1. Indicators and Drivers of Poor Ecosystem Function

	Drivers of Poor Ecosystem Function *								
Indicators of Poor Ecosystem Function	Physical habitat loss	Flow-related habitat loss	Connectivity and interface loss	Nuisance Invasives	Altered flow regimes	Altered geometry	Low residence time variability	Entrainment	Contaminant loadings
1) Population decline	✓	✓	✓	✓	✓	✓	✓	✓	✓
2) Impaired primary and secondary production	✓	✓	✓	✓	✓	✓	✓	✓	✓
3) Low variability in the aquatic environment	✓	✓	✓	✓	✓	✓	✓		
4) Minimal and uniform habitats and poor connectivity	✓	✓	✓		✓	✓	✓		
5) Poor transit corridor for migratory fish	✓	✓	✓	✓	✓	✓	✓	✓	✓
6) Poor water quality	✓	✓	✓		✓	✓			

Agents of Ongoing Change

The final piece informing development of strategies and actions are those forces that will drive ongoing change in the Delta, the lower estuary, and the watershed:

- Land use and population growth

- Sea level rise
- Climate change
- Seismicity
- Levee stability
- New invasions of nuisance species

3 Desired Ecosystem Characteristics, Their Indicators, and Performance Targets

This section will be expanded in a subsequent draft to provide explanatory text to help the reader understand how the Ecosystem Work Group arrived at the information presented

We have developed two categories of desired ecosystem characteristics, following the general concept of the restoration recipe presented above: (1) the species and human outcomes and (2) the underlying habitats, processes, and stressor reductions necessary to achieve the species and human outcomes.

Group 1: Characteristics and Indicators: Species and Human Outcomes

In order to have a Delta that highly productive, variable conditions, extensive diverse habitats, good migration corridor, and free of contaminants, the Ecosystem Work Group recommends establishing the following five desired ecosystem characteristics and their associated indicators:

1) Viable populations of native resident fishes and migratory birds

a. Abundance of selected species that represent a diversity of functional groups
b. Geographic distribution

2) Functional corridors for migratory fish species

a. Migration success
b. Connectivity to upstream and downstream habitats
c. Suitable environmental water quality and flow along migratory corridors

3) Ecosystem functions that support human services

a. Flood protection
b. Water quality
c. Recreation
d. Buffers

Group 2: Characteristics and Indicators: Habitats, Processes, and Stressor Reductions

4) Diverse mosaic of habitats and ecosystem processes to support native resident and migratory estuarine species

a. Areal extent of tidal marsh, seasonal floodplain, uplands, and open water
b. Attributes of the target ecosystems: complexes of multiple habitats, spatial distribution of complexes, connectivity within and between complexes, productivity, and durability or resiliency

5) Stressors reduced to below levels of adverse effects

a. Reduced contaminants impacts
b. Reduced or eliminated entrainment
c. Reduced impact of current and possible future nuisance invasive species

Performance Targets for Each Indicator

Table 2 presents the full suite of performance targets for each of the indicators listed above.

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

Desired Ecosystem Characteristics and Their Indicators		Performance targets
1 Viable populations of native resident fishes and migratory birds		
Abundance (population size and partial proxy for genetic diversity)		
	Fish	**delta smelt:** ≥100% 1967-1983 Fall Midwater Trawl index
		longfin smelt: ≥100% 1967-1983 Fall Midwater Trawl index
		splittail: exceed low levels observed during 87-91 drought
	Birds	**Ducks:** ≥1.4 million sustained at peak wintering abundance (CVJV population objective) Delta and Suisun combined
		Shorebirds: ≥70,000 sustained at peak wintering abundance, January through February (CVJV population objective) Delta and Suisun combined
		Aleutian Canada goose: Sustain 50% of the world's population during winter residence
		Tundra swan and white-fronted goose: Sustain 40% of the Pacific Flyway population during winter residence
		Canvasback: Sustain 20% of the Pacific Flyway population during winter residence
		Raptors (Swainson Hawks) & Song Birds
	Plants, Herps, Mammals	***Does the Task Force want targets here or too detailed?***
Distribution (partial proxy for genetic diversity and habitat quality)		
	Fish	**delta smelt:** present in all FMWT sites that occur within the target fall habitat (see below)
		splittail: spawning adults present in all accessible seasonal floodplain habitats
	Birds	***Pending***
	Plants, Herps, Mammals	***Does the Task Force want targets here or too detailed?***

