The Changing Tides of the Delta

A Species Specific Restoration Plan for the McCormack-Williamson Tract

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Senior Thesis

Ashley Lemay - June 12th, 2014

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Abstract

The entire Sacramento-San Joaquin Delta has been severely altered from its historic state. Large levees have been constructed adjacent to the water edge, disconnecting the river from its floodplain while isolating plant and animal communities. Additionally, the historic tule marsh wetlands within the levee borders have been drained in order to create suitable land for agriculture. Agricultural land has very little habitat value so the Delta system was further degraded. Although the Delta can never be restored to its historic conditions, alterations can be made to maintain and preserve the ecological integrity of the Delta. The McCormack-Williamson site provides a unique opportunity for riparian flood control and restoration. Suitable habitat will be designed through the examination of several key indicator species. If the needs of these species are meet, other species will benefit from the created habitat as well.

Acknowledgments

Steve Greco: For your dedication to teach me how to apply GIS to my design and for spending extra hours with me, outside of our meeting times, to assist me in GIS and to explain concepts I did not fully understand.

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Bill Fleenor: For applying hydraulic modeling software to my design to see how it would be actually influenced by tidal action.

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Figure 0.1: Croplands have Replaced Historic Wetlands

"The delta is essentially a "man-made" landscape. Few rural regions have been so altered from the natural state as this sacramento-san joaquin delta, the cultural imprint takes several forms, depressed crop land has replaced the sea-level tule swamp of the pre-reclamation era. Natural hummocks and natural levees are planned to flatten island floors. The major landmarks in the delta are the massive earthworks that cloak the natural levees. Channels have been altered and even created by dredging. The delta soils are essentially man made; they could not have evolved without draining the tules. Neither would the incidence of mineral soil be what it is without mining debris and peat subsidence. The atmosphere, too, occasionally clouds up with evidence of man's impact upon the area; not only are we consuming the peat, but in draining the swamps we have interrupted the processes by which the very wealth of the dealt was created. While this may sound bleak, I am confident that any society that could produce a Sacramento-San Joaquin Delta is going to devise means to conserve it" (Thompson, 58).

Introduction

The Sacramento-San Joaquin River delta plays a vital role in water delivery and ecosystem services. It is home to hundreds of different species and over 65% of Californians receive a portion of their water from the delta. However, the state of the delta is in a steep decline, endangering its ability to purvey water and support its ecosystem services.

The delta was once a vast floodplain which provided prime habitat for a variety of species. However, due to human intervention, the Delta is now a highly altered environment with levees, reservoirs and other infrastructure. Much of the land has been reclaimed by filling in parts of floodplains and river channels to create agricultural lands from the fertile soil at the expense of destroying prime habitat. As time goes on, the land is subsiding, resulting in huge economic consequences since flooding is prevalent in the region.

The ecosystem services and natural resources of the delta are not being managed in a sustainable manner. As humans increasingly influence the delta and disrupt the delta's natural balance, the quality of habitat and hydraulic regimes are interrupted and exponentially decline, degrading the ecosystem.

Figure 0.2: Agricultural Fields at McCormack-Williamson

Context

The McCormack-Williamson Tract is located in the north-eastern part of the Sacranento-San Joaquin Delta near the intersection of the Cosumnes and Mokelumne Rivers. The Mokelumne River borders the eastern levee while Snodgrass Slough neighbors the western levee.

Nearby towns include Walnut Grove and Locke.

It provides a unique restoration opportunity as it is situated between two large, existing restoration projects – Staten Island and the Cosumnes River Preserve. There are existing plans to regraded a portion of the levees to increase the levee strength and stability as well as removing the southernmost levee to allow for tidal inundation and the creation of marshes and wetlands.

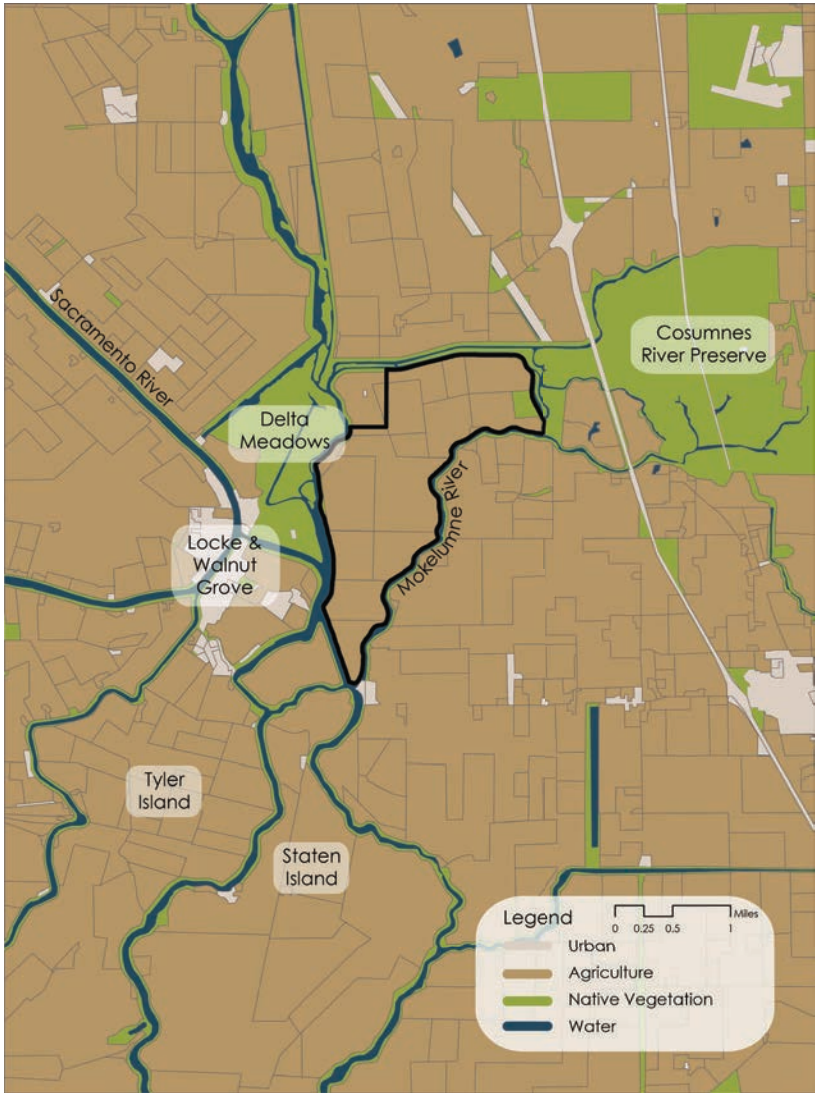

Figure 0.3: Context Map

Figure 0.4: Nearby Wimpy's Marina

History

Figure 1.0: Old Tractor On Site


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Ecology

The North Delta historically consisted of flood basins with broad zones of non-tidal and tidal freshwater emergent wetlands of continuous, dense stands of tule. Perennial ponds and lakes existed behind natural levees or at the edges of upland habitat. Riparian forests bordered major channels or seasonal wetlands at the upland edges. Large natural levees and broad zones without channels were seasonally isolated from the tides and depended on the sediment-laden flood flows in the wet season.

Historically there were over 200,000 acres of freshwater emergent wetlands that were strongly influenced by the tides. Tidal areas had an increase in channel density and sinuosity but less than what would naturally be found in saline marshes. During flood events, the natural levees would overtop and whole islands would be inundated. The dominant species of the tidal wetland area consisted of willows, grasses, ferns, and tule (Ecosystem Restoration Program, 2014).

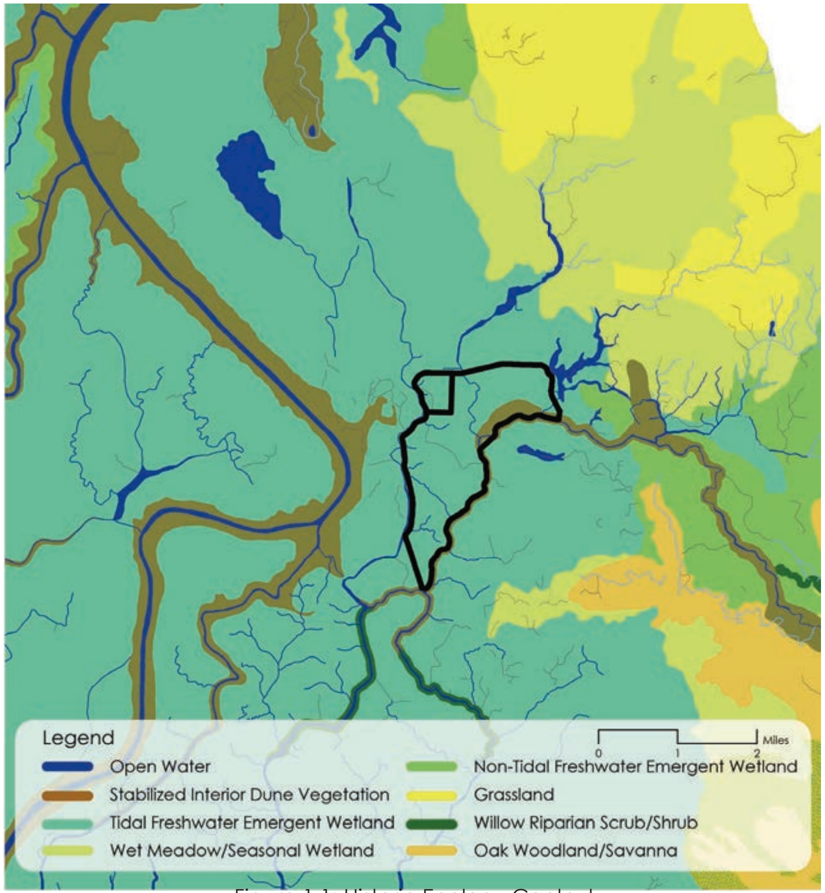


Figure 1.1: Historic Ecology Context

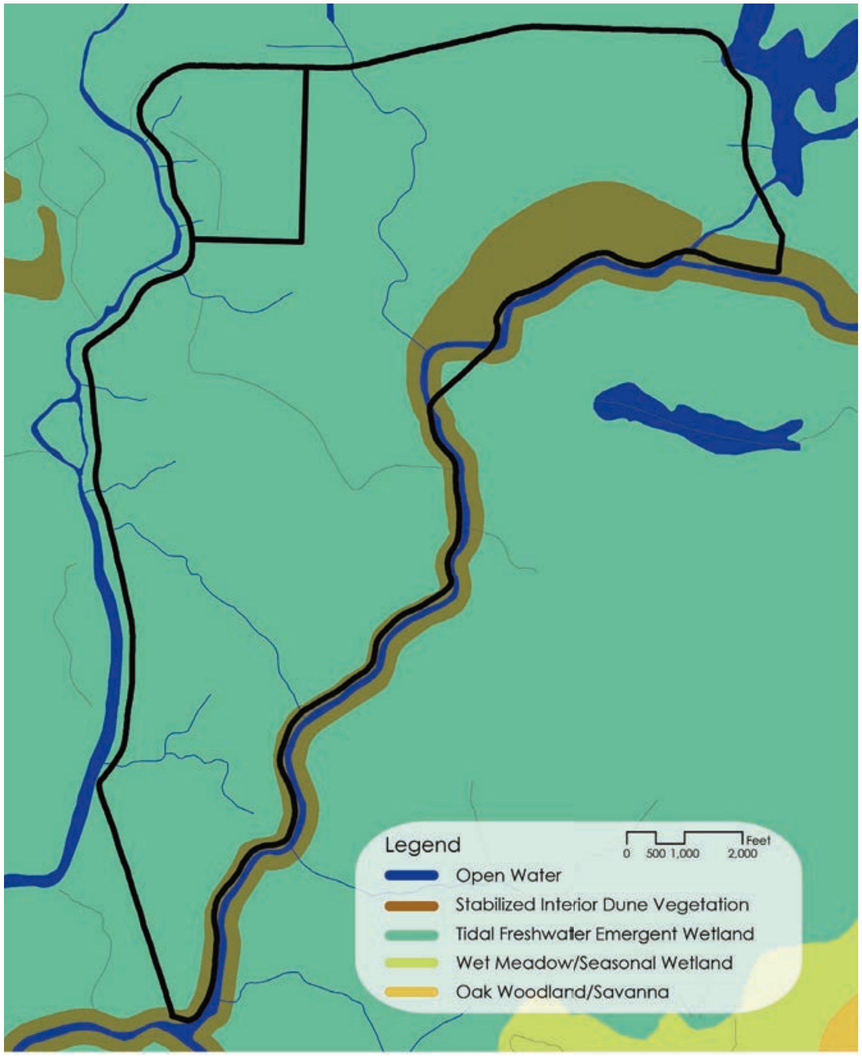


Figure 1.2: Historic Ecology on MWT

This historic delta was unusual compared to other delta systems due to its high amount of organic peat. Usually deltas are created through the deposition of rock particles but in the Sacramento-San Joaquin Delta, plants and rocks both contributed to the creation of the system. Historically the peat was about 50-60' thick in the western portions of the delta and thinned out towards the north, east, and south. The rich peat soil and ample water supply made the Sacramento-San Joaquin Delta the prime location for agriculture as settlement in the west expanded (Thompson).

After the Gold Rush, people began to settle around the natural levees because of the immense amount of trees growing on them for timber, the reliable water supply, easy trade routes through the channels, and good soil. The tules marshes were used as grazing lands.

"By 1857, the Sacramento River east bank settlers had established a continuous corridor of farms from Sacramento to opposite Rio Vista" (Thompson, 52).

About every one or two years in the 1850's, high water threatened crops and land on higher elevations and protection by natural levees was preferred.

Figure 1.3: Farmer examining flooded land

By 1852, settlers began forming levees to protect their lands and were first common near the Mokelumne and Calaveras rivers on Grand, Tyler, and Merrit Islands. The State Board of Reclamation Commissioners formed districts and boards of supervisors which began the strong movement towards levee building. In the late 1860's, land developers and settlers began reclaiming land for farming operations. The artificial levees built the natural levees up in elevation by 3-17', 12-100' at the base, and 4-20' at the top of the levees. Hand labor and horse-drawn scrapers were mainly used to move the land until steam dredgers and ditchers were invented.

Delta farmers now had a competitive edge over San Francisco agriculture because the soils were richer, irrigation was rarely needed, transportation was cheap, and the crops ripened early. Orchards of peaches, plums, apples, and pears were extremely prosperous near the Sacramento River. However as floods persisted, pears endured the environmental conditions better so pears began to dominate the North Delta.

For every acre of land that was reclaimed, there was an acre less of floodplain. Debris from the gold mining era began to accumulate and fill the channels. Flooding potential was also increased since the levees were built directly on the water's edge instead of being setback. The race of who could build the higher levees began. However, seepage and high water tables still affected the crops in the delta. The peat soils began to dehydrate and oxidize causing a reduction in volume of 1/3 to 1/2, which amplified the issue.

> "...of the 300,000 acres of land more or less permanently reclaimed between 1870 and 1910,... recurring levee breaks and seepage problems have required three or more post-reclamation drainings for each tract" (Thompson, 56).

When the levees where constructed, most of the tracts had less than 5' difference in elevation between the water and the flattened portion of the tract. However, now subsidence of the peat soils has caused some tracts to lower 10-25' below sea level. This large difference between water level and surface level is causing the tracts to be more susceptible to flooding since they levees have to now withstand increased water pressures than they were originally designed for. Since the 1930's, there have been over 35 levee failures due to overtopping, seepage, or instability. As the tracts continue to subside, levee repair and maintenance will become more expensive and crucial to protect the agricultural lands.

Some studies indicate that subsidence can be stopped or actually reversed by permanently flooding the peat soils since flooding the peat would create anaerobic conditions. Without exposure to oxygen, mircoorganisms are not able to decompose the peat which can delay subsidence considerably and allow for sediment to reaccumulate onto the islands.

Flooding of Delta islands and allowing them to be tidally influenced can improve water quality, wildlife habitat, and recreational uses while decreasing the need for levee maintenance and repairs (Subsidence in the Sacramento-San Joaquin Delta).

Flooding at McCormack-Williamson

Historic inundation of MWT:

1938, 1950, 1955, 1958, 1964, 1986, 1997

During the '86 and '97 floods, then north eastern levee was breached, flooded the tract, and flowed to the southern part of the tract which is lower in elevation. The 1997 flood is estimated to be greater than the 100 year flood event. The height of the water at the New Hope Landing was 13.7' NGVD. During the 1998 flood, the water rose to an elevation of 9' NGVD at New Hope Landing, which is estimated to represent a 10 year event (Katzev et all).

Figure 1.4: North-Eastern Levee Break at MWT

Historically, riparian habitat extended for miles along the floodplains. However, human modification due to the construction of levees, dams, water diversions and land acquisition has altered the natural hydrology and ecological processes of river ecosystems. These changes have altered the ecology of the river channels and floodplains to such a degree that many characteristic riparian species reproduce only on rare occasions. In addition, the structure of the vegetation has changed thereby eliminated habitat for many wildlife species, and allowing many non-native invasive species of plants to dominate the floodplain (Physical River Processes).

Figure 1.5: MWT Completely Inundated

Timeline of Important Events

1849: Settlers arrived in the Delta to farm its nutrient rich soils

1861: The Reclamation District Act passed, allowing for the construction of sturdier levees and draining of Delta Islands

1869: The first levees are constructed at Sherman Island

1880: Levees are built quickly and most of the delta is reclaimed through dredging techniques.

1902: The Reclamation Act is passed by Congress for the development of irrigated lands in the U.S.

1911: The Reclamation Board is formed to create a flood control plan.

1919: The McCormack-Williamson tract is reclaimed with low levees

1930: All but some small areas in the Delta have been leveed and farmed

1947: New Hope and MWT agreement that MWT levees will be lower

1973: Senate Bill 541 is passed, allowing states to assist in the maintenance and improvement of delta levees.

1983: The MWT signed a 50 year land lease with KCRA for their tower. This lease will expire in 2033.

1992: The Delta Protection Act is passed and the Delta Protection Commission is formed to create a resource management plan. A Bay Delta Oversight Committee is formed for long-term Delta planning.

1993: Management actions are put into place to control pulse flows and limit certain flows to improve conditions for Delta Smelt and Winter-Run Chinook Salmon.

1999 - The Nature Conservancy obtained $5.6 million to purchase the MWT

(Delta Atlas, 1995).

Site Analysis & Inventory

Figure 2.0: Agricultural Fields on McCormack-Williamson

Land Use & Site Context

The MWT is almost one mile from I-5 with the only one existing access point at the north-eastern portion of the tract. However, this is not a public access road so currently only the owners of the tract can access the site.

Historically, the McCormack-Williamson Tract was primarily used for pear orchards. Now, the majority of the tract's land use is still for agriculture as seen in Figure 2.1.

The North-Western corner of the site contains a radio tower that is being leased by KCRA. This 50 year lease started in 1983 and will end in 2033. Since this tower must be protected until 2033, the tower will be a constraint in the design.

The McCormack-Williamson tract provides a unique restoration opportunity since it is the one of the last remaining pieces of the puzzle to create an ecological corridor, connecting the Cosumnes River Preserve to the Delta Meadows and Staten Island.

