Restoring Salmon Creeks Tidal Processes to Create a Diversity of Estuarine Habitats

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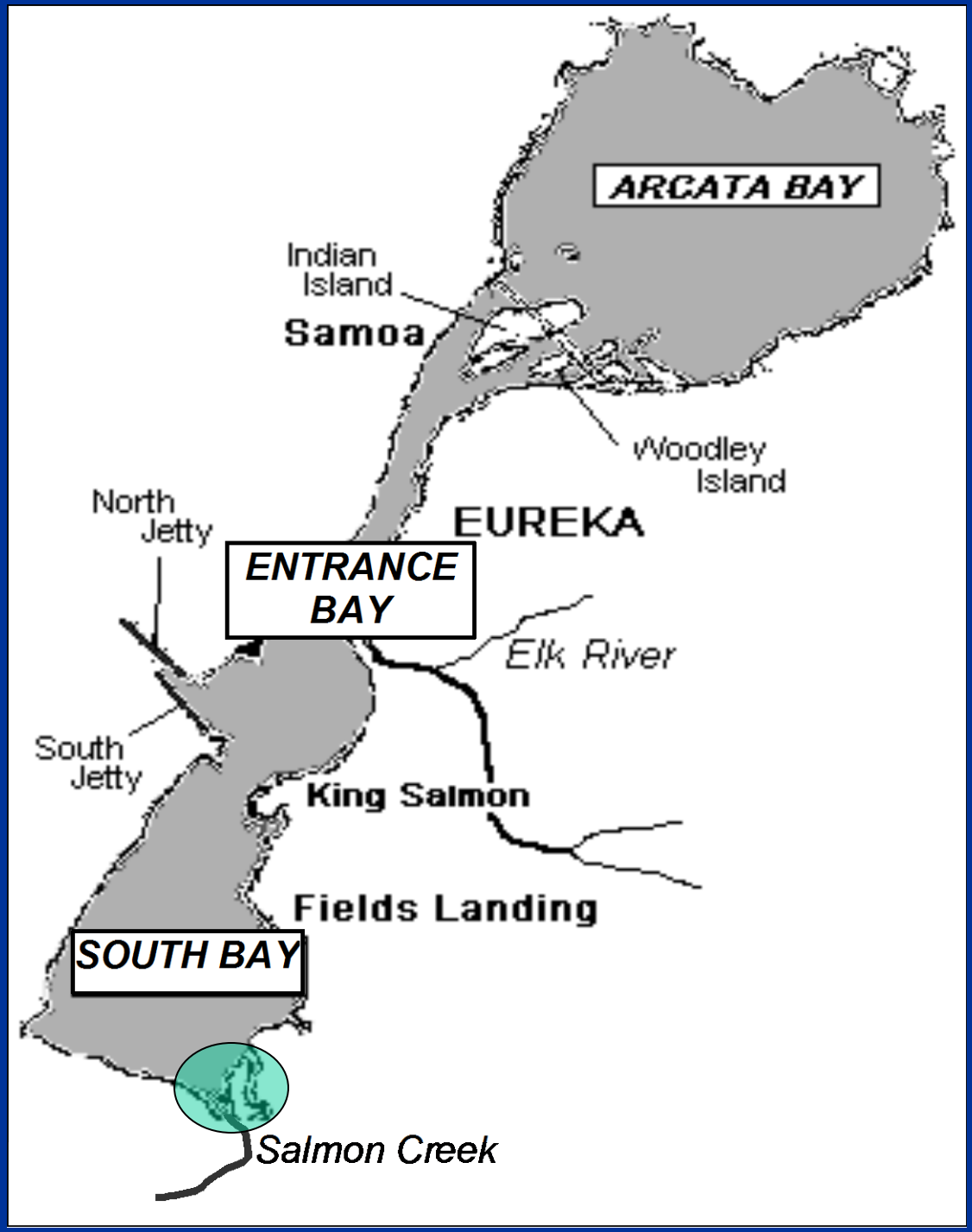
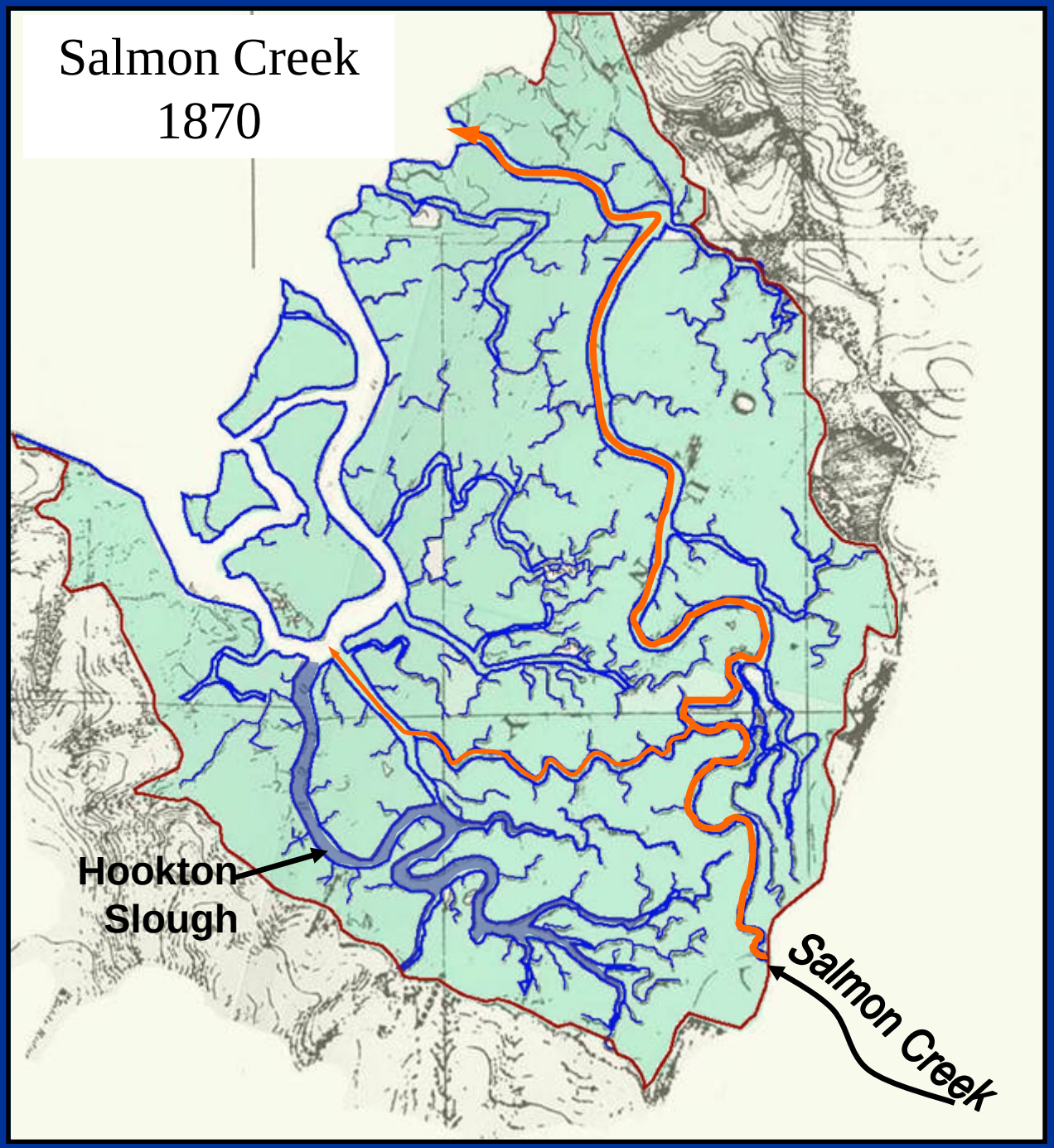