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

Desired Ecosystem Characteristics and Their Indicators	Performance targets
2 Functional corridors for migratory fish species	
Migration success	
Salmon and steelhead	≥95% survival of adult fish migrating through the Delta; ≥50% survival of juvenile fish migrating through the Delta (measured by tagging studies)
Sturgeon	≥95% survival of adult fish migrating through the Delta; ≥50% survival of juvenile fish migrating through the Delta (measured by tagging studies)
Connectivity to upstream and downstream habitats	
Salmon, steelhead, and sturgeon	Zero incidents per year of upstream or downstream passage delay, blockage or mortality blocked by physical barriers
Suitable environmental water quality and flow along migratory corridors	
Salmon, steelhead, and sturgeon	Zero incidents per year of upstream or downstream passage delay, blockage or mortality from low DO, high temperatures, or toxic contamination
San Joaquin salmon	>0 cfs net downstream flow on the San Joaquin River at Jersey Point (i.e., no reverse flow condtions) from October 1 through June 30
Dissolved oxygen	>5 mg/L in all locations at all times
3 Ecosystem functions that support human services	
Flood protection Water quality Recreation Buffers	***Pending***

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

Desired Ecosystem Characteristics and Their Indicators	Performance targets
4 Diverse mosaic of habitats and associated ecosystem processes to support native resident and migratory estuarine species	
A) Areal extent of tidal marsh, seasonal floodplain, uplands, and open water	
Tidal wetlands (on lands within tide range and <~5ft subsided; intertidal elevations currently being updated by DWR)	**Long-term (>30yr):** all suitable lands (80,000 acres Delta, 50,000 acres Suisun) **Short-term (<30yr):** half of all suitable lands (40,000 acres Delta, 25,000 acres Suisun) **Interval targets at 10 and 20 years:** 1/3 and 2/3 of short-term target
Floodplains (need to evaluate land elevations and river stages to improve opportunity area understanding)	> 50,000 acres with variable inundation conditions to support resident and migratory fish and migratory shorebirds and waterfowl and including annual vegetation (e.g., ongoing agricultural) and riparian forested lands
Terrestrial grasslands/seasonal wetland complexes/sea level rise accommodation (upper elevations not yet confirmed)	**Long-term (>30yr):** all suitable lands (~130,000 acres Delta, 5,000 acres Suisun) **Short-term (<30yr):** half of all suitable lands (~65,000 acres Delta, 2,000 acres Suisun) **Interval targets at 10 and 20 years:** lower-elevation lands, lands at high risk of urbanization, corridor between Suisun Marsh and Cache Slough
Open Water	**Delta smelt fall habitat:** Provide 14,000 hectares (quantity existing prior to the declines beginning in 1984) of fall open water habitat with salinities no greater than 10mS/cm **Delta smelt spring and summer habitat:** temperature within spawning range **Longfin smelt habitats:** pending
B) Attributes of the target ecosystems: value of restored ecosystems proportional to number of these attributes achieved; *we can probably improve the quantitative descriptions of these attributes*	
1) Complexes of multiple habitats	**Multiple large complexes of connected habitats** spanning the aquatic to terrestrial gradient in space and aquatic habitats in time
	Long interfaces (e.g., >500m) between uplands and tidal wetlands, tidal wetlands and open water
	Dendritic systems of large waterways that allow for in-channel geomorphic adjustment and are connected to adjacent tidal marshes and floodplains

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

Desired Ecosystem Characteristics and Their Indicators	Performance targets
	Direct organism and material transport between terrestrial grassland/seasonal wetland complexes, adjacent tidal wetlands and/or seasonal floodplains, and open water
2) Spatial distribution of habitat complexes	**Distributed along multiple locations** of gradients of salinity, riverine vs. tidal inundation, sediment supply
	Located in areas that **support populations of target species**
	Located in areas **not subject to adverse effects of stressors**
3) Connectivity within and between complexes	**Waterways linking patches** of tidal wetlands, seasonal floodplains, and open water with flow velocities and net direction allowing aquatic organisms freedom of movement within their physiological tolerances and production to be transported from source areas to target organisms
	Wetlands and uplands corridors that allow terrestrial species to move between patches of habitats
4) Productivity	**Pelagic food web:** predominantly diatom based **Wetlands:** predominantly native species vascular plant and diatom based **Floodplains:** *Pending from Jeff Opperman* **Upland/seasonal wetland complexes:** densities of small mammals, invertebrates, herps at levels found in similar systems locally (e.g., Jepson Prairie)
5) Durability/Resilience	All restored habitats **located in places not subject to natural or anthropogenic loss or degradation over time**, eg climate change, urbanization