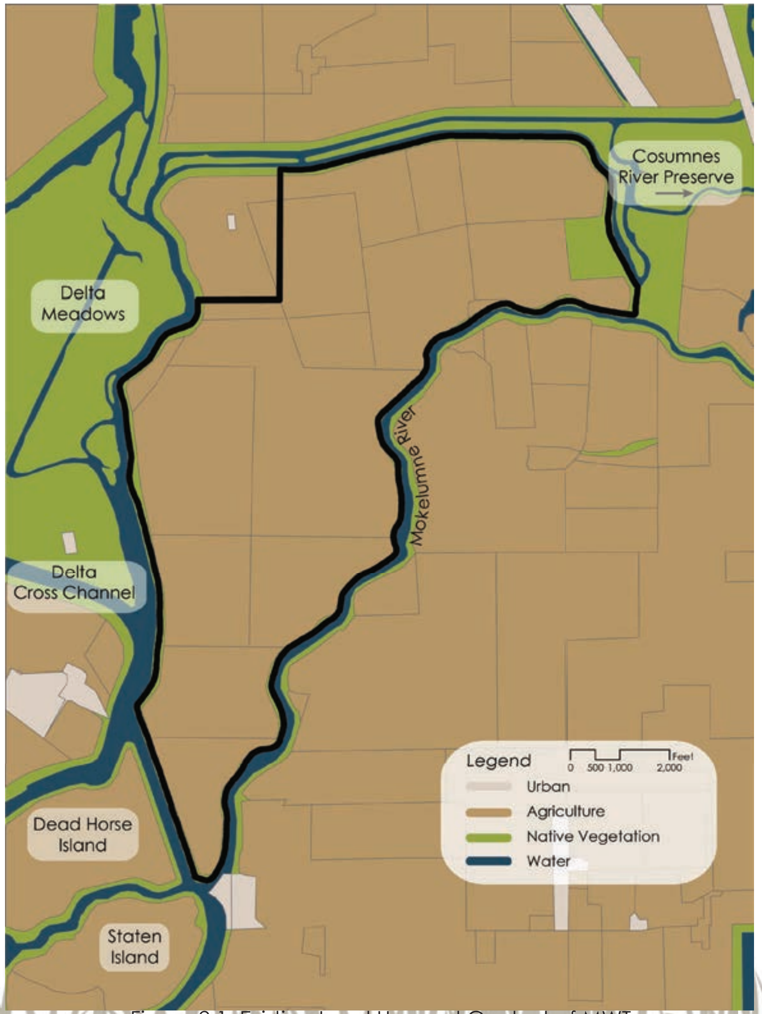


Figure 2.1: Existing Land Use and Context of MWT

Elevations & Levees

Elevations:

The Mccormack-Williamson tract spans about 4.5km, almost 3 miles, from North to South and only changes 6' in elevation in the base of the tract. Therefore the tract is very flat with a slope of about 0.04%. The levees surrounding the McCormack-Williamson tract average 18' in elevation but go up to 24' in some areas.

Subsidence:

Although the Sacramento-San Joaquin Delta system suffers immensely from land subsidence, the subsidence at the McCormack-Williamson tractis minimal, relatively speaking in the delta, which provides the opportunity for restoration.. The western portion of the tract has subsided 1'-2' while the eastern portion has subsided 0'-1'.

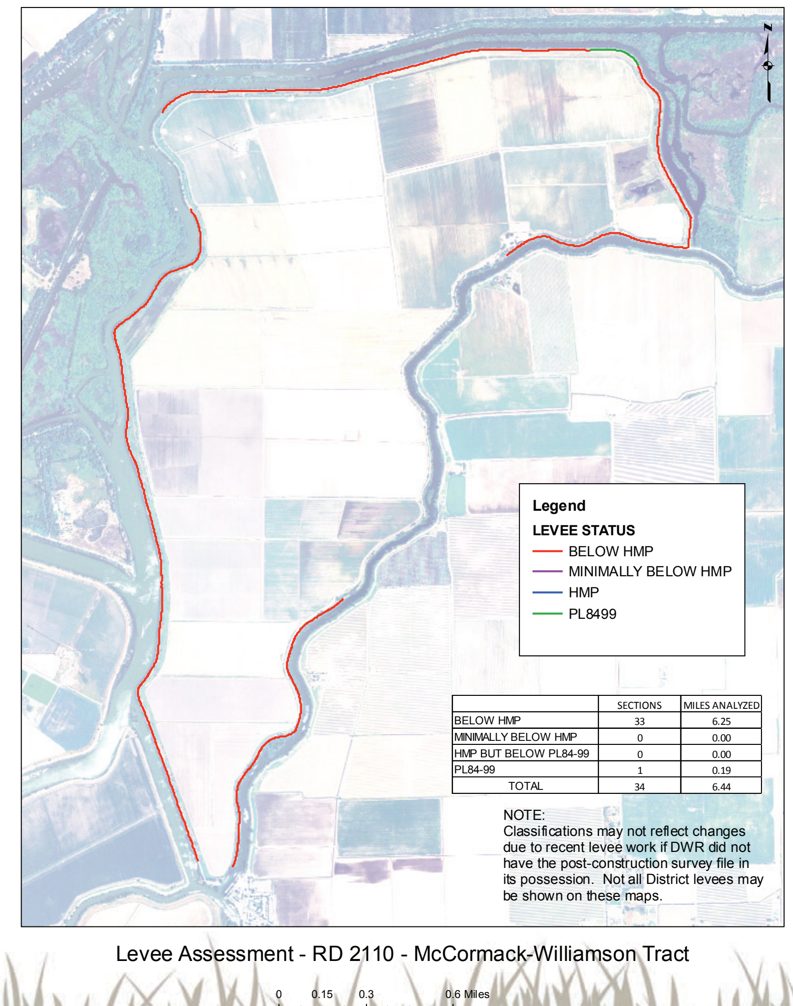
Figure 2.2: Existing DEM of MWT

Figure 2.3: Subsidence at MWT

Levees must meet minimal acceptable standards to remain eligible for federal rehabilitation assistance through USACE Rehabilitation and inspection program PL84-99. This program states that levees must be raised 6" over the basic State Hazard Mitigation Plan standards and interior slopes must be reduced to increase stability and resist seepage and erosion. The McCormack-Williamson tract is currently in the process of resloping its interior levees to a 5:1 slope to create habitat friendly levees as well as comply to the PL 84-99 standards. If the costs of upgrades and repairs exceed the economic benefits, upgrades and repairs are unlikely and conversion to flood control and restoration is increased.

The maps constructed by DWR indicate the estimated miles conforming to the levee standards. Figure 2.5 portrays the percentage of compliance with FEMA's Hazard Mitigation Plan (HMP). Figure 2.6 portrays the percentage of compliance with the Army Corps PL 84-99 standard.

(Delta Maps - Delta Levee Condition Maps)



	SECTIONS	MILES ANALYZED
BELOW HMP	33	6.25
MINIMALLY BELOW HMP	0	0.00
HMP BUT BELOW PL84-99	0	0.00
PL84-99	1	0.19
TOTAL	34	6.44

Figure 2.4: Levee Assessment of MWT

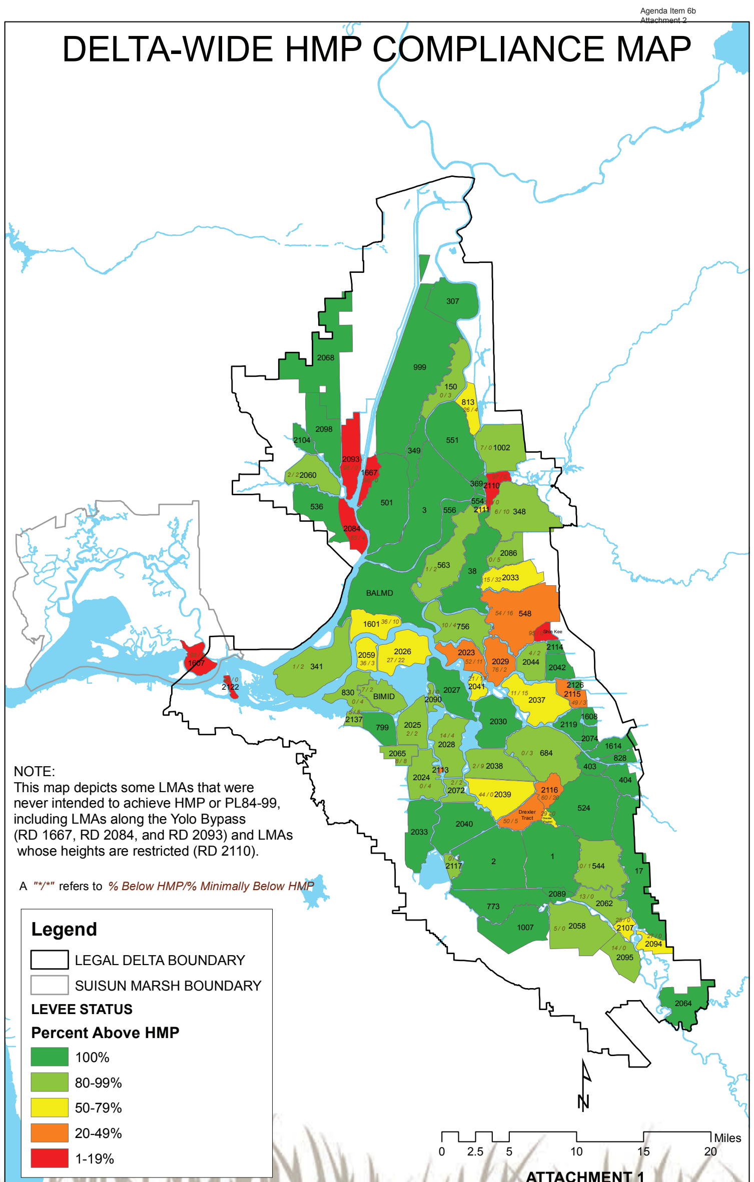


Figure 2.5: Delta Levee Compliance with HMP

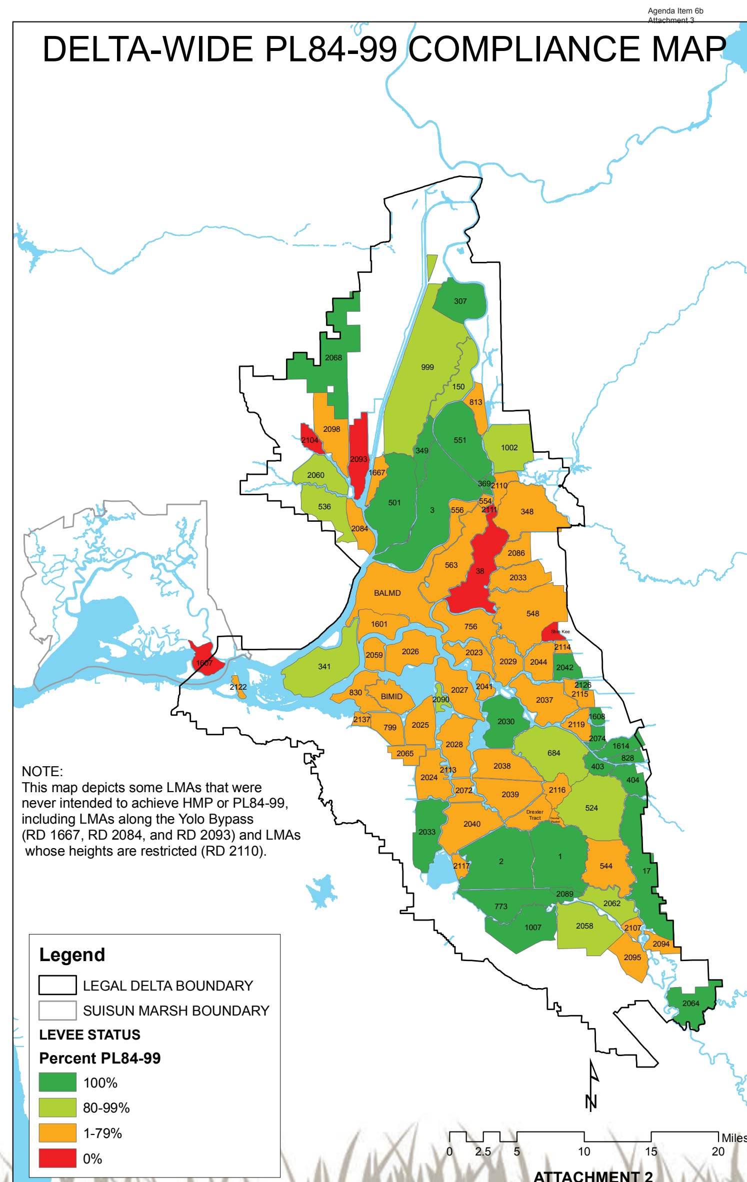


Figure 2.6: Delta Levee Compliance with PL84-89

Existing Vegetation Zones

A study was conducted by the Department of Fish and Game to locate existing habitat on the McCormack-Williamson tract as well as note any animal species that were sited. A total of 43 acres of levee-associated habitat and 26,400' of Shaded Riverine Aquatic habitat were recorded. The main habitat type found along the levees was Shrub-Scrub (24 acres) which mainly consists of willows and wild roses. The second most common habitat type recorded was Riparian Forest (19 acres), which mainly consists of cottonwoods, willows, and valley oaks. Riparian forest was located mainly along the southern and northern sections of the waterside levees (Department of Fish and Game).

Habitat Type	Length	Square Feet	Acres
Freshwater Marsh	0	0.0	0.0
Scrub Shrub	47909.0	1045224.9	24.0
Riparian Forest	21028.0	827140.7	19.0
Shaded Riverine Aquatic	26400.0	*	*
Total	95337.0	1872365.6	43

* SRA is inventoried in linear feet only

Table 2.1: Levee Habitat Assessment of MWT

Issues with Current Conditions

Levees:

Levees disconnect the river from its floodplain, creating isolation of plant and animal communities and ecological degradation.

Land-Leveling for Agriculture:

The land in the Sacramento Delta has been leveled. When levees fail, there are catastrophic effects because the natural drainage has been altered.

Conversion to Agriculture:

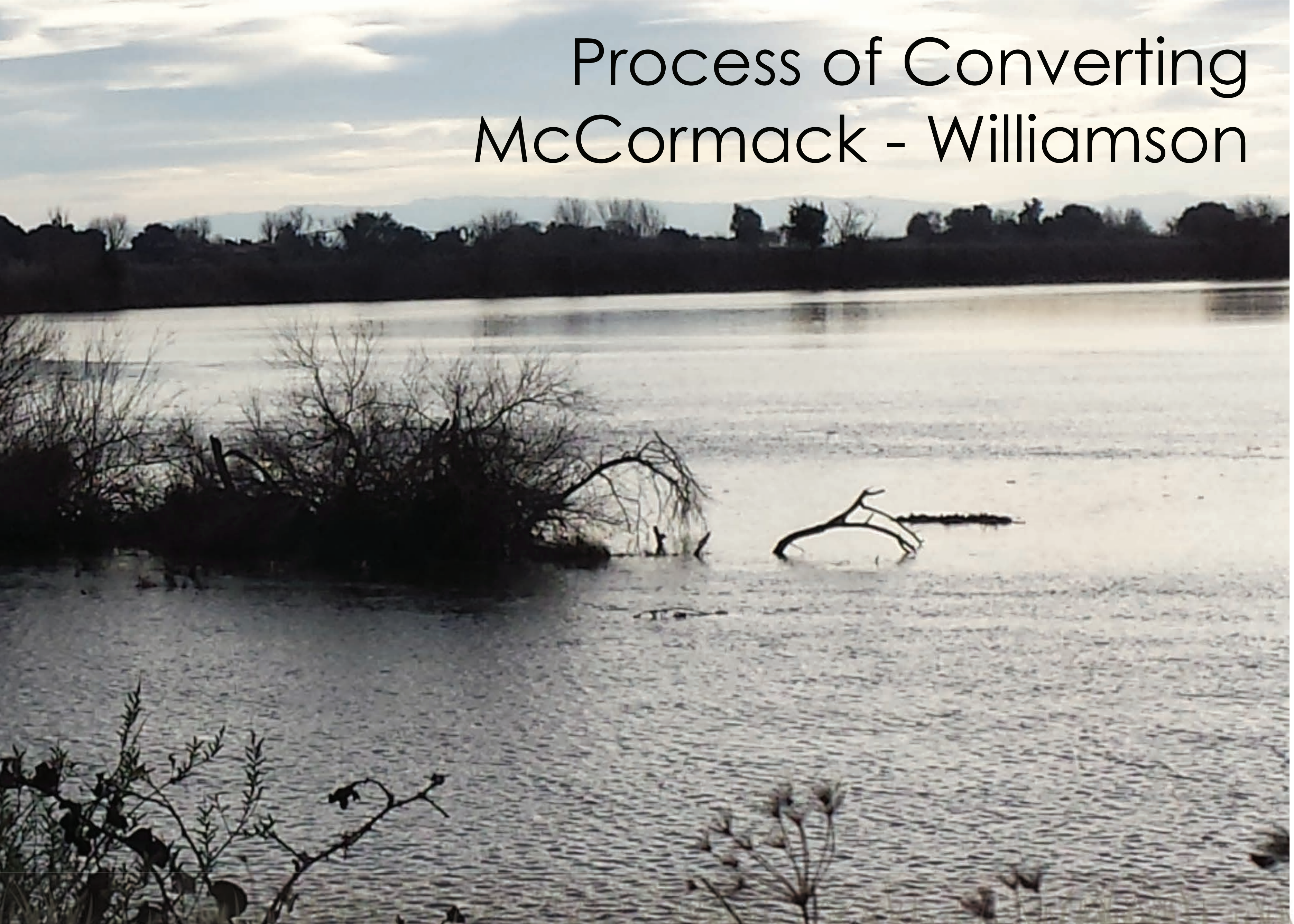
This area of the Sacramento Delta historically was emergent wetland and riparian habitat. Converting this land to agriculture lessened the habitat value of the land since species typically only use agricultural fields for movement between patches or seasonal uses such as foraging. Agriculture does not provide enough cover types or food by itself. Therefore, by converting a majority of the Delta to agriculture, the ecological value of this land is significantly decreased. In addition, agriculture creates highly fragmented habitats which are typically to small to support the needs of wildlife (Physical River Processes).

Land Use Attribution	Acres	% of Delta
Natural Vegetation	104,637	14
Agriculture	485,902	67
Urban	65,224	9
Water/Inundated	65,850	9
Baren/Scraped/Quarry	3,982	1
Total	725,595	100
Vegetation Attribution		
Natural Vegetation, Upland	109,995	15
Natural Vegetation, Floating Aquatic	4,164	1
Exotic Vegetation (plantings)	5,939	1
Sparsely Vegetated	8,312	1
Restoration-Related Vegetation	228	<1
Agriculture	473,971	65
Urban	62,220	9
Water	60,665	8
Unknown	100	<1
Total	725,595	100

Table 2.2: Land Use & Vegetation Attribution

Figure 3.0: Adjacent Riverine Habitat

Process of Converting McCormack - Williamson



Importance of MWT Conversion

Although the Delta system can never be restored to its historic conditions, alterations can be made to maintain and preserve the ecological integrity of the Delta. This site provides the unique opportunity to be a precedent for natural flood control by allowing for tidal inundation and seasonal flooding. Several focal species will be examined to determine their habitat preferences and how the Mccormack-williamson tract can provide habitat specific to those species. Riverine, intertidal, and terrestrial species will be considered to ensure the use of the site by many different kinds of animals.

Several goals will be examined throughout the design process:

1). Design for focal species to restore biotic communities that can benefit a variety of species

2). Recovery of endangered or at risk species

3). Rehabilitate ecological processes

Designing for Species

Each species of wildlife has its own habitat preferences to provide for the necessary life functions - cover, feeding, reproduction. By analyzing the requirements of several key indicator species with various habitat requirements, a more holistic design can be derived to provide for the necessary habitat components of a large range of species. The CA Department of Fish and Game created the Wildlife Habitat Relationships (CWHR) database to describe the life history and habitat requirements of species commonly found in California.

Designing for Birds:

By planting various plant communities adjacent to each other, the habitat value is increased. Bird species will use the same habitat to obtain different resources so by providing a variety of edge habitat conditions, bird species can find the necessary resources in one territory.

Designing for Andromous Fish:

Riverine floodplains are very beneficial for andromous fish like the chinook salmon. The overhanging trees and shrubs create shaded water habitat which have lower water temperatures in the summer. This habitat type also attracts an abundant source of insects and plant debris, which are critical to the aquatic food web. Vegetated floodplains are primarily used by the chinook salmon during prolonged flooding. Juvenile fish prefer vegetated floodplain habitat due to the abundance of nutrients and food provided by the vegetation and insects.

"Floodplains can provide higher biotic diversity and an increased production of fish" (Sommer_et_al).

Figure 3.1: Sandhill Crane on Staten Island

Criteria for Species Picked

To evaluate the suitability of species for the McCormack-Williamson tract, several criteria were considered:

1). How likely is that species to be found in the surrounding areas to repopulate on the McCormack-Williamson tract according to the EIR Report?

2). Is the species listed as threatened or endangered at the state or federal level?

3). Is the species endemic or native to California?

4). Does the species depend on the Sacramento Delta to complete its life cycle?

5). What is the overall distribution of the species in California? Can it be found throughout the state or mainly in this area?

Species	CWHR No.	EIS Report Probability	Threatened/ Endangered	Endemic/ Native	Critical Habitat	Special Distribution in CA
Modesto Song Sparrow	B505	High	Species of Concern	Y		All Over
Sandhill Crane	B150	High	Threatened			Sacramento Valley in Winter
Giant Garter Snake	R79	Moderate	Threatened	Y		Mainly Sac. Valley
Swainson's Hawk	B121	High	Threatened		Y	Sac Valley - only year round habitat
Tricolor Blackbird	B520	High	Species of Concern	Y		All Over
Western Pond Turtle	R4	High	Species of Concern	Y		All Over
Winter Chinook Salmon	N/A	N/A	Endangered	Y	Y	Sacramento River

Table 3.1: Species Criteria

Greater Sandhill Crane - *Grus canadensis*

Status: CA Threatened, CA Fully Protected, CA Species of Special Concern

Habitat Preferences: Fresh Emergent Wetlands, Lacustrine, and Grasslands

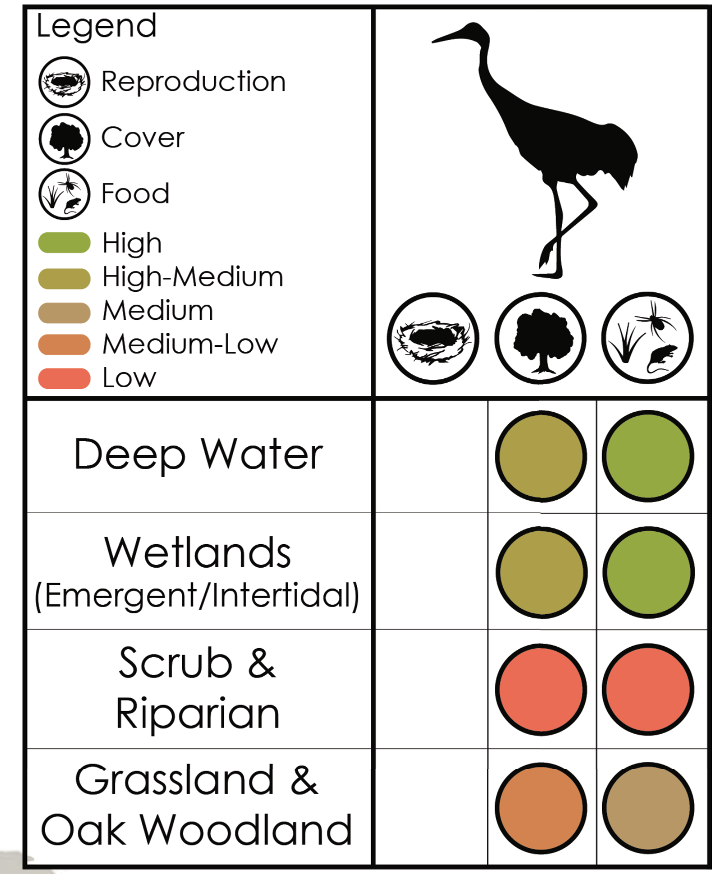


Figure 3.2: Habitat Preferences of Sandhill Crane

Feeding: Sites containing water are primarily used but they can also feed on dry lands such as grass plains and agricultural lands. They primarily eat grasses, forbs, and cereal crops but they also consume roots, seeds, grains, insects, crustaceans, mammals, amphibians, and reptiles.

Cover: Sandhill cranes roost in moist fields or shallow water primarily but they can also roost in grasslands and sandbars

Reproduction: Isolated, extensive wetlands are used for nests, ideally small islands that are concealed with tall vegetation. Nests are created from mounds of wetland plants in shallow water.

Water: Shallow lakes and fresh emergent wetlands are preferred.

Nesting Sites: Shallow lakes or fresh emergent wetlands with concealing vegetation are ideal.

Territory: 62 acres

Home Range: 1137 acres

Other: Sensitive to humans when nesting. Prefers treeless habitats so predators can easily be seen.

Figure 3.3: Spatial Distribution of Sandhill Crane in California

Giant Garter Snake - *Thamnophis gigas*

Status: Federally Threatened, CA Threatened

Habitat Preferences: Fresh Emergent Wetlands, Lacustrine, Riverine, Valley Foothill Riparian, Wet Meadow

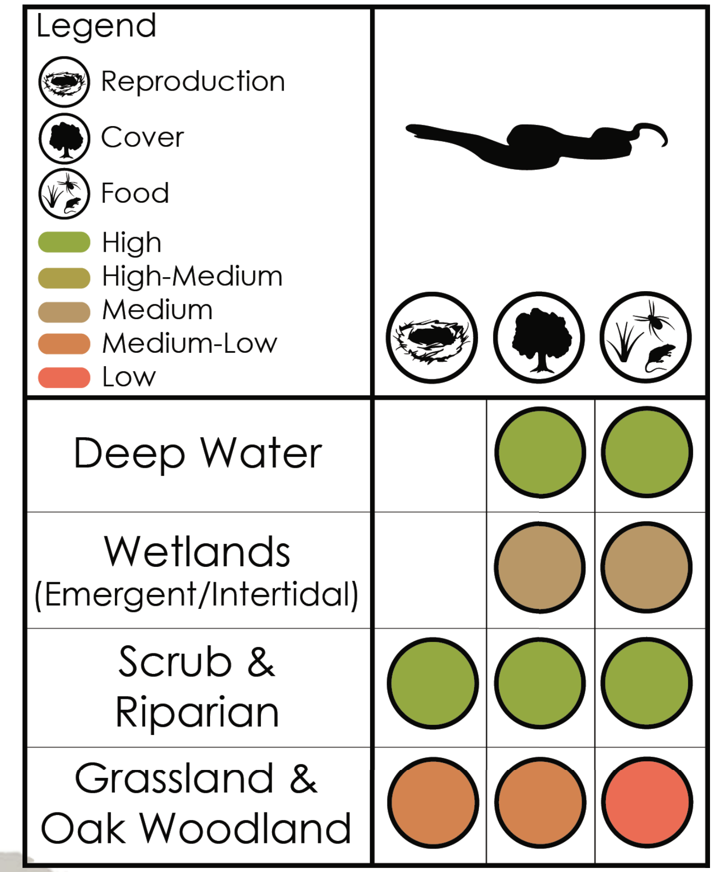


Figure 3.4: Habitat Preferences of Giant Garter Snake

Feeding: Preys on small fish, tadpoles and frogs. Giant Garter Snakes need water, especially freshwater emergent wetlands, during their active season for food. Both deep water and shallow pools are used.

Cover: They prefer grassy banks and clearings near waterside vegetation to bask in. Higher elevations are necessary to seek refuge from flood events. Freshwater emergent wetlands are also used for cover.

Reproduction: They begin mating after their dormancy period in higher elevations.

Water: Water is a very important aspect of the Giant Garter Snake's habitat requirements. There must be permanent water deep enough to support their prey and a sufficient amount of emergent vegetation cover.

Nesting Sites: Giant Garter Snakes take refuge in small mammal burrows during their winter dormancy period and flood season. The prefer south and west facing slopes to optimize sun exposure.

Home Range: 47 acres

(Species Account - Giant Garter Snake & U.S. Fish and Wildlife Service, 1999)

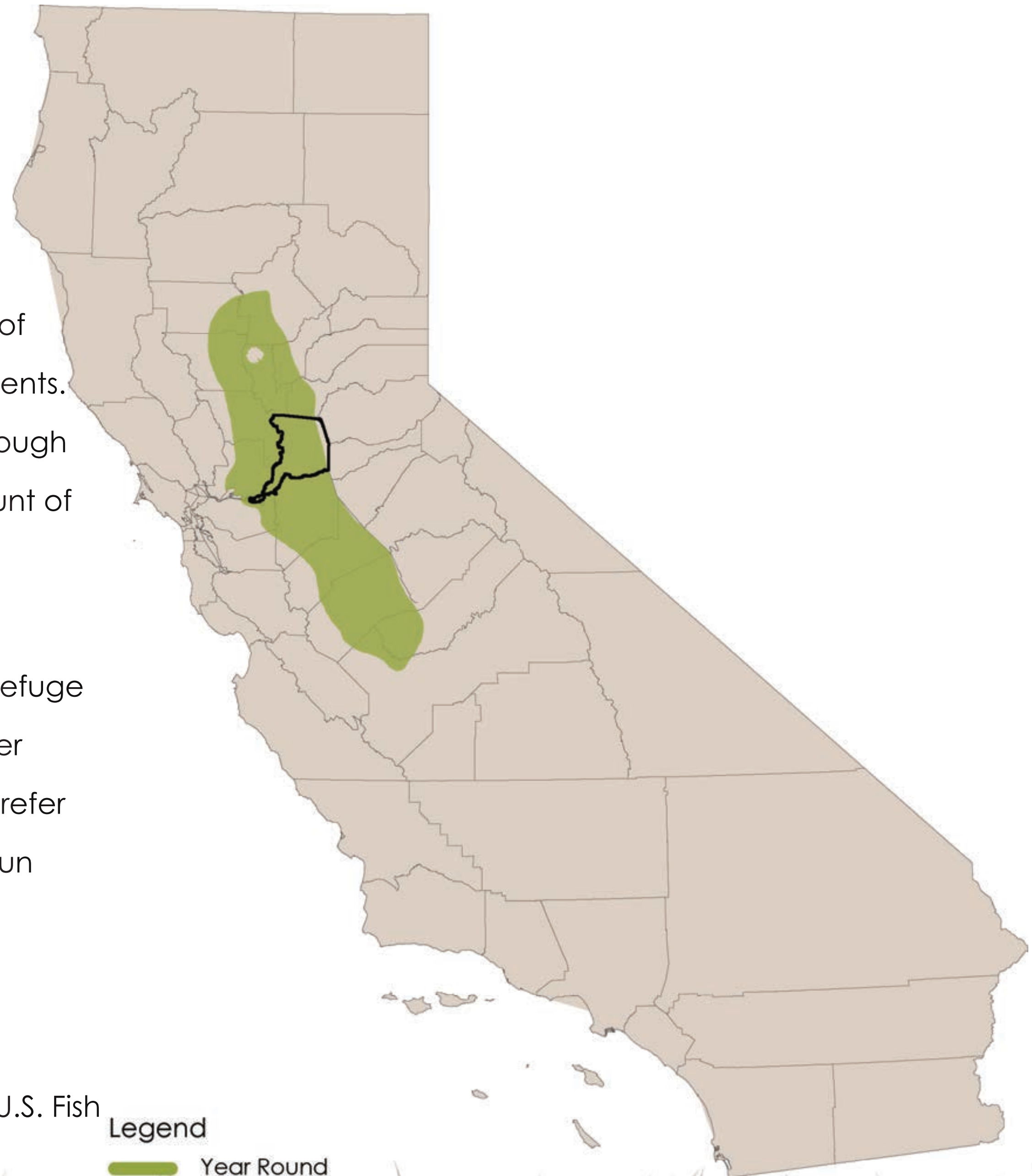


Figure 3.5: Spatial Distribution of Giant Garter Snake in California

Western Pond Turtle - *Actinemys marmorata*

Status: CA Species of Special Concern

Habitat Preferences: Fresh Emergent Wetland, Lacustrine, Riverine, Valley Foothill Riparian, Valley Oak Woodland

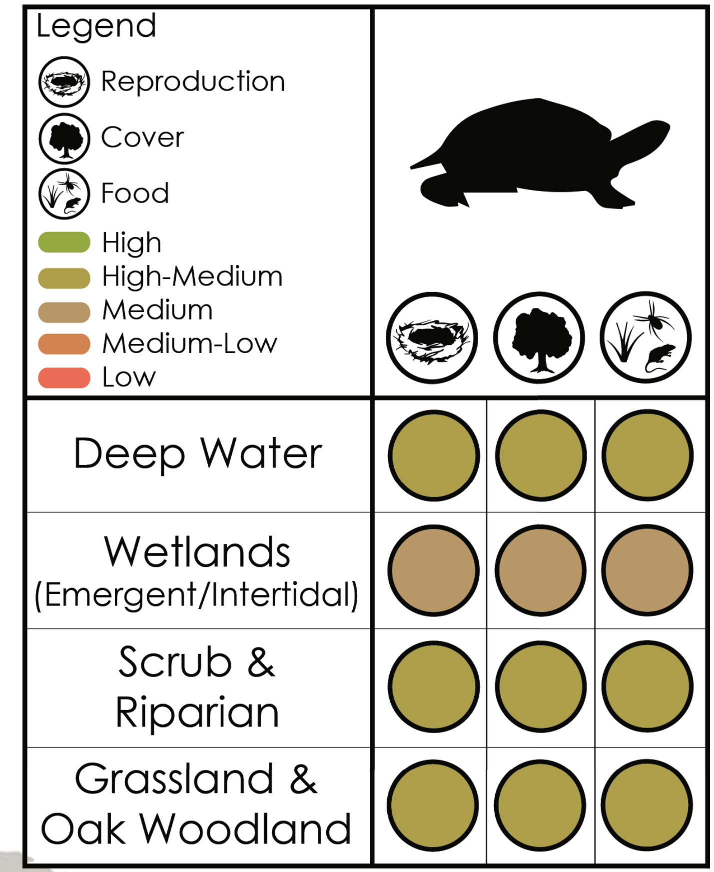


Figure 3.6: Habitat Preferences of Western Pond Turtle

Feeding: Western pond turtles are omnivorous and consume aquatic plant material, aquatic invertebrates, fish, amphibians, and insects.

Cover: Turtles require basking habitat on submerged logs, rocks, floating vegetation, or mud flats. They retreat underwater if predators or humans approach.

Reproduction: Large slow-moving streams and sandy banks are utilized for egg deposition. The soil must be at least 4" deep.

Water: Permanent ponds/pools, lakes, streams

Nesting Sites: Nests must have a high relative humidity for eggs to develop properly.

Territory: They are not known to be territorial

Home Range: Very restricted

Other: Only abundant native turtle of California

Figure 3.7: Spatial Distribution of Western Pond Turtle in California

Modesto Song Sparrow - *Melospiza melodia*

Status: CA Species of Concern

Habitat Preferences: Fresh Emergent Wetlands, Montane Riparian, Valley Foothill Riparian, Wet Meadow

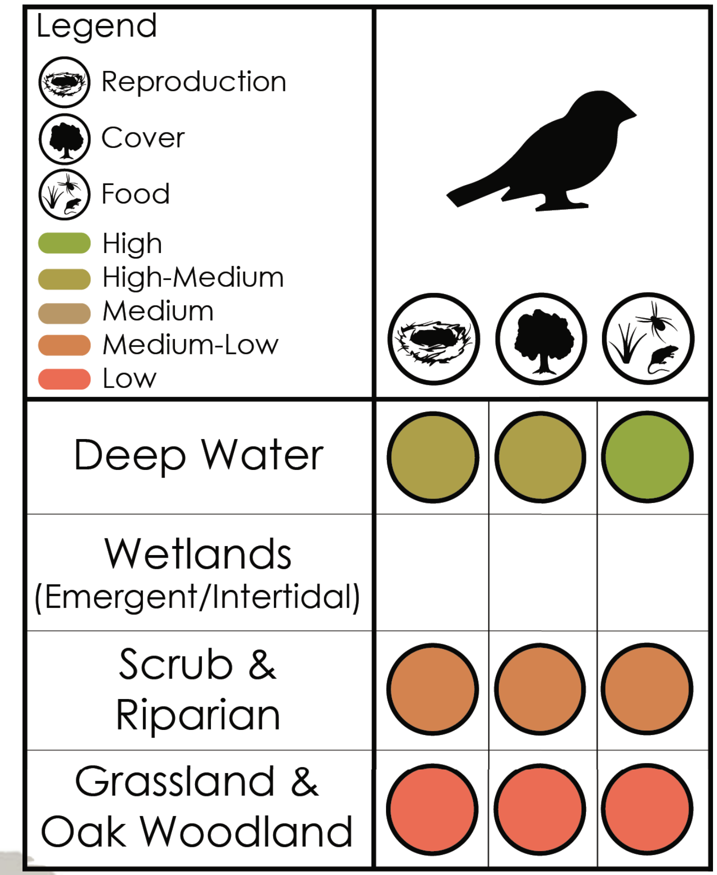


Figure 3.8: Habitat Preferences of Modesto Song Sparrow

Feeding: They primarily eat seeds but also consume small invertebrates, insects, and small fruits. They prefer to forage on the ground or in low vegetation within emergent wetlands (CWHR). Their year round diet consists of 21% animal matter and 79% vegetation (Humple and Geupel).

Cover: Low dense vegetation, usually near water, in emergent vegetation

Reproduction: Ground nesters near shorter vegetation. Breeding Habitat: source of water, moderately dense vegetation, light, exposed ground or leaf litter for foraging.

Water: nests along bodies of water

Nesting Sites: on the ground, in shrubs, emergent vegetation, or small trees within 4' of the ground

Territory: 0.1 acres

Home Range: 6.8 acres

Other: Abundance is increased with early successional riparian habitat, especially when willows are present along stream (Humple and Geupel).

Figure 3.9: Spatial Distribution of Modesto Song Sparrow in California

Swainson's Hawk - *Buteo swainsoni*

Status: CA Threatened

Habitat Preferences: Annual Grasslands, Valley Foothill Riparian, Valley Oak Woodland,

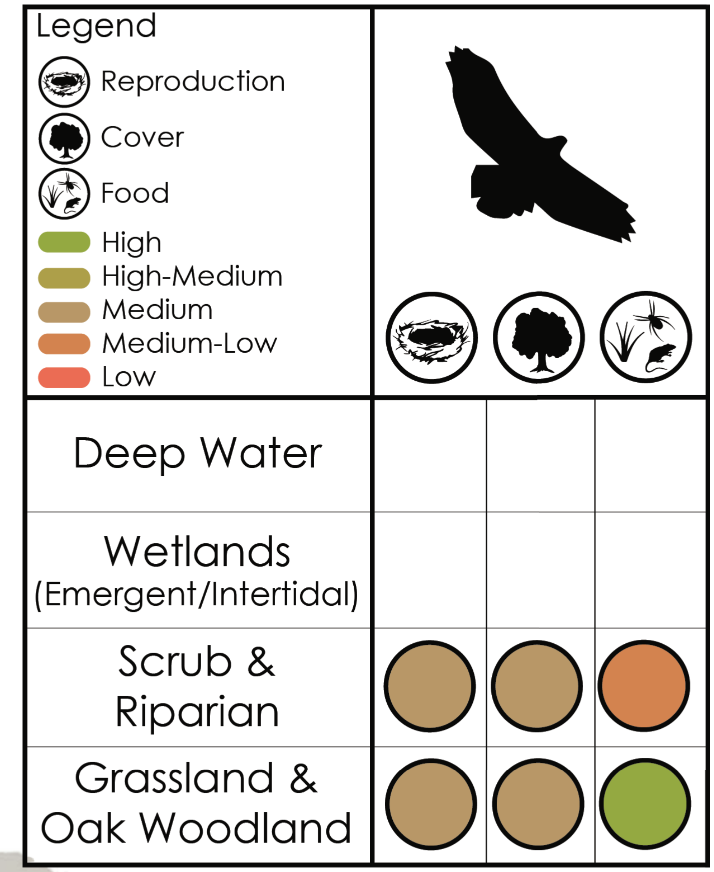


Figure 3.10: Habitat Preferences of Swainson's Hawk

Feeding: Soars to sight prey. Consumes small mammals, amphibians, reptiles, birds, and sometimes fish. Forages in grasslands, grain/alfalfa fields/pastures

Cover: Roots in large trees but will also roost on the ground if large trees are not available.