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Table 2
Performance Targets for Desired Ecosystem Characteristics and Their Indicators

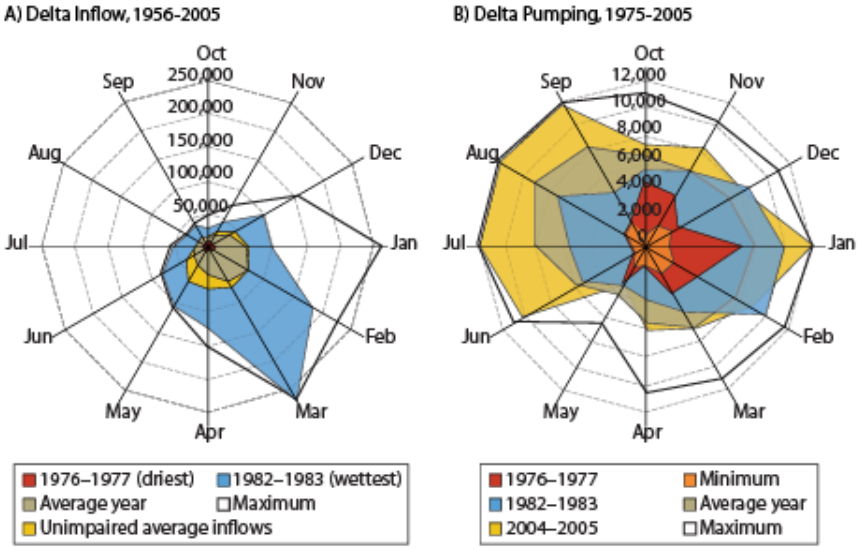
Desired Ecosystem Characteristics and Their Indicators		Performance targets
5 Stressors reduced to below levels of adverse effects on native resident and migratory species and their habitats		
	Reduced contaminant impacts	
	Concentrations in Delta waters and/or sentinel organisms (details to be worked out)	Ammonia: <0.01 mg/L unionized ammonia in all Delta waters
		Herbicides:
		Pesticides:
		PCBs:
		PAHs:
		Copper:
		Selenium (potentially as measured in sturgeon)
		Mercury (potentially as measured in inland silversides)
	Nitrogen:Phosphorus ratio	Restore nutrient loadings to N:P ratios supportive of diatoms
	Reduced or eliminated entrainment	
	Delta smelt, longfin smelt	Entrainment proportional to preceding FMWT adults and juveiles separately - see DWSG notes for numbers
		Entrainment of pre-spawning females least in Jan-Feb - half of DSWG for numbers, double in March-April
	Salmonids	Entrainment no more than 2% of outmigrating population
	Productivity	***Pending***
	Reduced impact of current and possible future nuisance invasive species	
	Corbula	<100% of 1995-2000 average abundance and distribution
	Corbicula	***Pending***
	Egeria	<50% average 1990-2000 abundance and distribution
	Control future invasions	No new introductions from ballast waters No new introductions from commercial and recreational vessels No new introductions from other accidental or intentional releases

4 The Complex Delta: Opportunities and Constraints

The complexity of the Delta defines the opportunities and constraints within which we must develop restoration strategies and actions. Inadequate knowledge, unpredictability, lack of control, uncertainty, and tightly coupled human-natural systems undermine our abilities to develop effective approaches. Ecological improvements will necessitate finding mutual human-ecological interests, accepting some trade offs, and working with complexity.

Flow

Restoring flows for the Delta ecosystem can be accomplished in numerous ways and developing and evaluating options is an active pursuit of other Delta planning efforts. Critical to defining how to restore flows is to understand the timing of needed flows to accomplish its many purposes. Native species evolved under natural Mediterranean climate conditions – winter wet, summer dry. We regulate inflows via dam operations and upstream diversions (Figure 3A). We export throughout the year at varying magnitudes (Figure 3B), a setting relatively disconnected from natural conditions.