Reproduction: Nests on a platform in a tree, bush, or pole, 4-100' above the ground. Nests in open riparian habitat, scattered trees or small groves

Water: Found near Water

Nesting Sites: On a platform above the ground in riparian habitat.

Territory: 0.7 miles

Home Range: 1-2 miles

Other: Swainson's Hawks are in decline due to the lack of nesting habitat.

Figure 3.11: Spatial Distribution of Swainson's Hawk in California

Tri-colored Blackbird - *Agelaius tricolor*

Status: CA Species of Special Concern

Habitat Preferences: Grasslands, Fresh Emergent Wetlands, Valley Foothill Riparian

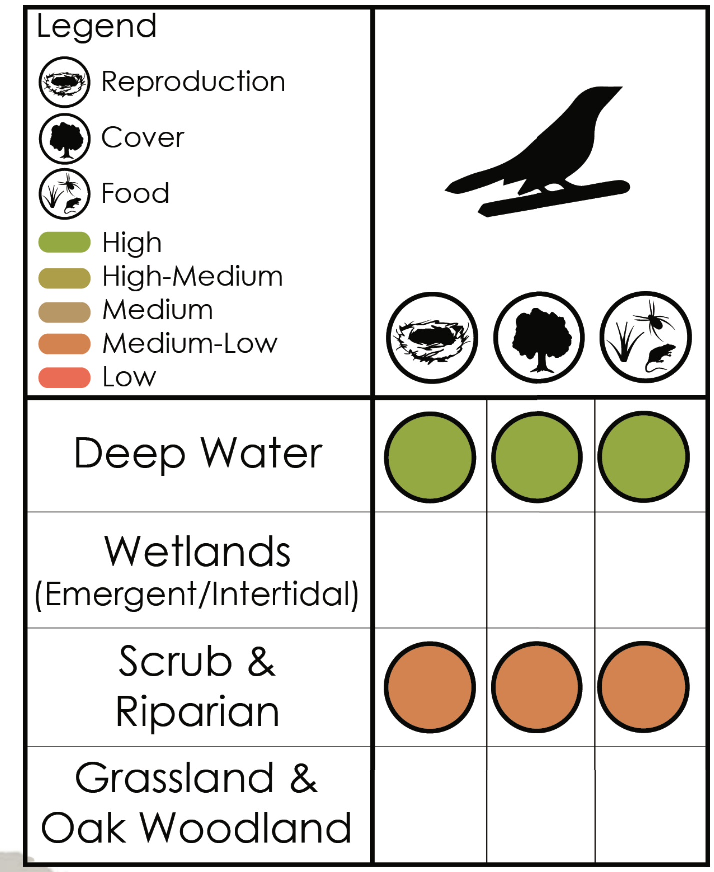


Figure 3.12: Habitat Preferences of Tri-Colored Blackbird

Feeding: Eats insects and seeds such as rice and oats. They forage on the ground in croplands, grassy fields, flooded land, and along the edges of water.

Cover: Seeks cover in emergent wetland vegetation such as tules and cattails, as well as trees and shrubs

Reproduction: nests in dense cattails, tules, or thickets of willows, blackberry, wild rose, or tall herbs.

Water: Nests located near water especially fresh water emergent wetlands

Nesting Sites: Located a few feet over or near fresh water. Can be hidden in low vegetation. Nesting area needs to be large enough to support 50 pairs

Territory: 3.3 miles

Home Range: 4 miles

Other: Swainson's hawks prey on the tri-colored blackbird

Figure 3.13: Spatial Distribution of Tri-Colored Blackbird in California

Chinook Salmon - *Onchorhynchus tshawytscha*

Status: Threatened

Habitat Preferences: Water

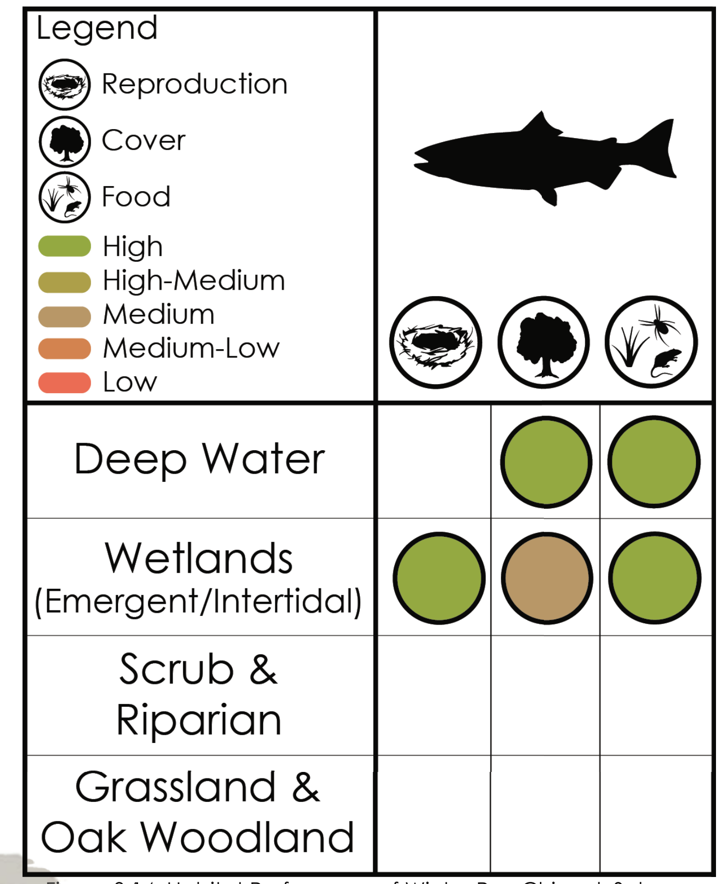


Figure 3.14: Habitat Preferences of Winter Run Chinook Salmon

Feeding: Chinook Salmon eat insects and crustaceans during their early development phases and mainly fish after maturity.

Cover: Juvenille Chinook Salmon seek deep water and avoid light as they mature. They also use shaded riverine habitat.

Reproduction: Chinook Salmon are anadromous; they migrate from the ocean into freshwater streams and rivers to mate.

Water: Salmon are anadromous. Juvenile Chinook spend 3 months to 2 years in freshwater before migrating to estuarine and marine waters.

Nesting Sites: Nests are built in an area of a stream with suitable gravel composition, water depth, and velocity. Larger gravel is used by Chinook Salmon than other salmon species.

Other: Winter run means that they enter freshwater during the winter to begin their spawning migration (Chinook Salmon - Oncorhynchus Tshawytscha, 2014).

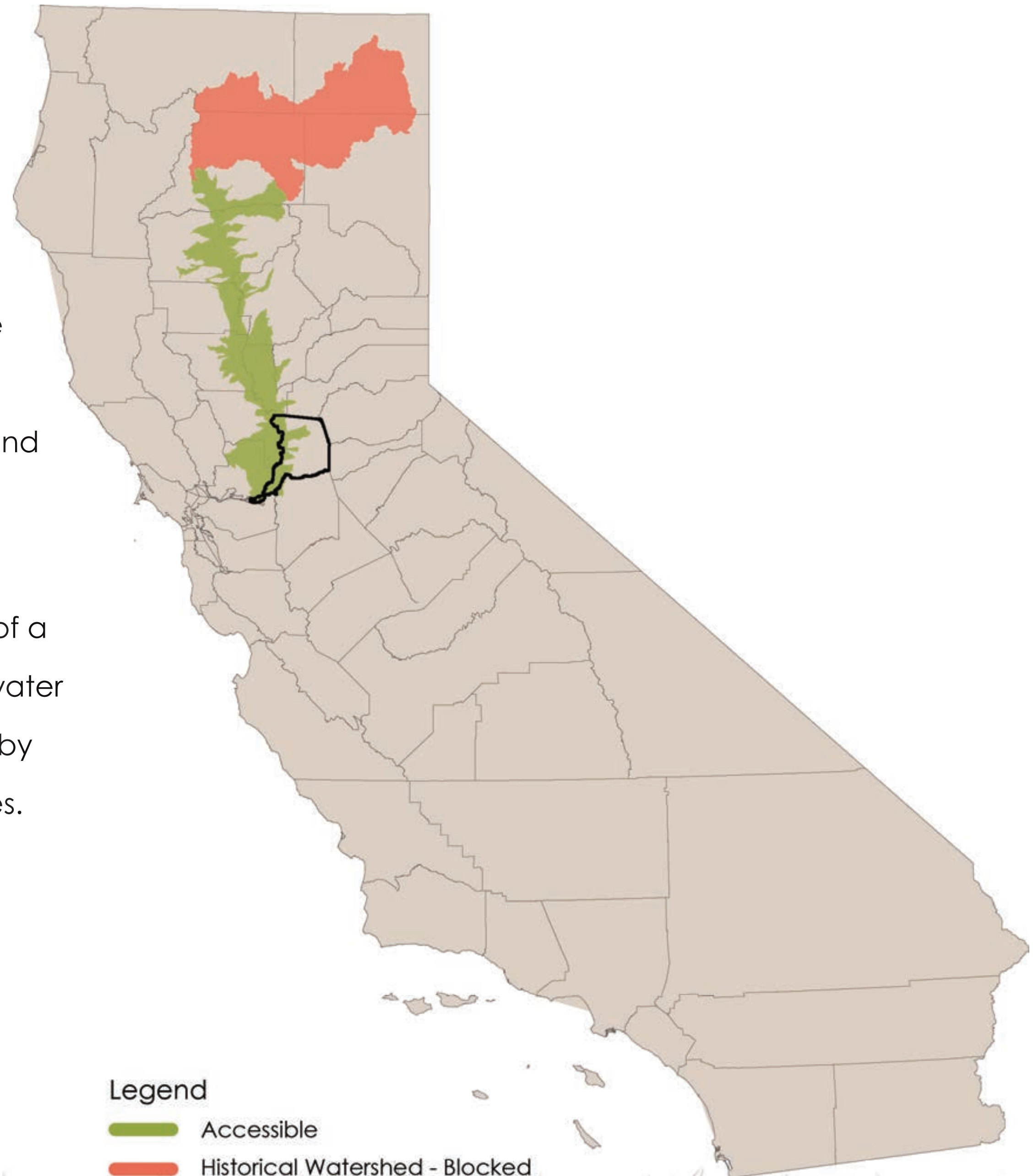


Figure 3.15: Spatial Distribution of Winter-Run Chinook Salmon in California

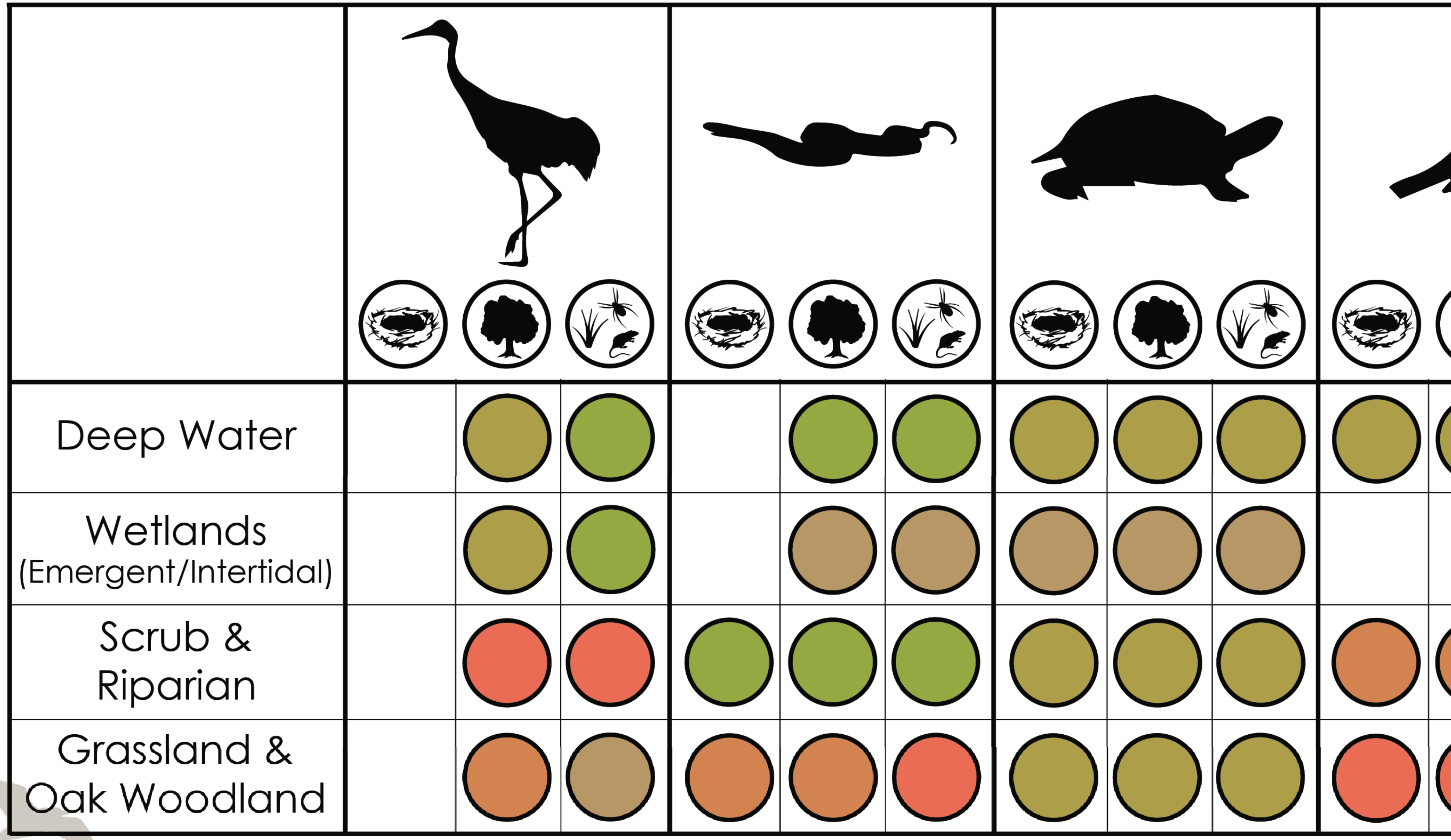
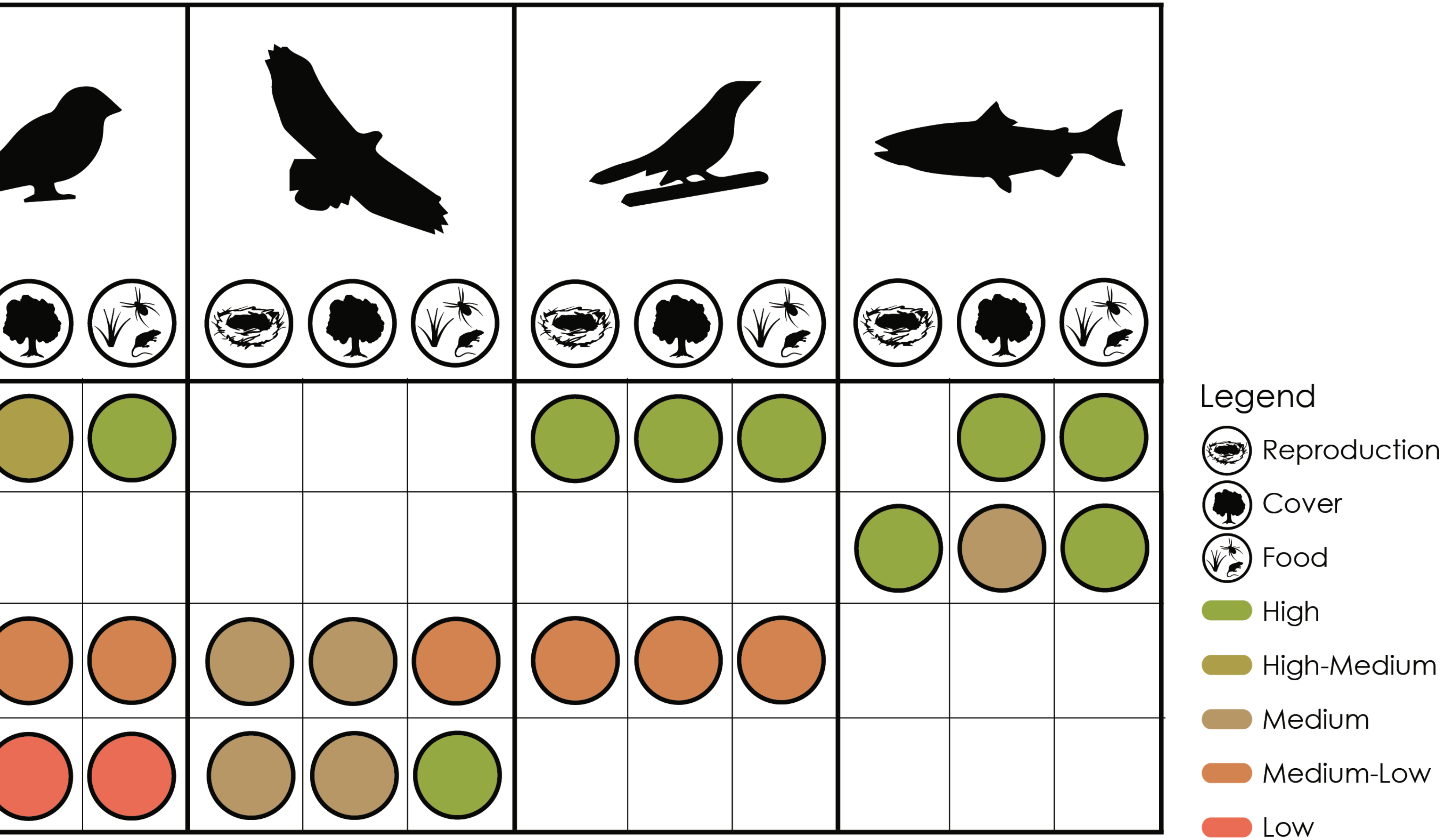


Figure 3.16: Habitat Preferences of all Focal S


Legend
Reproduction
Cover
Food
High
High-Medium
Medium
Medium-Low
Low
Species

Riverine

Structure: Intermittent or continually running water. Slower water bodies have an increase in water temperature and turbidity, while dissolved oxygen decreases and the bottom is more muddy. Open water is 6.6' or deeper, which is beyond the depth of floating rooted plants. Small rivers may not have open water.

Composition: Inhabitants live in riffles or near rocks and gravel to be shielded from the current. Emergent vegetation grows along the banks.

Associations: Lacustrine, Fresh Emergent Wetlands, Riparian

Wildlife Considerations: Open water provides opportunity for resting and escape cover for waterfowl.

Physical Setting: Exposure to direct sunlight results in warmer temperatures than if the river is shaded by trees, shrubs, and high, steep banks. Riffles create high dissolved oxygen content.

Figure 3.17: Riverine Habitat

Fresh Emergent Wetlands

Structure: Flooded frequently so plants must be able to function in anaerobic conditions. Wetlands are characterized by herbaceous hydrophytes and perennial monocots that can grow up to 6.6m tall.

Composition: The upper margins of FEW are saturated or periodically flooded. Species typically found in these areas include big leaf sedge, Baltic rush, and redroot nutgrass. In wetter Sites, species include cattail, tule bulrush, river bulrush, and arrowhead.

Associations: Riverine, Lacustrine, wet meadows. The boundary between fresh emergent wetlands and deep water is the ability of plants to grow at water depth - 6.6' or shallower.

Wildlife Considerations: Wetlands are among the most productive wildlife habitats in CA; they provide habitat for over 160 species of birds. Giant Garter Snake uses wetlands as its primary habitat.

Physical Settings: Wetlands can be found in a basin or depression that is saturated. They are most common on level to gently rolling topography. They occur as a series of concentric rings which follow basin contours. Soils are typically characterized by silt, clay, and sometimes peat.

Figure 3.18: Fresh Emergent Wetland

Lacustrine

Structure: Vary from inland depressions filled with water to large bodies of standing water and vary in depth from a few cm to 100s of meters. Typical examples include flooded lakes, reservoirs, intermittent lakes, and ponds.