Seasonal and Annual Variability of (A) Delta Inflows and (B) Delta Pumping, from DWR DAYFLOW DATA. Note scale difference in flow rates between the two diagrams. *From PPIC 2007*

Figure 3. Delta Inflow and Pumping, Seasonal and Annual Variability

The Narrow Elevation Band of Intertidal Marshes, Tide Ranges, and Land Elevations

Tidal marsh exists within a narrow elevation band associated with the local tidal range (Figure 4). Tidal freshwater marsh vegetation grows at most intertidal elevations; Suisun's tidal brackish marsh

vegetation grows across a narrower range of intertidal elevations; and the lower estuary's tidal salt marshes grow in the narrowest upper intertidal elevations.

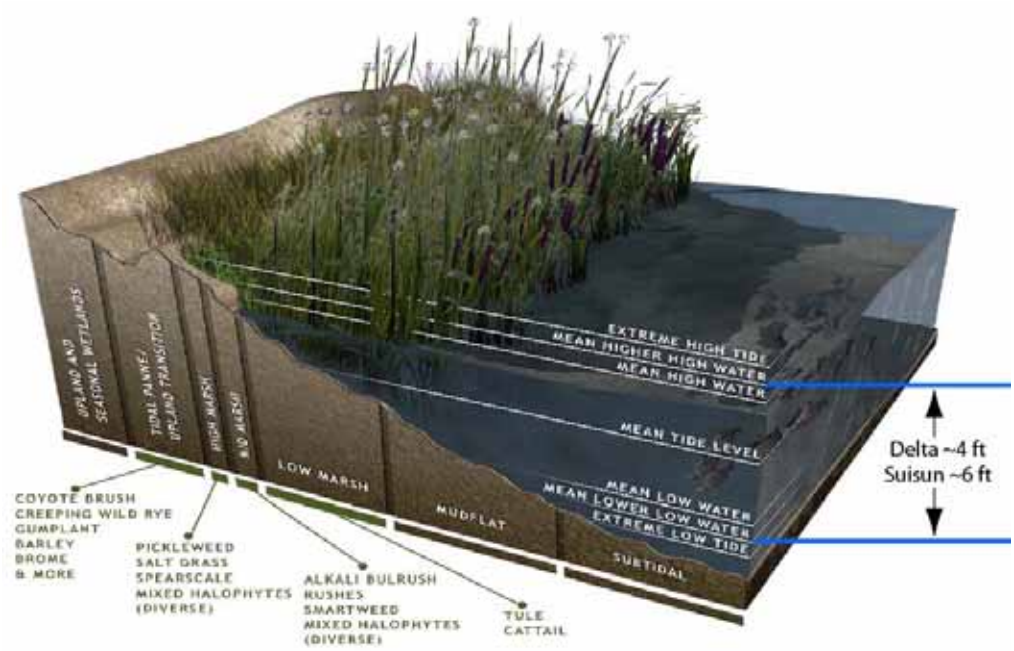
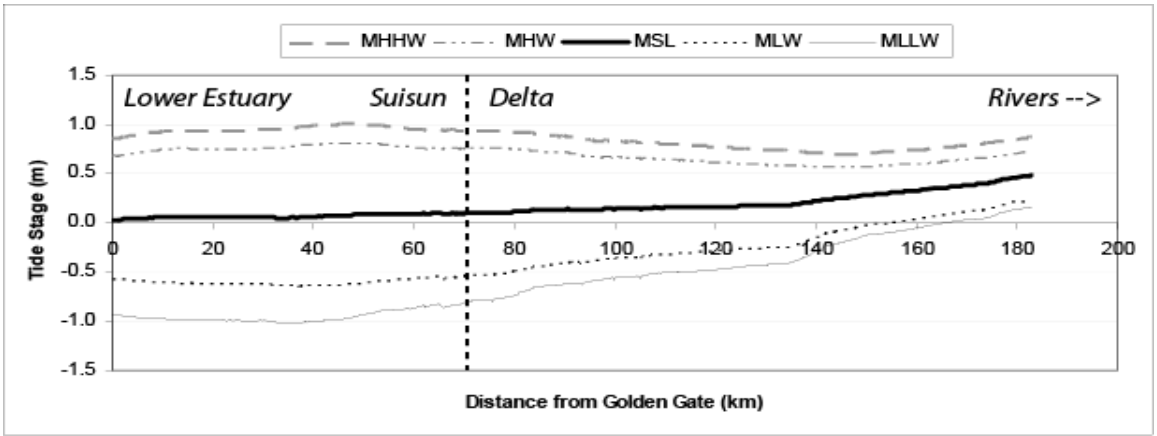


Figure 4. Tidal Marsh Profile with Adjacent Uplands and Open Water
Moffatt & Nichol and Stuart Siegel, 2007

The vertical range of the tides is not large – much of the Delta experiences tidal variations of around four feet; Suisun tides are closer to six feet. Not only does tide range decrease moving up the estuary to the rivers, the base height or mean sea level also rises because of the river inflows. Consequently, the actual elevations that are "intertidal" vary around the Delta and establishing the relationship between the land and water requires more than a simple analysis and to date has not been accomplished though DWR has efforts underway to provide these data.

Within the ~500,000-acre Delta, there are about 58,000 acres of undeveloped, diked lands at intertidal elevations of which about 3,000 acres are at moderate to high risk of development (Figure 6). Suisun has about 28,000 acres at suitable intertidal elevations. Where sediment supply is higher such as the North Delta and parts of Suisun Marsh, sedimentation can raise land elevations; thus, lands that have very shallow subtidal elevations may be suitable for tidal marsh restoration as well. Suisun has another ~23,000 acres of shallow subtidal lands and the Delta about 25,000 acres. ***Areas will be updated with new data pending from DWR.***



San Francisco Estuary-California Delta Tidal Datum Profile (modeled). *From DWR 2004*

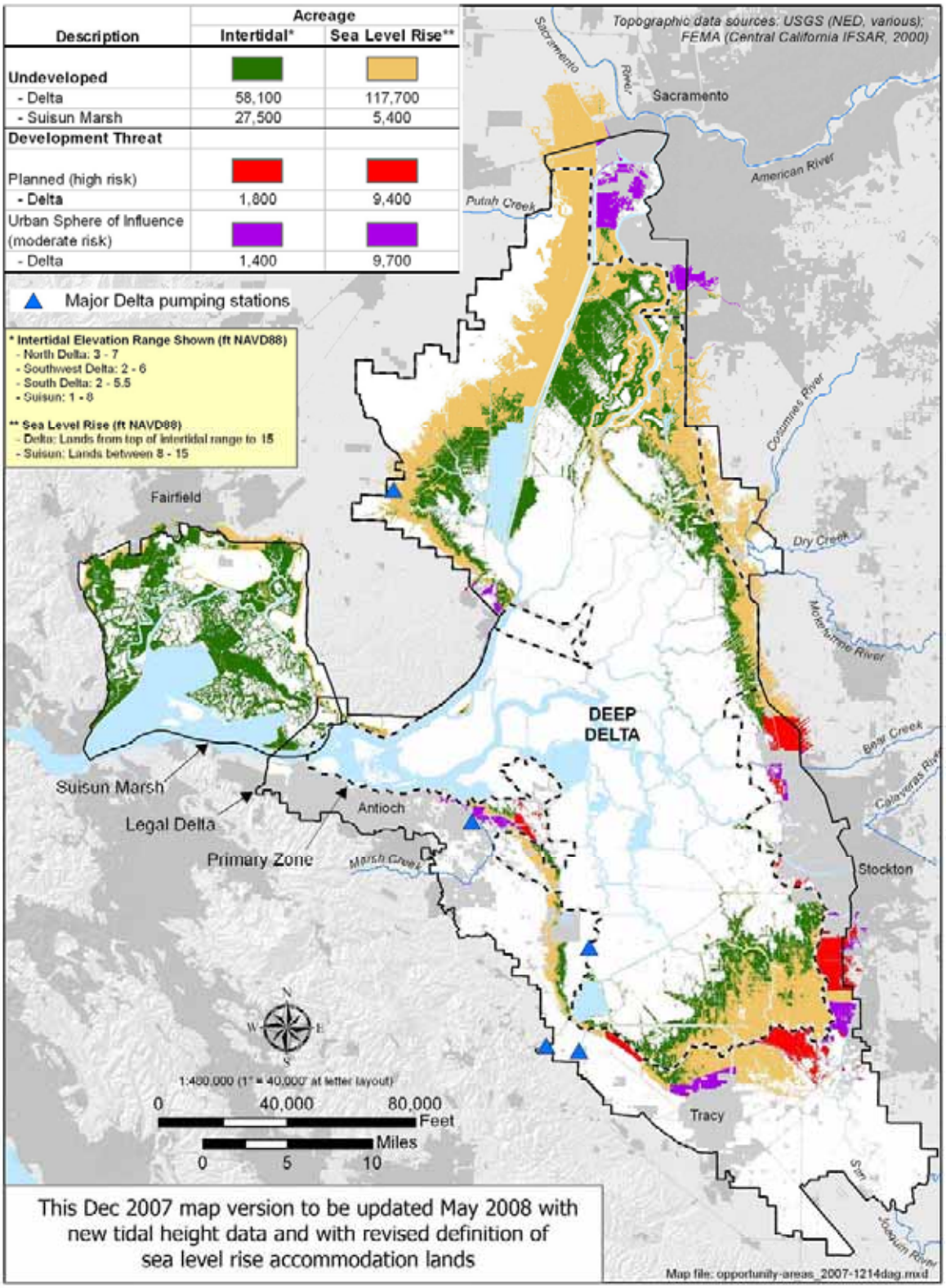
Figure 5. San Francisco Estuary Tidal Datum Profile (modeled)