Composition: Phytoplankton are the dominant species found in this habitat type. The distribution of species is dependent on water depth. Submerged plants support smaller plants as well as provide food and cover for aquatic organisms. As sedimentation increases, floating aquatic vegetation appears which offers support for many animals.

Habitat: There are several aquatic zones that correlate with water depth. Limnetic, open water, encompasses the deepest portions to the parts where light stops penetrating. The littoral, submerged zone, is shallow enough for light to penetrate through.

Associations: Lacustrine habitats can be found in association with fresh emergent wetlands, riverine, and any terrestrial habitats.

Wildlife Considerations: Lacustrine habitats are used by over 20% of animal species for reproduction, cover, and food.

Physical Setting: The water is much calmer than in habitats with running water. The dissolved oxygen content is lower than other aquatic habitats because the water typically is not moving much and only a small portion of the water is in contact with the surrounding air. Temperatures vary with seasonality and depth while light quality and quantity depend on the turbidity of the water.

Valley Foothill Riparian

Structure: 100' tall for mature riparian forest with 20-80% cover. Most trees are winter deciduous. Subcanopy tree layer and an understory shrub layer. The understory is typically impenetrable and includes fallen limbs and other debris.

Composition: Dominant species include cottonwood, CA sycamore, and valley oak. Subcanopy: white alder, box elder, Oregon ash. Understory: wild grape, wild rose, CA blackberry, blue elderberry, poison oak, buttonbrush, and willows. Herbaceous: sedges, rushes, grasses, poison-hemlock.

Habitat: transition to adjacent habitat types is usually abrupt, especially near agriculture.

Associations: Riverine, Grassland, Oak woodland, and Agriculture

Wildlife Considerations: provides habitat for an abundance of wildlife, including at least 50 amphibians and reptiles 147 species of birds, and 55 species of mammals.

Physical Setting: found in valleys by sloping alluvial fans, terraces, low foothills, and coastal plains. low velocity flows, floodplains and gently topography. coarse, gravelly, or rocky soils.

Figure 3.19: Riparian Habitat (Natural Resource Conservation Service)

Annual Grasslands

Structure: The plant species typically found in annual grasslands can also be found as the understory of Valley Oak Woodlands. Plants grow slowly during winter and spring and their growth is stimulated by the warm late-spring, early summer temperatures. The structure of grasslands depend on weather patterns and livestock grazing.

Composition: Introduced annual grasses are the dominant plant species, including wild oats, bromes, wild barley, foxtail fescue, California poppy, and purple needlegrass.

Habitat: Annual grasslands occupy the land that native grasslands used to thrive in. Species composition is strongly correlated with the weather patterns, both seasonally and annually. Grasses typically germinate in fall, and rapidly grow in late-spring and early-summer. Livestock grazing is essential in this habitat type because without it, tall grasses such as wild oats and brome would dominate.

Associations: Annual grasslands can be found above or surrounding valley foothill riparian zones, fresh emergent wetlands, agriculture, and below valley oak woodlands.

Wildlife Considerations: Many animal species need annual grasslands for foraging. In the Delta system, the Swainson's Hawk can be found foraging here. Garter snakes and other reptiles typically breed in grasslands.

Physical Setting: They can be most commonly found on either flat plains or gently rolling hills. Annual grasslands thrive in Mediterranean climates with cool, wet winters, and hot, dry summers.

Valley Oak Woodland

Structure: This habitat type ranges in structure from dense forest-like stands to open canopies. Stands tend to be denser along areas of natural drainage and is also correlated with elevation; density decreases as soils become less fertile and drier. If grazing is not present, then a shrub understory develops, consisting of species such as coffee berry, poison oak, and toyon. The shrub understory has the same density correlation. The ground cover of valley oak woodlands consists of annual grasses and forbs, similar to annual grasslands.

Composition: Valley oaks are the dominant species present in this habitat type but sycamores, walnuts, interior live oaks, box elders, and blue oaks can also be found. Understory and ground cover plant species include California wild grape, toyon, California blackberry, wild oats, brome, rye grass, and needle grass. Valley oaks can live up to 400 years old and are tolerant of flooding.

Habitat: There is very little recruitment of young oaks to replace older, dying oaks due to urbanism, agricultural development, and predation on acorns and seedlings. Since there is very little recruitment occurring, valley oak woodlands are shifting towards annual grasslands.

Associations: Valley oak woodlands can be typically found adjacent to annual grasslands, agricultural fields, and valley foothill riparian zones. They are also associated with other oak woodland habitats.

Wildlife Considerations: Valley Oak woodlands are an important source of food for over 30 species of birds that primarily consume acorns.

Physical Setting: Stands are best developed on deep, well drained alluvial soils, typically found on the bottom of valleys.

River Ecology & Floodplains

As rivers meander, sediment is deposited in layers along the edges of the river channel. A typical floodplain is tiered away from the river channel and increases in elevation the further it is from the river channel. The floodplains at higher elevations require large flows to become inundated while floodplains closer to the river channel is inundated more frequently.

"The frequency and duration of flood events over time shape the physical habitat and create the ecological restrains that determine the species composition and community structure on a site" (Physical River Processes).

The location of riparian plants on the floodplain depend on their tolerances of inundation, depth of the water table and soil composition and texture. The closer plants are to the river channels, the more the plants have to be adapted to tolerate frequent inundation and physical damage from hydraulic forces. These species typically have specialized adaptations for anaerobic conditions and flexible stems to withstand the physical stress from the water. Many of these plants root easily from branches that have been torn off.

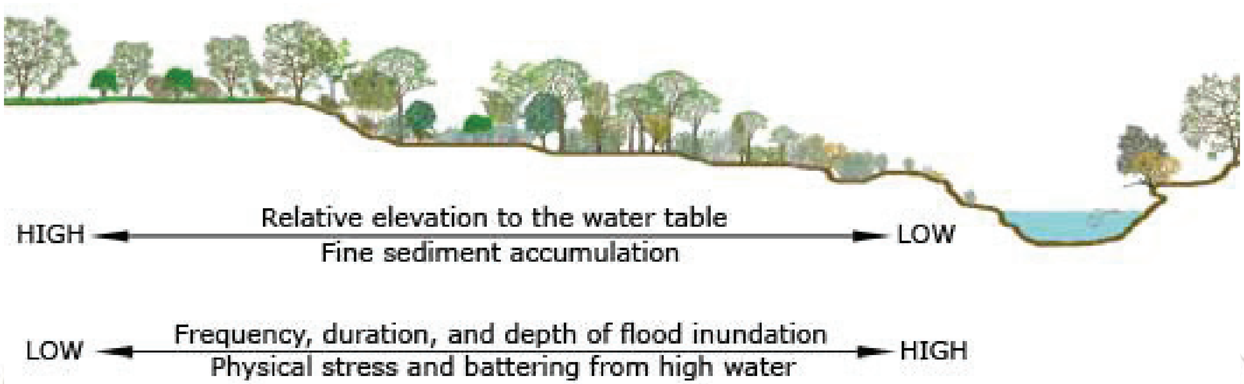


Figure 3.20: River Ecology

River Ecology & Floodplains

Soil particle size tends to be larger, courser closer to the channel because the larger particles are more difficult to move further distances. Since the courser particles are closer to the channel, these areas drain more quickly in a flood event. These plant species have to be tolerable of dry conditions or be able to send their roots down into the water table because of the soils ability to drain rapidly. Slopes further away from the main channel have finer particle sizes since they can be carried further distances on the floodplain. These nutrient rich sediments allow riparian habitat to form due to their high organic and nutrient content. Soil particles that are smaller in size have a higher water holding capacity, allowing riparian species to endure drier conditions and less flooding events. Because these plant species are higher in elevation, they must have the ability to send long roots to obtain water from the water table in times of drought (Ecological Tolerances of Riparian Plants).

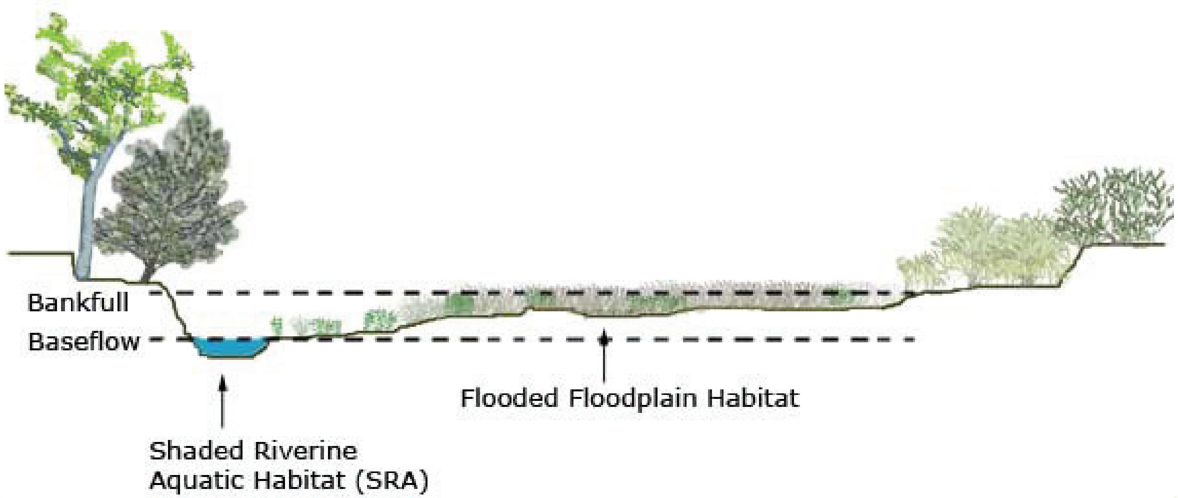


Figure 3.21: Floodplain and Shaded Riverine Habitat

Vegetation Zonation

Littoral Zone: Area below waterline that is too deep for emergent plants but shallow enough that light can penetrate through to the bottom. This zone is typically 1-4’ deep.

Emergent Zone: Part of the bank that lies below the water line but is shallow enough for aquatic plants to root and emerge from the water. This zone is typically 1’ deep (Caflisch et all.).

Shaded Riverine Aquatic Habitat: Trees, grasses, and shrubs are planted along the channels to create shaded riverine aquatic habitat, which keeps the water temperatures cooler in the summer, benefitting fish by providing food and coverage. The roots, branches, and submerged vegetation provides coverage for juvenile fish as well as a food source for invertebrates. Additionally, woody debris from fallen and decaying vegetation enhances the food web by providing food and coverage for invertebrates and fish (Riparian Plant Community Classification).

Figure 3.22: River Ecology - Vegetation Zonation

Vegetation Zonation

Willow Scrub: Part of the riparian forest but lower in elevation and dominated by willows. Due to the increasing inundation and physical forces from water, willow scrub is comprised of round willows and cottonwoods that can survive these conditions. Sandbar willows are typically found on point bars. Willows cause finer sediments to accumulate, resulting in the establishment of other riparian plants. The dense structure creates nesting, cover, and foraging habitat for many species (Riparian Plant Community Classification). Predominantly less than 20' tall and includes woody trees, shrubs, and vines such as alder, willow, wild rose, buttonbush, box elder, ect (Department of Fish and Game).

Riparian Zone: The part of the bank that is above the water surface but the soil may be permanently wet or saturated. The riparian zone becomes inundated during storm events so plants in this zone need to be able to withstand periodic anaerobic conditions while preferring to grow just above the water line. Riparian forests attract a large diversity of animal life due to its structural complexity of both dense, closed canopy and openings. Dense coverage from various sized trees provides habitat for both ground nesting birds as well as tree nesting birds. The mid story canopy is typically comprised of medium sized trees and shrubs such as sycamores and box elders while the understory has a greater proportion of smaller shrubs. Riparian forests may be dominated by tall (>30m) cottonwoods and medium sized arroyo willows and black willows (Riparian Plant Community Classification). Woody plants taller than 20' with dense, shrubby understory (Department of Fish and Game)

Vegetation Zonation

Upland Zone: Valley Oak Woodlands: The part of the bank where soils are not permanently wet. This area is typically dry because the water travels down the slopes to the lower zone types (Caflisch et all.). Common on floodplains higher and farther from main channel than other riparian plant communities. Valley oaks dominate this habitat type and are typically widely spaced. The structure of Valley Oak Woodlands provides both high and low perching and nesting sites due to its variety in species. Adult Oaks range from 15-35m in height while the understory is comprised of grasses and forbs, particularly creeping rye grass. Species such as blue elderberry, box elder, western sycamore, Oregon ash, Fremont cottonwood, poison oak, and wild grape can be found here as well (Riparian Plant Community Classification).

Figure 3.23: Upland - Valley Oak Woodland

Vegetation

Aquatic Vegetation:

Ceratophyllum demersum, Elodea spp, Hydrilla verticillata, Myriophyllum spp, Potamogeton spp, Vallisneria americana

Low Marsh:

Nuphar advena, Peltandra virginica, Pontederia cordata, Sagittaria latifolia, Zizania aquatica

High Marsh:

Acorus calamus, Ambrosia trifida, Aster spp, Bidens spp, Carex spp, Cicuta maculata, Cuscuta gronovii, Cyperus spp, Echinochloa spp, Eleocharis spp, Galium tinctorium, Impatiens capensis, Iris spp, Ledwigia spp, Hibiscus virginica, Phragmites australis, Pilea pumila, Polygonum spp, Scirpus spp, Schoenoplectus spp, Typha spp.

Forests:

Trees:

Acer rubrum, Chamaecyparis thyoides, Fraxinus pennsylvanica, Magnolia virginiana, Nyssa biflora, Carpinus caroliniana.

Shrubs:

Clethra alnifolia, Ilex verticillata, Itea virginica, Leucothoe racemosa, Rhododendron viscosum, Taxodium distichum, Vaccinum corymbosum, Viburnum spp.

Vines:

Parthenocissu quiquefolia, Smilax spp.

Toxicodendron radicans

Herbs:

Cinna arundinacea, Viola cucullata, Osmunda spp, Thelypteris thelyperiodes, Woodwardia spp, and many of the species listed in the low and high marsh (Barendregt et. all).

Figure 3.24: Existing Wetlands on McCormack-Williamson

Case Study - Wetland Design

The West Davis Ponds is one of the most successful, created, emergent wetland habitats. Its design features have many benefits and purposes to positively influence the local wildlife. Examining the successes of the West Davis Ponds and applying them to the McCormack-Williamson site could inform a successful wetland design. West Davis ponds feature islands of many sizes to provide habitat for shorebirds, waterfowl and small rodents. Potholes that are permanently flooded increase the ecological benefit for aquatic wildlife such as fish, frogs, and crustaceans, while providing feeding and loafing habitat for migrating and resident waterfowl. Interconnecting channels of various widths provide habitat for aquatic wildlife as well as feeding habitat for wading birds and shorebirds (Chainey et. al, 1989).

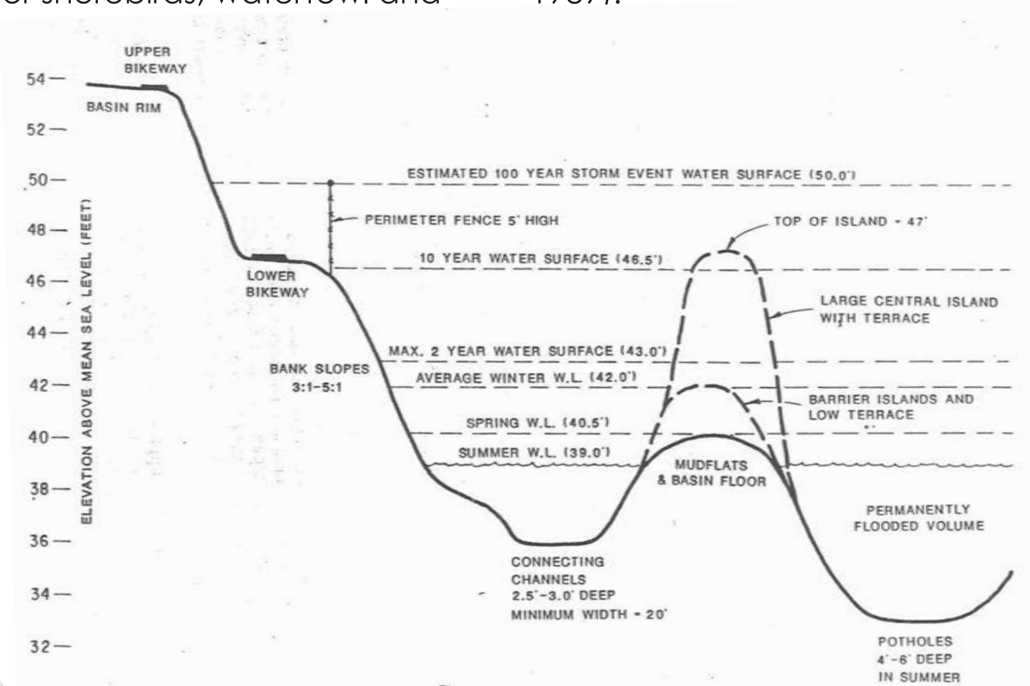


Figure 3.25 Section of Wetland Design of Davis West Ponds

Design

Figure 4.0: Existing Habitat Friendly Levees

Proposed Changes by DWR

The EIR report calls for the modification of four parts along the levees. First, the north eastern levee will be degraded from 17' to 8.5' to act as a weir in large flood events, allowing the excess water to overtop and flood the McCormack-Williamson tract. On the south western end of the tract, the levee will be completely removed to allow for a tidal influence into the tract. Additionally, a 300' breach is proposed along the Mokelumne River to establish hydraulic connectivity throughout the tract. Due to an increase of hydraulic forces on the surrounding Dead Horse Island, additional erosion protection is proposed to maintain levee integrity (California Department of Water Resources, 2006).

These altered levees, in addition to the rest of the levees, are proposed to be regraded to create wildlife friendly levees. These levees are graded at a 5:1 slope, instead of the typical 2:1 slope. Resloping the levees to be "wildlife-friendly" will increase the habitat value of the area by providing riparian and upland habitat when

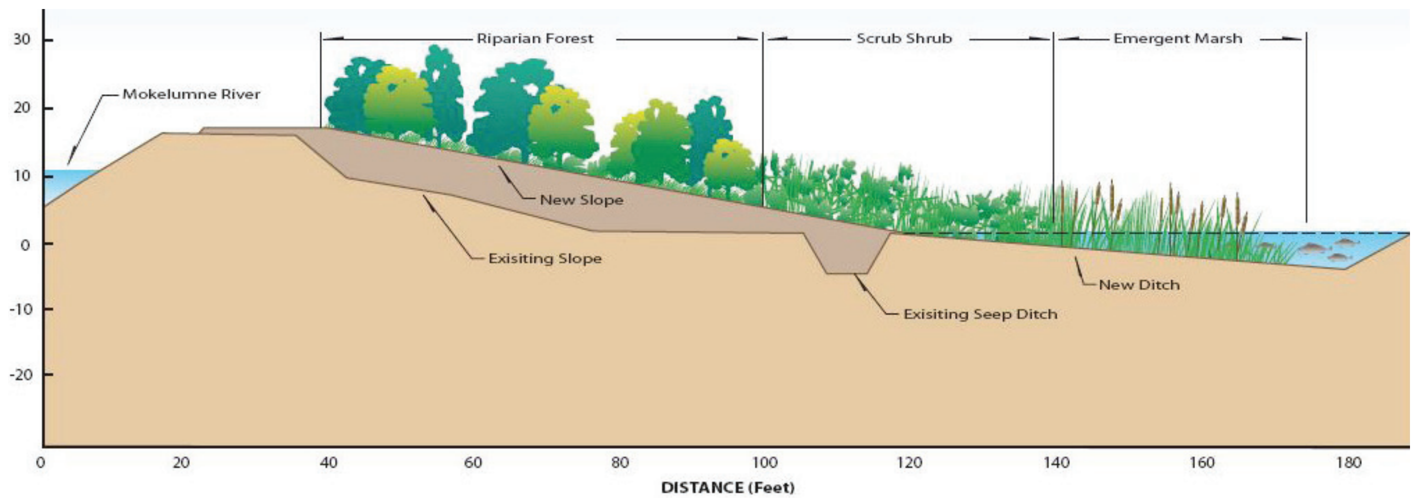


Figure 4.1: A Typical Habitat-Friendly Levee Section with 5:1 slopes

the interior is flooded. Habitat-Friendly levees provide more diverse vegetative cover than typical levees while providing additional levee stability and interior erosion protection from inundation (California Department of Water Resources, 2007).

Approximately 70 acres will be planted with native trees, shrubs, and grasses on the new Habitat-Friendly Levees. In addition, breaking the levee will increase the wetland and riparian habitat, improving the habitat for wildlife and migratory birds. Finally creating dendritic channels throughout the site by lowering the north-east levee, will provide an increase in edge habitat for fish. Connecting Staten Island and the Cosumnes River Preserve creates an opportunity for the McCormack-Williamson tract to be the last piece of the puzzle for an ecological corridor.

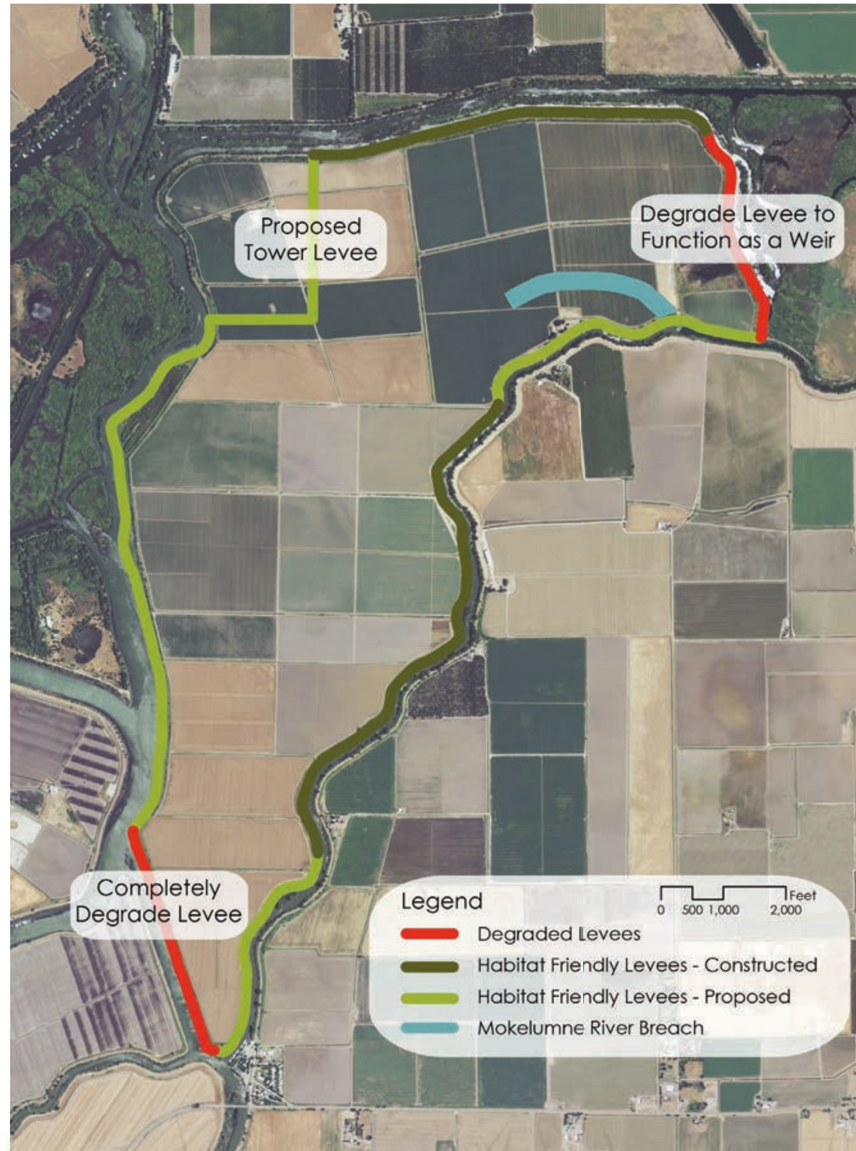


Figure 4.2: Proposed Changes from DWR

Levee A is proposed to be lowered from 17' in elevation to 8.5' NGVD. By lowering the levee, it would act like a weir in large flood events because the water would overtop the degraded levee. To protect the levee from deteriorating from the hydraulic forces of floods, 2' of rip rap is proposed to be placed on top of the levee. Flow velocities over the weir should reach a maximum of 3-4 feet per second. A 10' road is proposed to be on the levee to allow for connectivity to the surrounding levees. This road features 1' concrete cut-off walls to protect from undercutting (California Department of Water Resources).

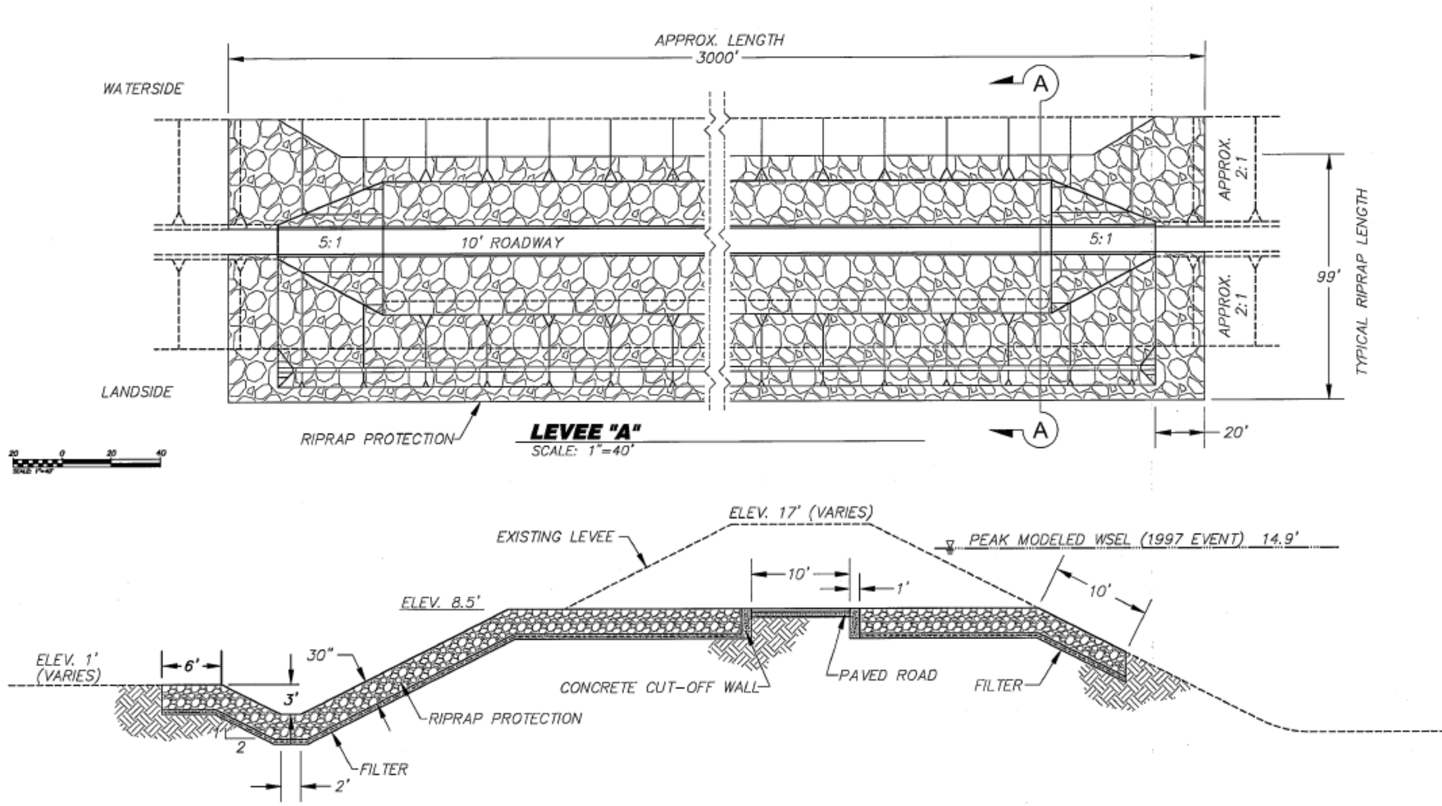


Figure 4.3: Levee Alterations to the North-East Levee

Levee B features a 300' breach into the east levee which borders the Mokelumne River which will establish hydraulic connectivity between the upper portions of the tract and the parts that are intertidal. The proposed cut will have two side tiers at 3.5' and a main middle channel at 0'. This breach is not armored by rip rap to allow the channel to scour and form a more natural channel inlet (California Department of Water Resources).

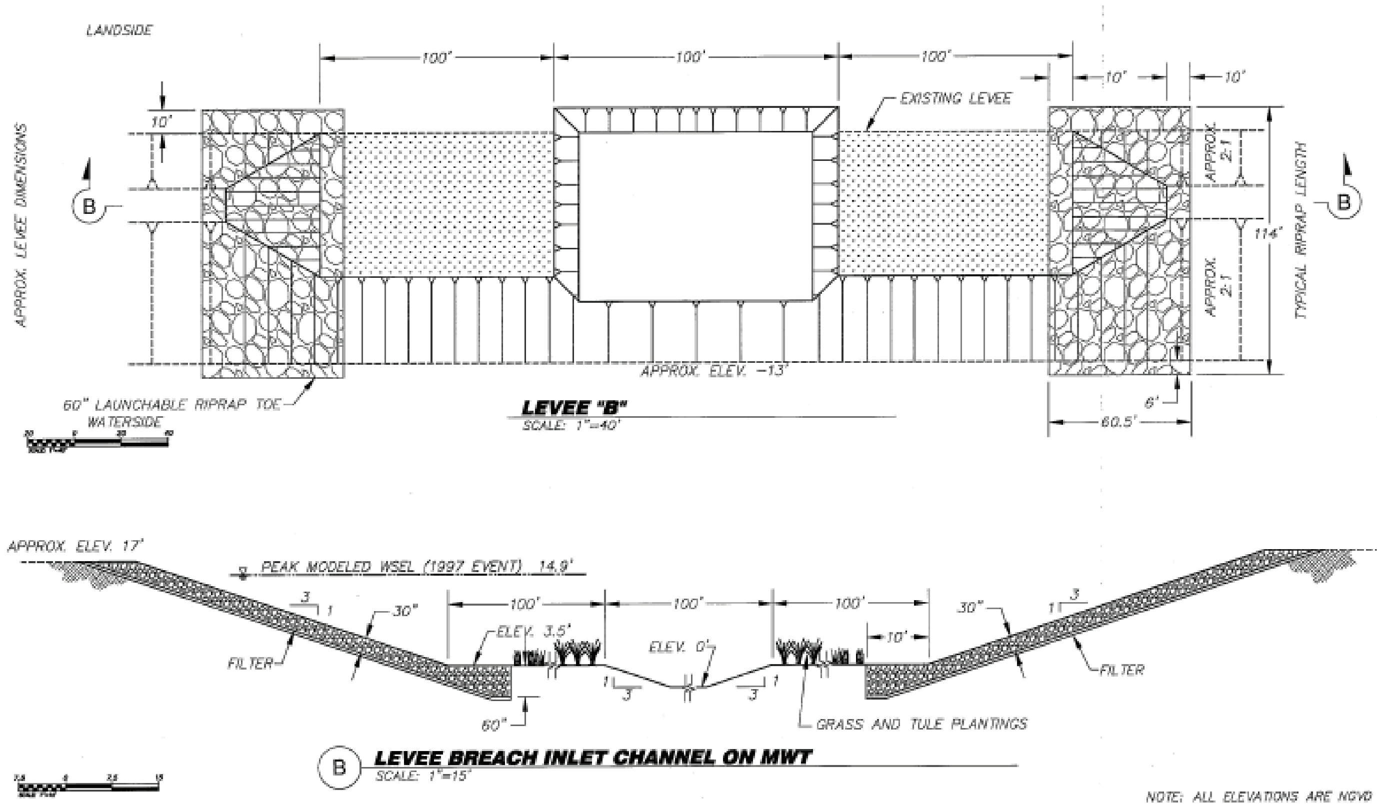


Figure 4.4: Levee Alterations to the Easter levee breach

Levee C, located on the south west end of the tract by Dead Horse Island, is proposed to be degraded down to -2.5'. Removing this levee allows for the tides to influence the tract to allow for a more historic condition of intertidal emergent wetlands (California Department of Water Resources).

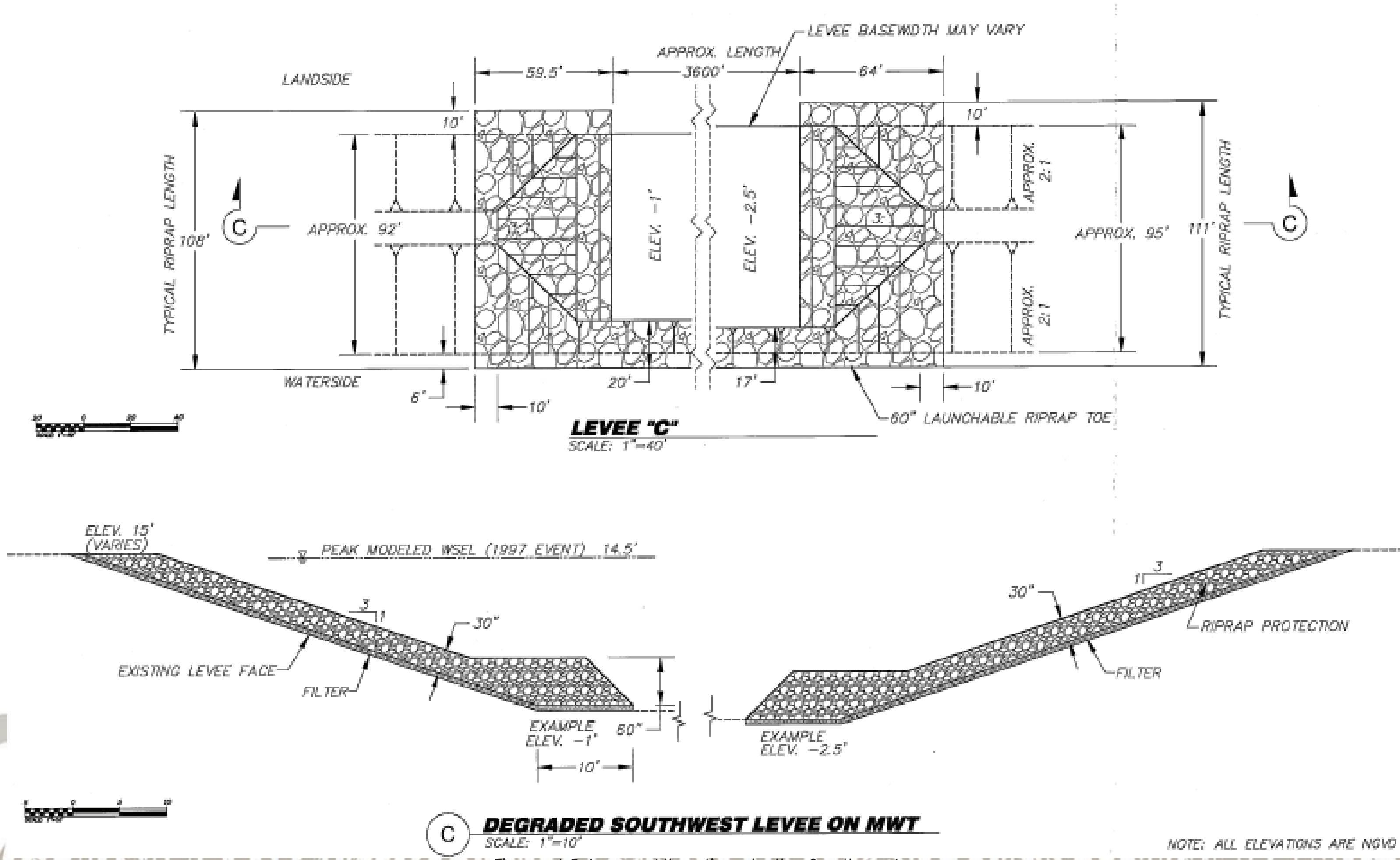


Figure 4.5: Levee Alterations to the Southern Levee

Because there will be an increase in flows and higher velocities on the tract, the riverside northeast levee will require additional protection. 2' of rip rap is proposed to cover the levee with a 4' toe to prevent scouring (California Department of Water Resources).

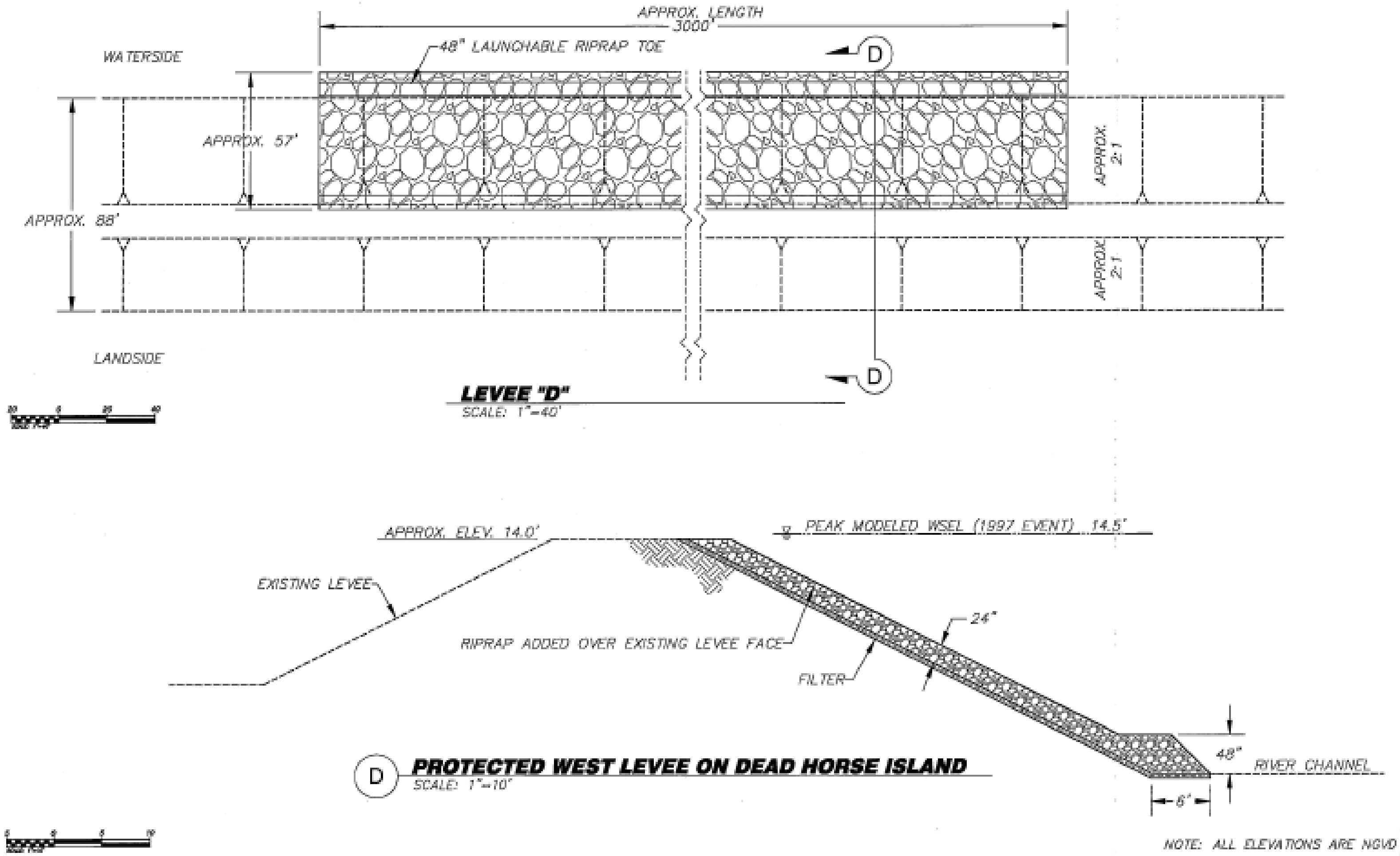


Figure 4.6: Levee Alterations to Dead Horse Island

Topography & DEM

If the topography of the McCormack-Williamson tract was left in its existing conditions, except for the levee degrading, a majority of the land area would be converted into wetlands. However, due to the lack in topographic variation, the wetlands would be overtaken by tule, leading to a monotypical habitat type. Creating channels deeper than 6' would prevent tules from growing in those areas because that is the extent that the roots can withstand.