Floodplains and Lowland Grasslands

About 118,000 acres in the Delta are undeveloped lowlands extending above current high tide heights to the +15 ft elevation; Suisun Marsh has about 5,000 acres. These lands could be used for accommodating sea level rise, floodplain restoration where land elevations and river stage can be reconnected effectively (large tracts already are actively managed floodplains: Yolo and Cosumnes), and habitats for wildlife species that utilize landscape mosaics of estuarine and grassland areas. Floodplains can and do extent further upstream than this somewhat arbitrary elevation indicates. About 19,000 acres are at moderate to high risk of development in the Delta. Were a higher sea level rise accommodation elevation used, then there would be more land acreage of this type.

Geometry

Humans have constructed numerous "connecting" waterways throughout the Delta for shipping and water supply conveyance (Figure 7). Connecting what were naturally disconnected waterways that produced significant heterogeneity in the aquatic environment has radically altered flow geometry and homogenized the aquatic environment, changing flow routes and residence time that affects fish, their food resources, and water quality. Native species evolved under natural heterogeneous conditions and likely a cause of their decline is the modern homogeneity of the Delta's remaining aquatic environments. The current water surface area of the Delta is about 57,000 acres (excluding Liberty Island and Little Holland Tract which add another 6,000 acres), much of which could be enhanced to provide improved open water habitats for aquatic species. Suisun has about 26,000 acres of open water.



Description	Acreage: Intertidal*	Acreage: Sea Level Rise**
Undeveloped		
- Delta	58,100	117,700
- Suisun Marsh	27,500	5,400
Development Threat		
Planned (high risk)		
- Delta	1,800	9,400
Urban Sphere of Influence (moderate risk)		
- Delta	1,400	9,700