By examining the historic channels in the SFEI report and maps, channel width, sinuosity, and curvature of the proposed channels were determined. Historically the main channels ranged from 80'-200' on the Mokelumne River surrounding the present day McCormack-Williamson Tract. These conditions were taken into consideration when designing the channels.

After the channel dimensions and locations were determined, islands were placed between the channels to provide mudflats for wading birds as well as upland habitat as refugia during high tides. These islands are shaped parallel to the existing levees to allow water to move through the site more efficiently. If the islands were placed facing east to west, the islands would block the flood waters, erode more quickly due to the increased hydraulic pressure, and result in an increase amount of suspended sediment in the water.

Figure 4.7: Existing Digital Elevation Model

Figure 4.8: Proposed Digital Elevation Model

Tide Levels

If the McCormack-Williamson tract's topography is left as is, there would be a deficiency in deep water habitat and upland habitat. By altering the topography of the tract, the habitat types can be controlled and designed in correlation with the needs of the focal species. The proposed topography provides a wider, range of habitat with more spatial heterogeneity.

Through the hydraulic modeling of Bill Fleenor, high and low tides were able to be determined. Low tide, if the southern levee was degraded, would be at 3.28' while high tide would be at 6.4'. Deep water is defined as about 6' under the surface of the water since that is the depth where rooted plants are not likely to survive (CWHR). The intertidal/mudflats consist of the area between high and low tide and are important source of food for wading birds. Upland is defined as being above the tidal influence.

	Existing		Proposed	
	Acres	Percent of Total Land	Acres	Percent of Total Land
Deep Water at Low Tide	0	0.00%	92	6.15%
Deep Water at High Tide	37.5	2.53%	422	28.36%
Shallow Water at Low Tide	729.5	49.20%	369	24.76%
Intertidal/Mudflats	651	43.91%	229	15.37%
Upland	64.6	4.36%	378	25.36%

Table 4.1: Inundation - Existing vs. Proposed

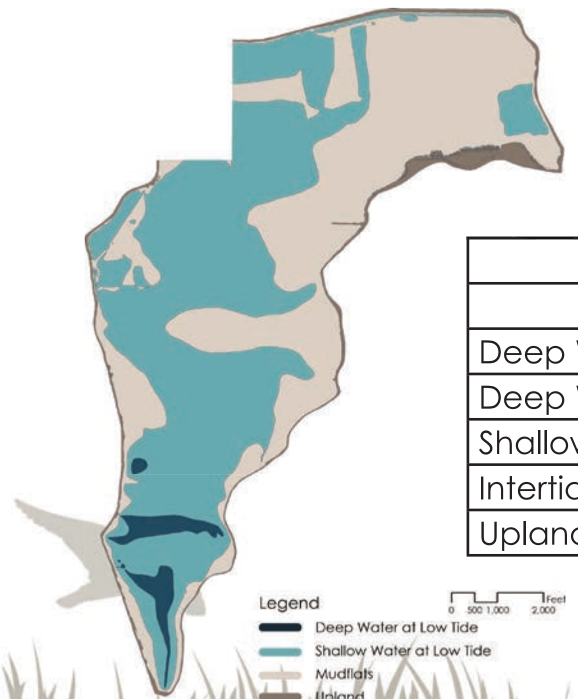


Figure 4.9: Existing Inundation if Southern Levee is Removed

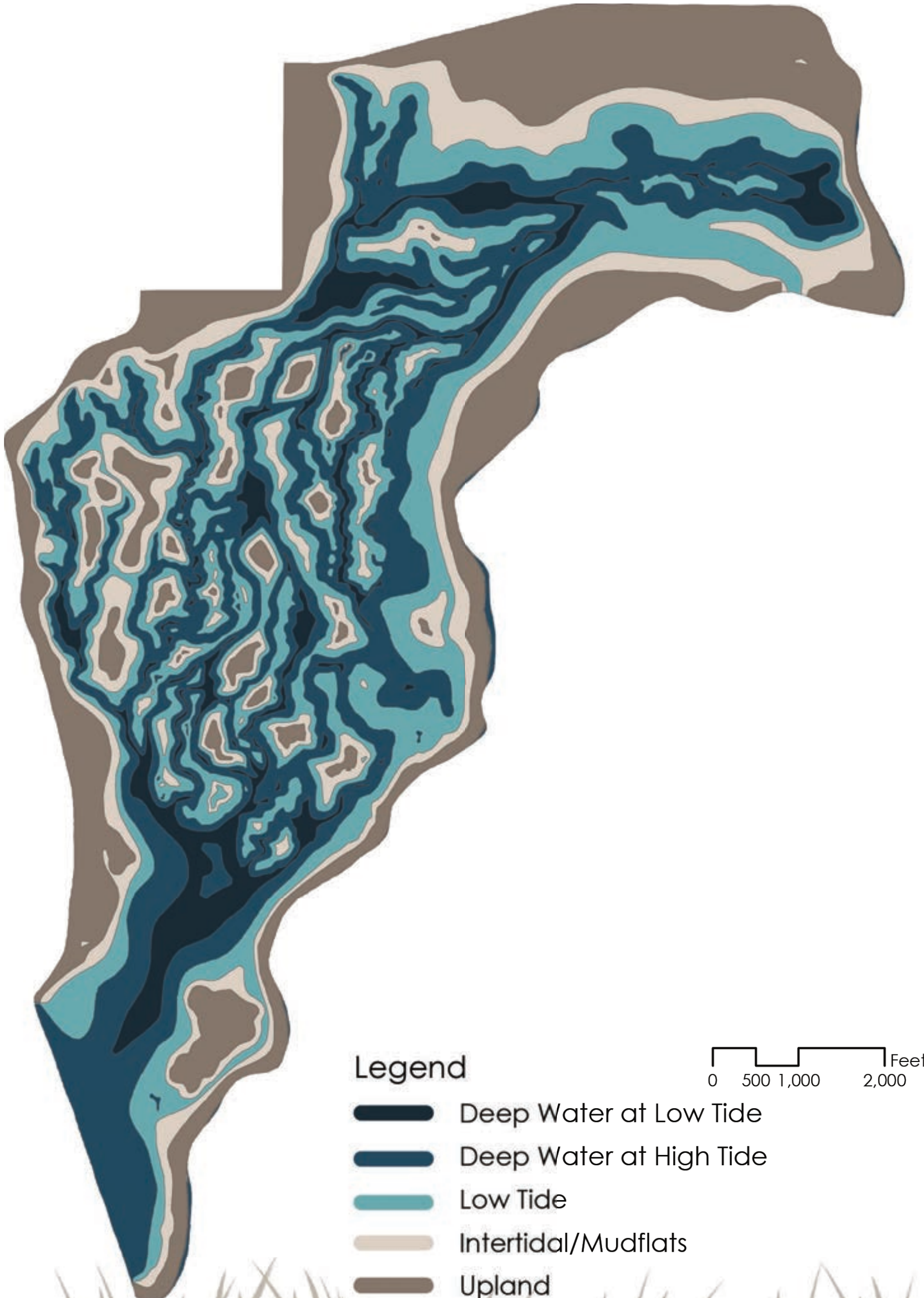
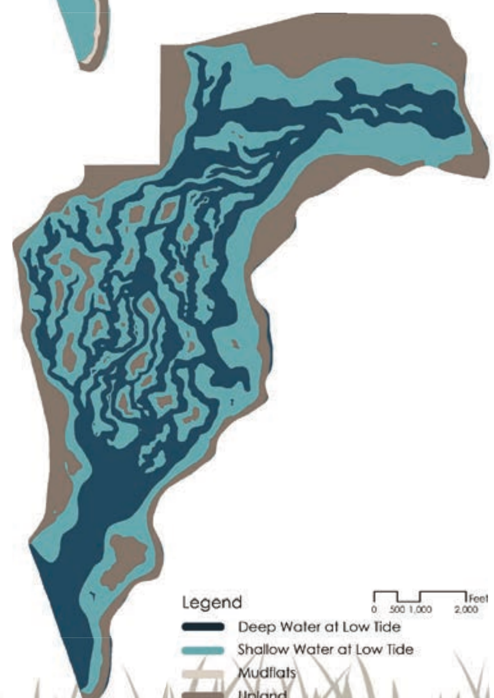


Figure 4.10: Proposed Inundation



Top: Figure 4.11: Proposed Design at Low Tide

Bottom: Figure 4.12: Proposed Design at High Tide

Habitat Types

If the McCormack-Williamson tract's topography is left as is the entire site would be inundated with shallow water and there would be a lack of scrub/riparian habitat. By altering the topography, a variety of habitat types can be created to provide for spatial heterogeneity and increase the habitat suitability for more species.

The proposed design features potholes, islands and upland habitat. Potholes are deeper sections of the water which provide cooler temperatures in the summer months and cover from aerial predators. Additionally, small island are distributed throughout the site to allow for refugia for species during high tide as well as flood events. In large storm events, animals can seek refuge either along the levees or on larger created mounds.

	Existing		Proposed	
	Acres	Percent of Land	Acres	Percent of Land
Deep Water	0.0	0%	91.61	6.15%
Wetland (Emergent/Intertidal)	1418.02	95.64%	1019.53	68.48%
Scrub/Riparian	43.79	2.95%	300.57	20.19
Grassland/Oak Woodland	20.88	1.41%	77.02	5.18%

Table 4.2: Habitat Types - Existing vs. Proposed

Deep water is defined as the lower limit of rooting plants to establish, roughly 2m or 6'. Wetlands are defined as emergent vegetation and intertidal lands. Scrub/Riparian was defined with an upper dominant limit of 400cm, 14', above the tidal influence and grassland/oak woodland was defined as above 400cm, 14' (Greco 480).

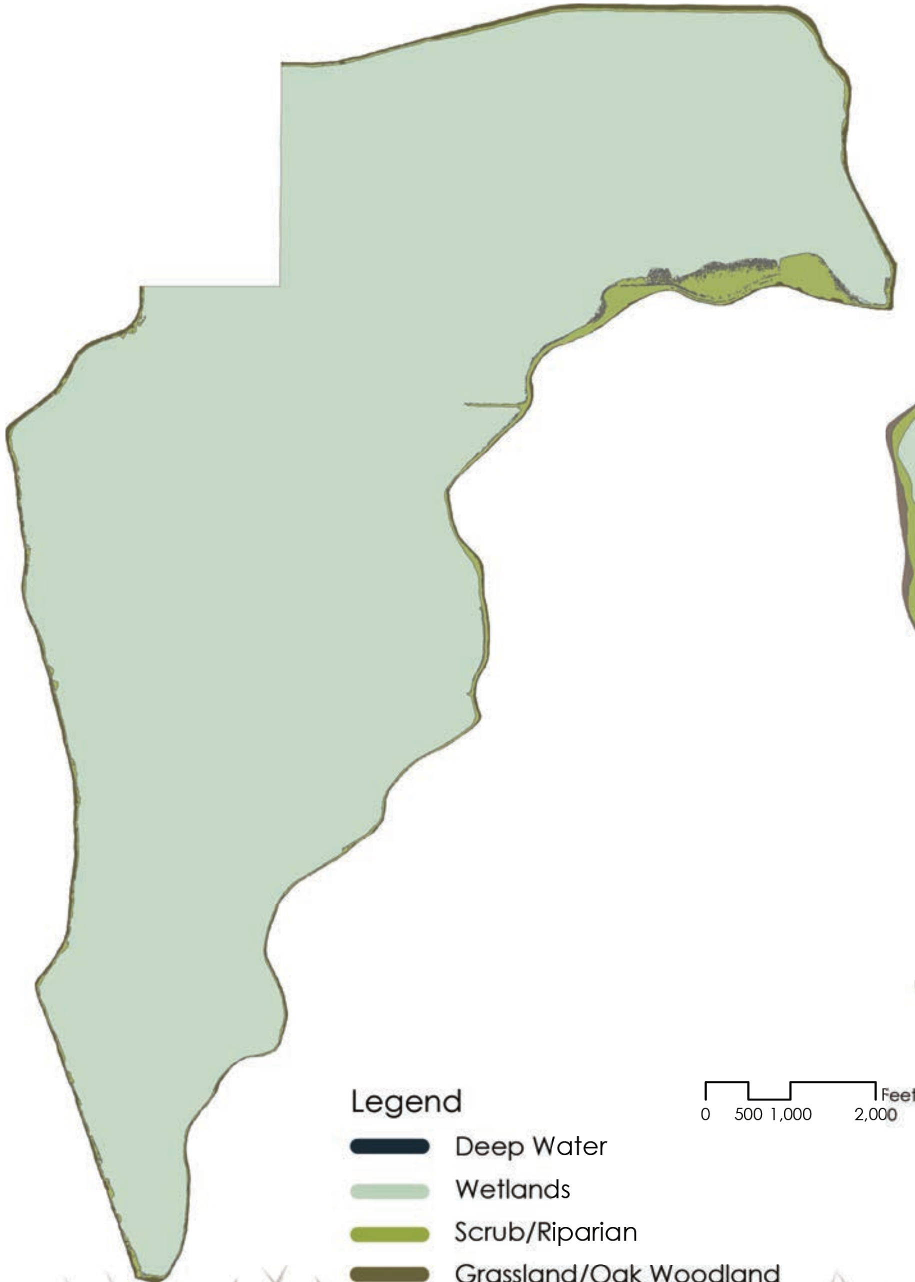


Figure 4.13: Existing Habitat Types Created if Southern Levee is Removed, Based on Elevations