Figure 6. Intertidal and Low-Lying Uplands Elevations in the Delta and Suisun

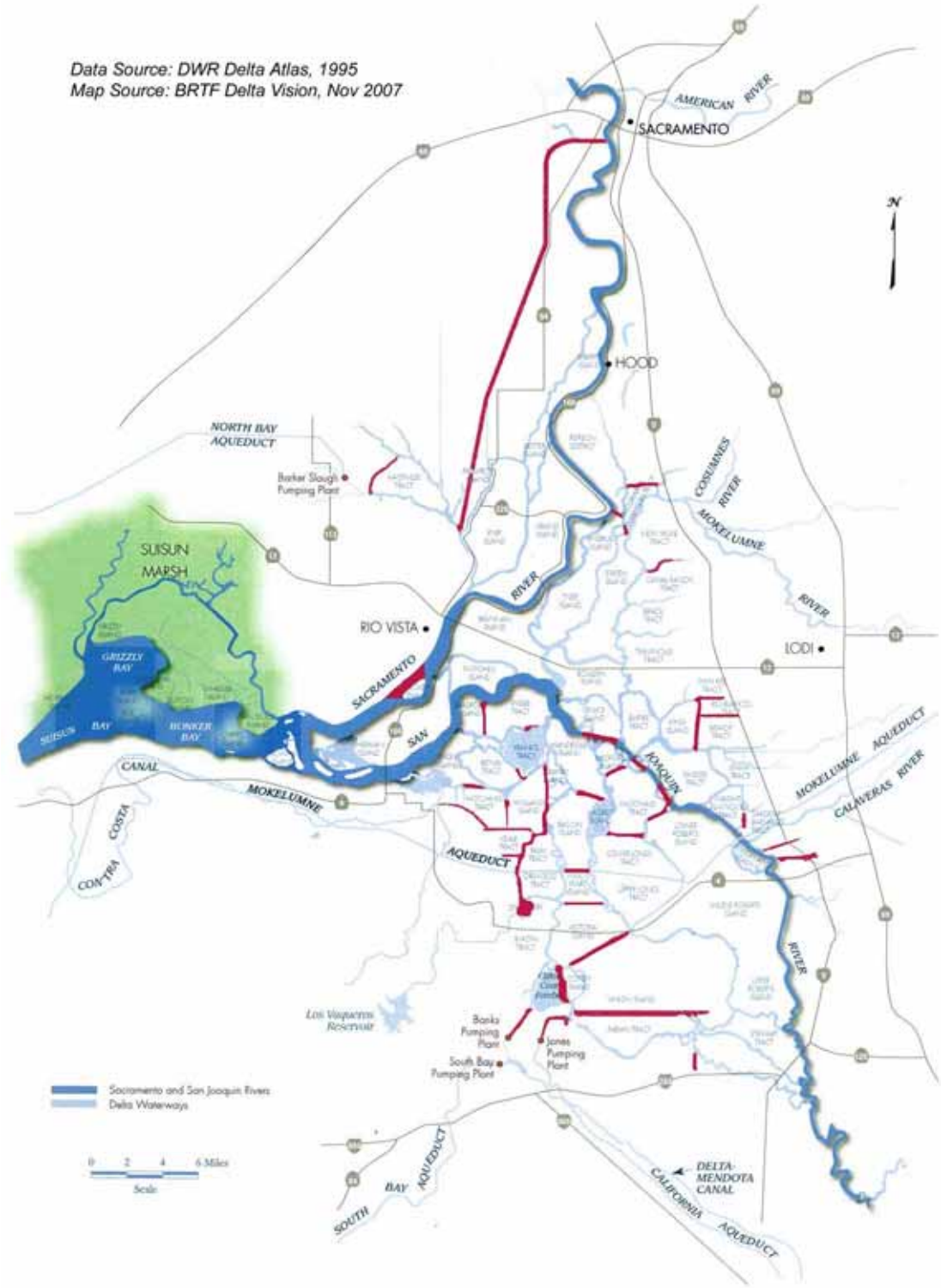


Figure 7. Constructed Delta Waterways

5 Strategies to Achieve Targets

This section to be written. Refer to Figure 1

Concepts Guiding Ecosystem Recovery Strategies

1) Restoration recipe
2) Healey principles of estuaries
3) Fifteen Delta Vision elements of a resilient, regenerated ecosystem
4) Conceptual models
5) Anticipating future agents of change

Strategies

6 Actions to Implement Strategies

This section to be written. Refer to Figure 1

This section will describe what actions will be necessary to implement the strategies identified in Section 4. At the level of the Strategic Plan, these actions will be more broad categories, such as land/easement acquisition, development of specific Delta Ecosystem Restoration Plan, coordinated modifications to through-Delta conveyance to benefit the ecosystem, undertaking site-specific - engineering design and permitting to move near-term actions to implementation, establishing reliable long-term funding stream, formulation of comprehensive Adaptive Management Plan that links science with management, and coordination with efforts on governance as it relates to long-term implementation of Delta ecosystem recovery efforts.

7 Evaluating Effectiveness of Identified Strategies

This section to be written.

This section will describe approaches to measuring the effectiveness of strategies to resolve the drivers of poor ecosystem function and achieve the desired ecosystem characteristics.