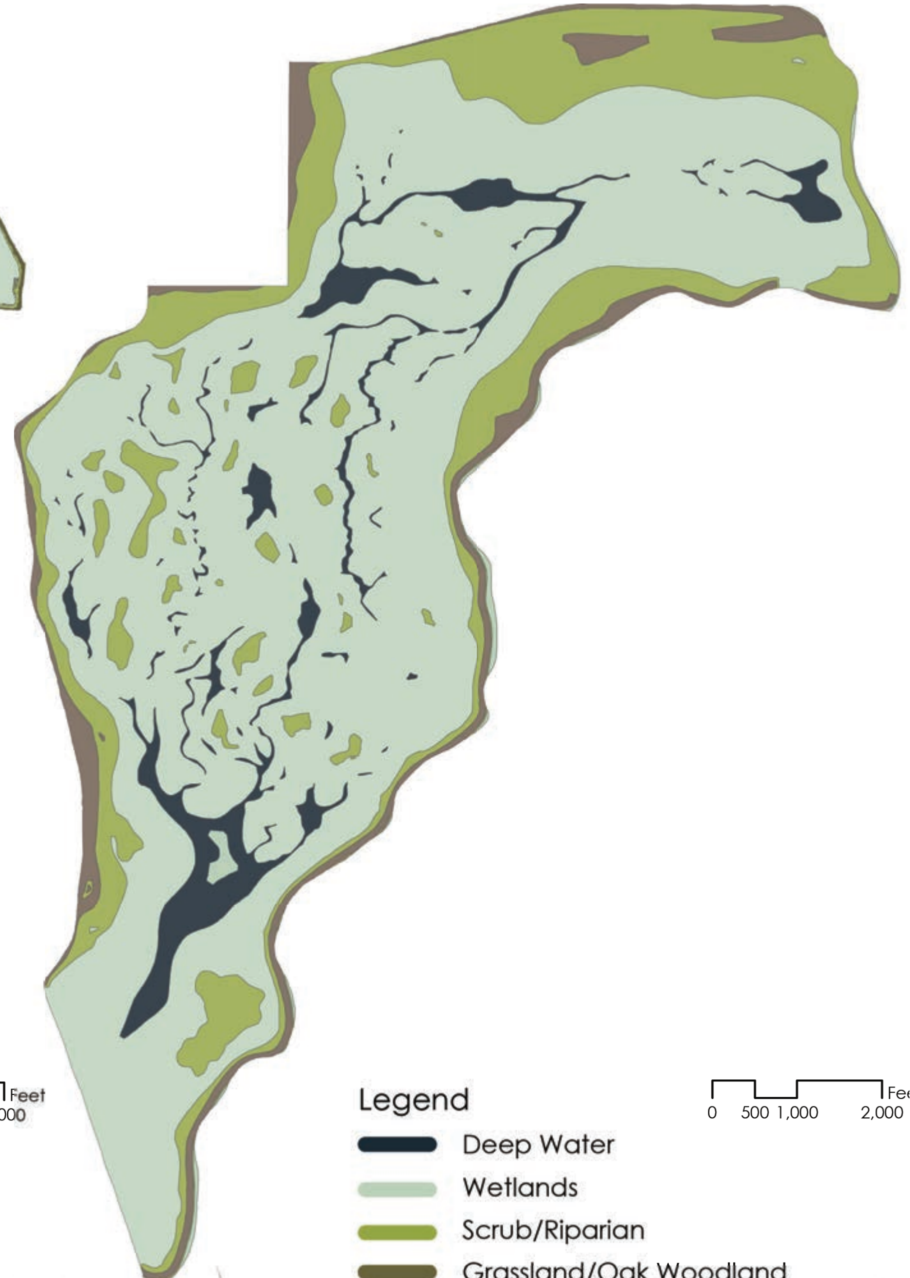


Figure 4.14: Proposed Habitat Types Based on Elevation

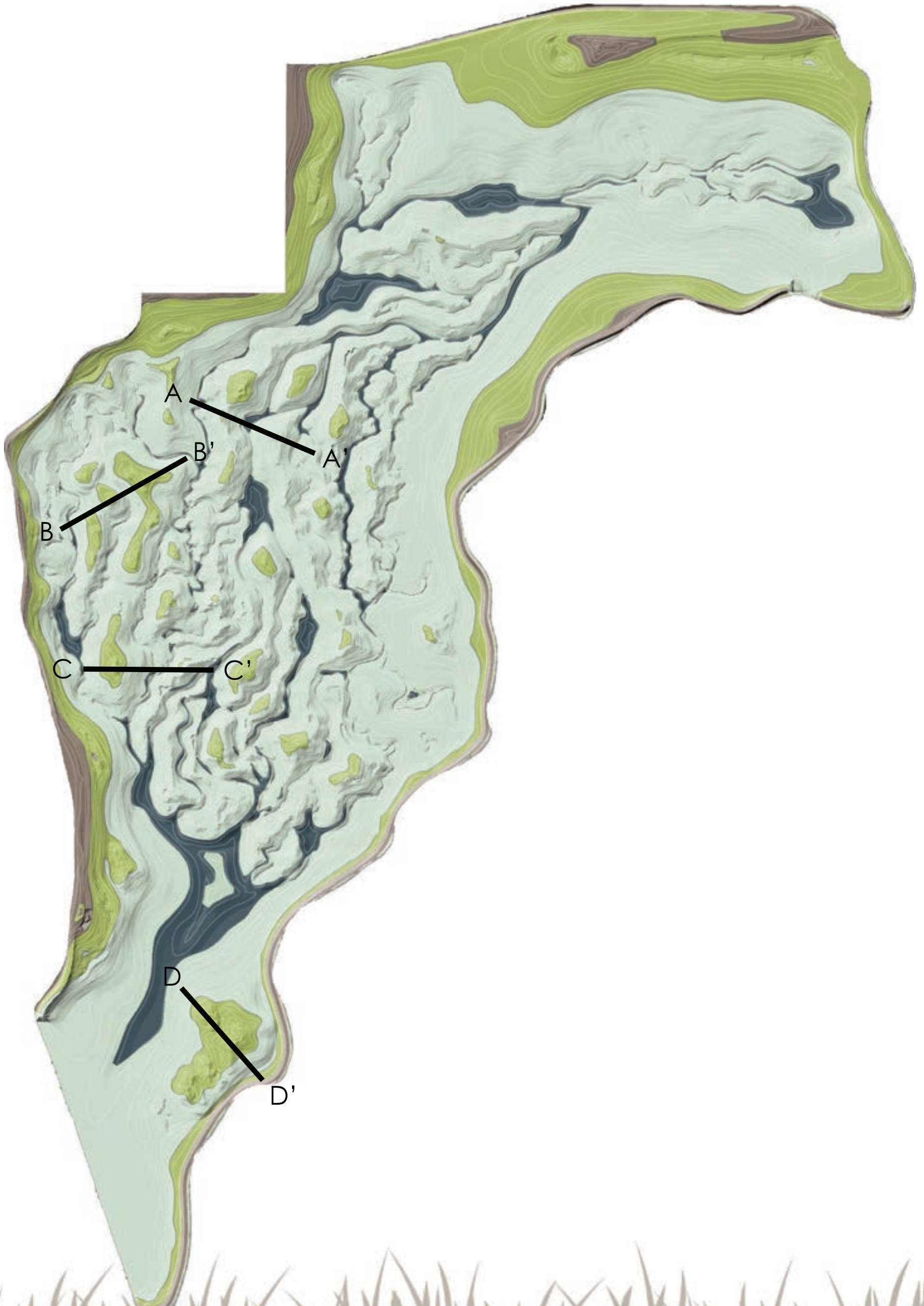


Figure 4.15: Habitat Master Plan

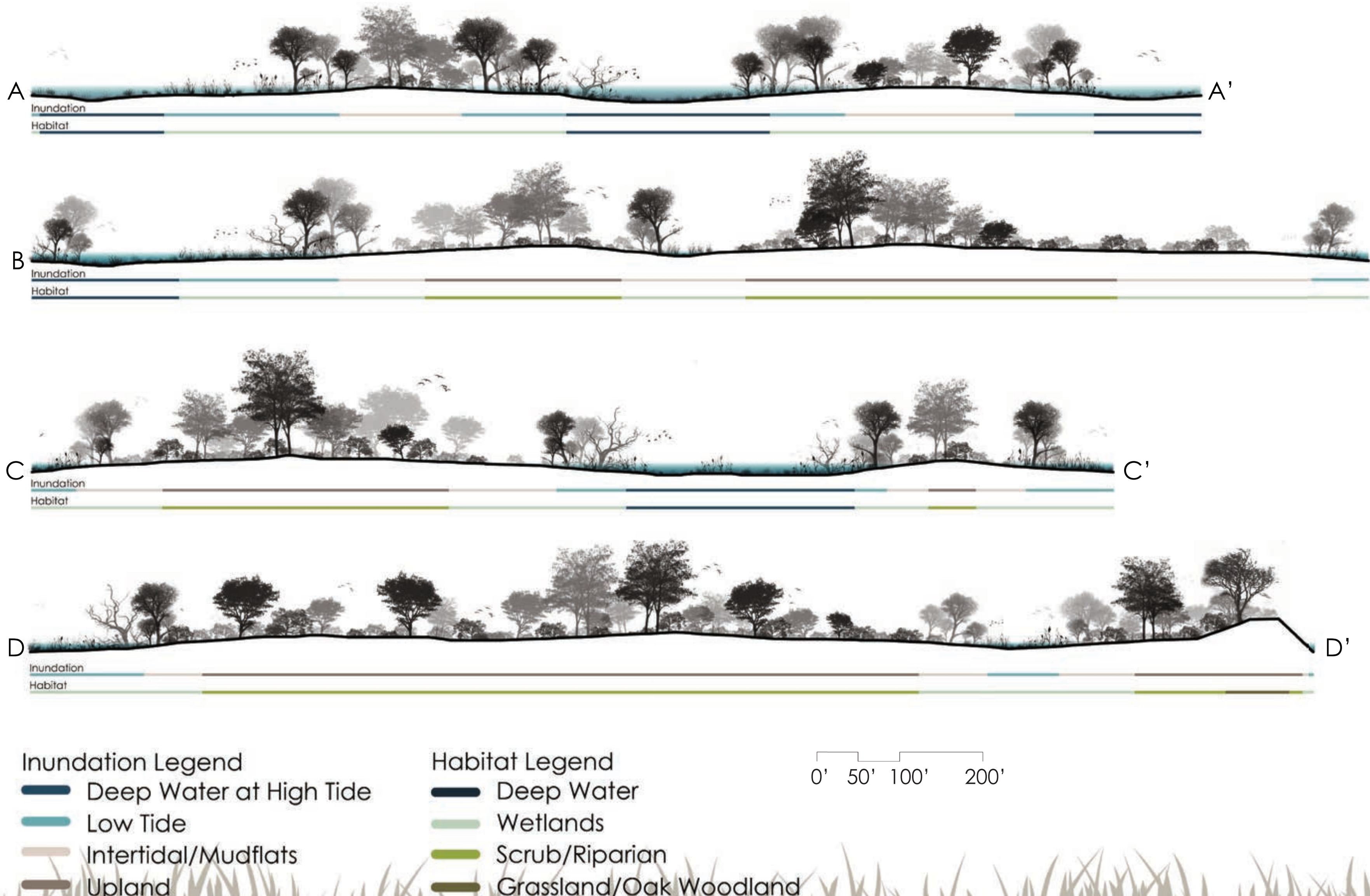


Figure 4.16: Sections

Linear Channels

The proposed design features 48.22km of channels, with a density of 8km/km^2. This historic ecology of the site, as provided by SFEI, show 12.67km of channels, with a density of 2.10 km/km^2. Although the proposed changes feature a significant increase in channel length and density, the data of the historic channels did not portray the smaller second and third order channels that were present, so a direct comparison is not possible.

By including an increased amount of channels, the acres of shaded riverine habitat and edge habitat for is also increased, which has direct benefits for fish populations. By having a variety of depths within the channels, the habitat types are increased which allows for a variety of species to utilize the site. For example, the Chinook Salmon only require water deep enough to cover their bodies to spawn while they prefer to seek refuge in deeper waters. By providing a variety of aquatic conditions, the site can be utilized at various stages of development as well. Juvenile salmon prefer to find cover in shaded aquatic habitat due to the amount of vegetation and prey that can be found there.

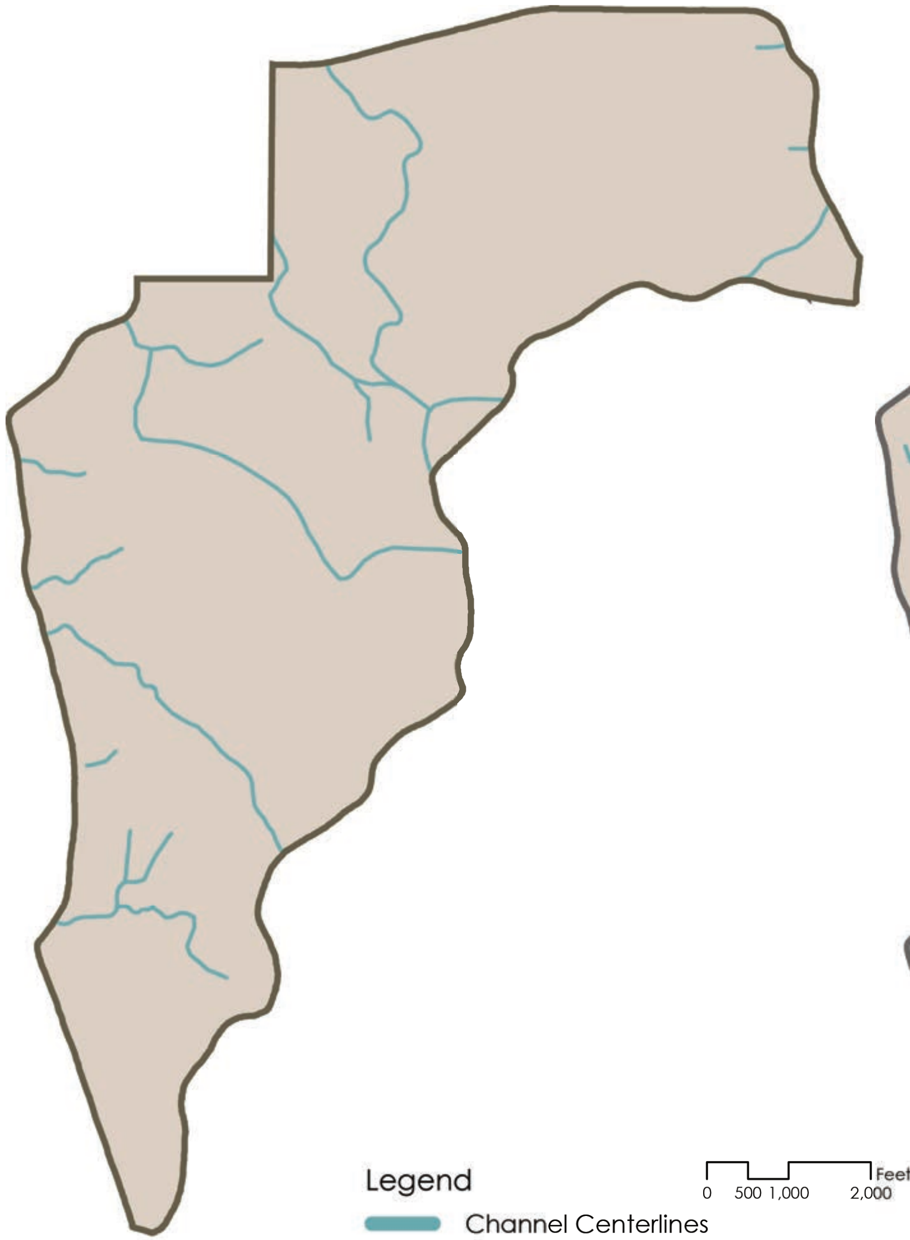


Figure 4.17: Historic Centerlines of Channels

Figure 4.18: Proposed Centerlines of Channels

Flooding

Flooding is a very important environmental aspect to take into consideration when designing habitat. Animal species need to be able to seek refuge in flood events to ensure the survival of their species.

By comparing the existing conditions to the proposed design, the amount of land either inundated or protected in various flood events can be determined. Although flood events will inundate a majority of the site, the proposed design provides refugia for land based animals during the 10 year event, while the existing conditions only provides refugia on the levees in either flood event.

The 1997 flood is estimated to be greater than the 100 year flood event. The height of the water at the New Hope Landing was 13.7' NGVD. During the 1998 flood, the water rose to an elevation of 9' NGVD at New Hope Landing, which is estimated to represent a 10 year event (California Department of Water Resources).

	Existing		Proposed	
	Acres	Percent Covered	Acres	Percent Covered
Flooded in 10yr Event	1447	97.58%	1274	85.55%
Flooded in 100yr Event	17	1.12%	149	9.98%
Safe in 100yr Event	19	1.30%	66	4.47%

Table 4.3: Flooding Event Influence - Existing vs Proposed

Figure 4.19: Existing Conditions during Flood Events

Figure 4.20: Proposed Changes during Flood Events

Cut & Fill

Although all of these design considerations are important, feasibility for constructed is also an important consideration. Optimally, the amount of cut and fill on a site should be equal in order to decrease construction costs, although this is rarely the case. 518,101 cubic yards of fill is needed to construct this design. In comparison, there are plans to fill Little Franks Tract and Bethel tract with 1 million cubic yards. Therefore, the need for half of a million cubic yards at the McCormack-Williamson tract is reasonable.

Figure 4.21: Cut vs. Fill if Proposed Conditions are Constructed

Figure 4.22: Lack of Elevation at McCormack Williamson

Conclusion

By altering the topography of the McCormack-Williamson tract, the habitat types can be controlled and designed in correlation with the needs of the focal species. If the McCormack-Williamson tract was left in its current conditions, except for the proposed levee changes, the entire tract would be inundated by shallow water. Due to the lack in topographic variation, a monotypic habitat would be created as it would be overrun with tule. The creation of deep channels would prevent tule from dominating the tract and would increase the variation of habitats. Created Islands would also be created to allow for terrestrial species to colonize and provide high ground refugia during flood events. Overall, the proposed changes to the McCormack-Williamson tract provide more habitat heterogeneity to accommodate a large variety of species.

Bibliography

1940. Delta Revision. Web. 1 June 2014. <http://www.deltarevision.com/2011/historic-timeline/historic_maps/1940sacriver_flood_farmers.jpg>.

1860. Delta Revision. Web. 1 June 2014. <http://www.deltarevision.com/2011/historic-timeline/historic_maps/san_joaquin_river_1860.jpg>.

Barendregt,A., P. Meire, and S. Van Damme. "Wetlands in the Tidal Freshwater Zone." Wetlands: Functioning, Biodiversity Conservation, and Restoration. By Roland Bobbink, Boudewijin Beltman, Jos T. Verhoeven, and Dennis Whigham. Berlin: Springer, 2006. 117-48. Springer Link. Web. 2 June 2014. <http://link.springer.com/chapter/10.1007/978-3-540-33189-6_6>.

Caflisch, Mary, Cathy Foster, Sarah White, and Katie Giacalone. "Shorescaping Freshwater Shorelines."South Carolina Waterways. Clemson University, Apr. 2013. Web. 02 June 2014. <http://www.clemson.edu/extension/hgic/water/resources_stormwater/shoreline_plants_in_south_carolina_waterfronts.html>.

California Department of Water Resources. Draft Environmental Impact Report: North Delta Flood Control and Ecosystem Restoration Project. Vol. 2. Sacramento, CA: California Dept. of Water Resources, 2007. Print.

California Department of Water Resources. North Delta Improvement Program - Conceptual Designs of Erosion Protection for Hydraulic Elements. N.p.: n.p., 2006. Print.

"California Wildlife Habitat Relationships." California Department of Fish and Wildlife. California Department of Fish and Wildlife, n.d. Web. 07 May 2014. <https://www.dfg.ca.gov/biogeodata/cwhr/>.

Chainey, Steve, Ed Whisler, Ed Wallace, and Paul Deering. Wildlife Habitat Enhancement and Management Plan for West Davis Pond. Sacramento, CA: Jones & Stokes Associates, 1989. Print.

"Chinook Salmon - Oncorhynchus Tshawytscha." NOAA. NOAA Fisheries - Office of Protected Resources, 15 May 2014. Web. 04 June 2014. <http://www.nmfs.noaa.gov/pr/species/fish/chinooksalmon.htm>.

Clark. 2011. Blogspot. Web. 3 June 2014. <http://livingthewildlifewithclark.blogspot.com/2011/08/aqua-kids-stormwater-treatment-wetland.html>.

"Delta Atlas." Bay Delta Office. Department of Water Resources, 1995. Web. 1 June 2014. <http://baydeltaoffice.water.ca.gov/DeltaAtlas/>.

"Delta Maps - Delta Levee Condition Maps." Delta Stewardship Council. Delta Stewardship Council, n.d. Web. 01 June 2014.

<http://deltacouncil.ca.gov/delta-maps>.

"Delta Species of Concern." CALFED Bay Delta Program. CALFED Bay Delta Program, n.d. Web. 07 May 2014. <http://www.calwater.ca.gov/delta/species/index.html>.

Department of Fish and Game. Sacramento Valley and Central Sierra Region.McCormack-Williamson Tract - Levee Habitat Assessment. By Jason Holley, Mark Philipp, Paul Forsberg, Frank Gray, and Kip Young. N.p.: n.p., 202. Print.

"Design for Anadromous Fish." River Partners. River Partners, n.d. Web. 04 June 2014. <http://www.riverpartners.org/resources/riparian-ecology/veg-wildlife-habitat/wildlife-habitat/design-for-fish.html>.

"Design for Birds." River Partners. River Partners, n.d. Web. 04 June 2014. <http://www.riverpartners.org/resources/riparian-ecology/veg-wildlife-habitat/wildlife-habitat/design-for-birds.html>.

"Ecological Tolerances of Riparian Plants." River Partners. River Partners, n.d. Web. 03 June 2014. <http://www.riverpartners.org/resources/riparian-ecology/veg-wildlife-habitat/ecological-tolerances/index.html>.

Greco, S. E., E. H. Girvetz, E. W. Larsen, J. P. Mann, J. L. Tuil, and C. Lowney. "Relative Elevation Topographic Surface Modelling of a Large Alluvial River Floodplain and Applications for the Study and Management of Riparian Landscapes." Landscape Research 33.4 (2008): 461-86. 16 July 2008. Web. <http://www.tandfonline.com/doi/abs/10.1080/01426390801949149#.U5VMkvldWul>.

Hickson, Diana, and Todd Keeler-Wolf. Vegetation and Land Use Classification and Map of the Sacramento-San Joaquin River Delta. N.p.: California Department of Fish and Game, 2007. Print.

Humple, D. and G. R. Geupel. 2004. Song Sparrow (Melospiza melodia). In The Riparian Bird Conservation Plan: a strategy for reversing the decline of riparian-associated birds in California. California Partners in Flight. http://www.prbo.org/calpif/htmldocs/riparian_v-2.html

"Hydrograph of Delta Cross Channel Gaging Station." Delta Revision. N.p., n.d. Web. 1 June 2014. <http://deltarevision.com/1848-1989_docs/1986-tyler_island_flood.pdf>.

Jeffres, Carson. N.d. California Water Blog. Web. 3 June 2014. <http://californiawaterblog.com/2012/04/16/when-good-fish-make-bad-decisions/>.

Katzev, David, Bob Battalio, and Chris Bowles. "McCormack-Williamson Tract, Habitat Friendly Levee Design." Letter to

Gilbert Cosio. 2005. N.p.: Philip Williams & Associates, 2005. 1-17. Print.

Natural Resource Conservation Service. Web. 3 June 2014. <http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/idpmcbr10757.pdf>.

"North Delta." Department of Water Resources. State of California, n.d. Web. 07 May 2014. <http://www.water.ca.gov/floodsafe/fessro/levees/north_delta/facts/opportunities.cfm>.

"North Delta." Department of Water Resources. State of California, n.d. Web. 04 June 2014. <http://www.water.ca.gov/floodsafe/fessro/levees/north_delta/photos/index.cfm>.

Panoramio. Web. 3 June 2014. <http://www.panoramio.com/user/5546276/tags/Round%20Valley%20Regional%20Park>.

"Physical River Processes." River Partners. River Partners, n.d. Web. 02 June 2014. <http://www.riverpartners.org/resources/riparian-ecology/physical-river-processes>.

"Riparian Plant Community Classification." River Partners. River Partners, n.d. Web. 02 June 2014. <http://www.riverpartners.org/resources/riparian-ecology/veg-wildlife-habitat/communities-classification/index.html>.

"Sacramento-San Joaquin Delta Historical Ecology Study." San Francisco Estuary Institute. San Francisco Estuary Institute, n.d. Web. 07 May 2014. <http://www.sfei.org/DeltaHEStudy>.

Sommer, Nobriga, Harrell, Batham, and Kimmerer. "Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival." (2001): n. pag. Department of Water Resources. Web. 3 June 2014. <http://www.water.ca.gov/aes/docs/Sommer_et_al_2001.pdf>.

"Species Account - Giant Garter Snake." U.S. Fish & Wildlife Service. U.S. Fish & Wildlife Service, Mar. 2013. Web. 3 June 2014. <http://www.fws.gov/sfbaydelta/species/giant_garter_snake.pdf>.

"Subsidence in the Sacramento-San Joaquin Delta." Department of Water Resources. State of California, n.d. Web. 01 June 2014. <http://www.water.ca.gov/floodsafe/fessro/subsidence.cfm>.

Thompson, John. "How the Sacramento-SanJoaquin Delta Was Settled." The Pacific Historian 3.3 (1959): 49-58. Delta Revision. College of the Pacific. Web. 1 June 2014. <http://deltarevision.com/1848-1989_docs/Pacific%20Historian1959_delta_history.pdf>.

U.S. Fish and Wildlife Service. Draft Recovery Plan for the Giant Garter Snake (Thamnopsis Gigas). By Karen J. Miller and Kelly Hornaday. N.p.: U.S. Fish and Wildlife Service, 1999. Print.