ARCATA BAY
Indian Island
Samoa
Woodley Island
North Jetty
EUREKA
ENTRANCE BAY
Elk River
South Jetty
King Salmon
Fields Landing
SOUTH BAY
Salmon Creek



Salmon Creek

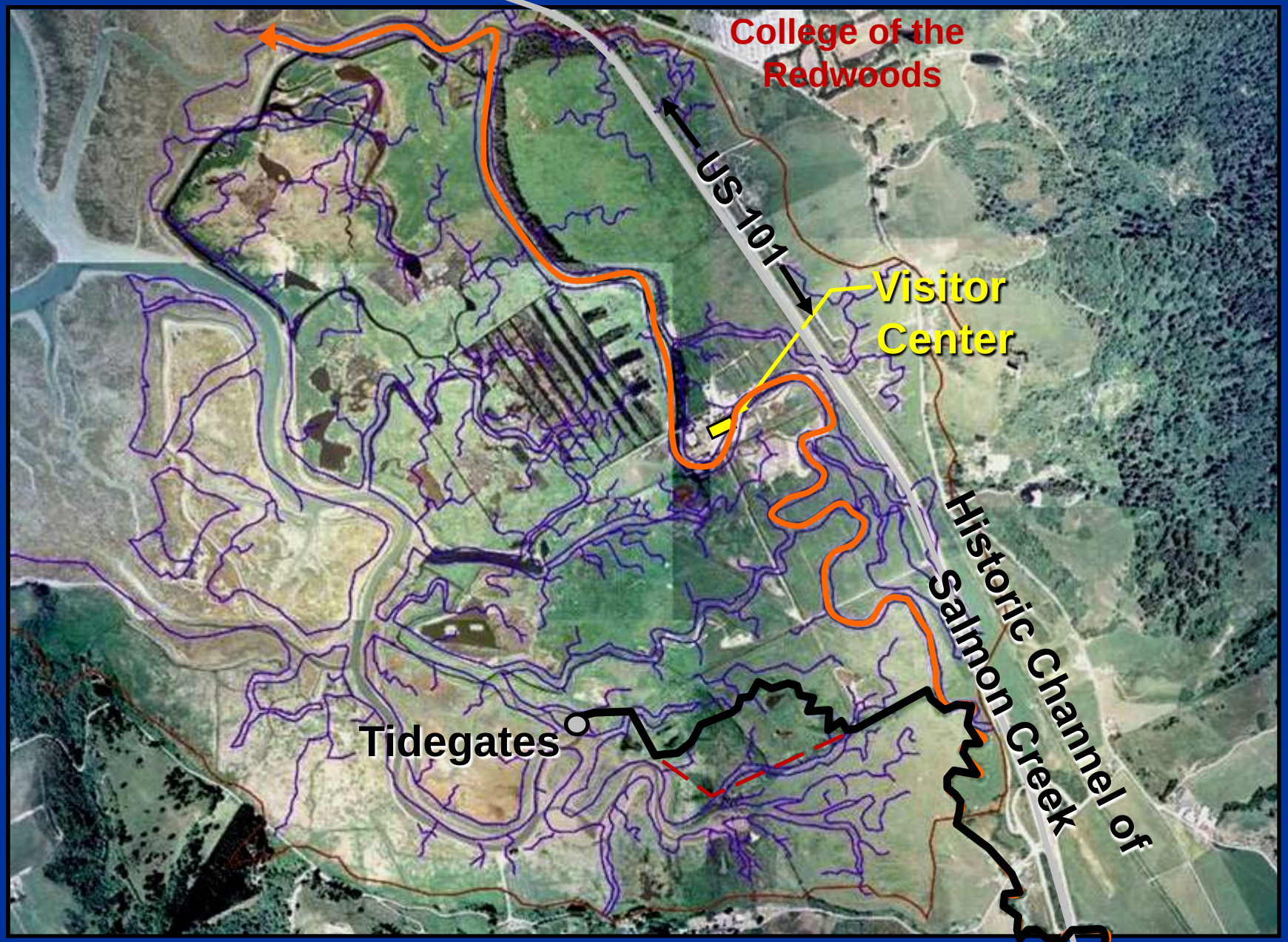
Drainage Area = 18 mi^2

Ave. Rainfall: 40-65 in/yr

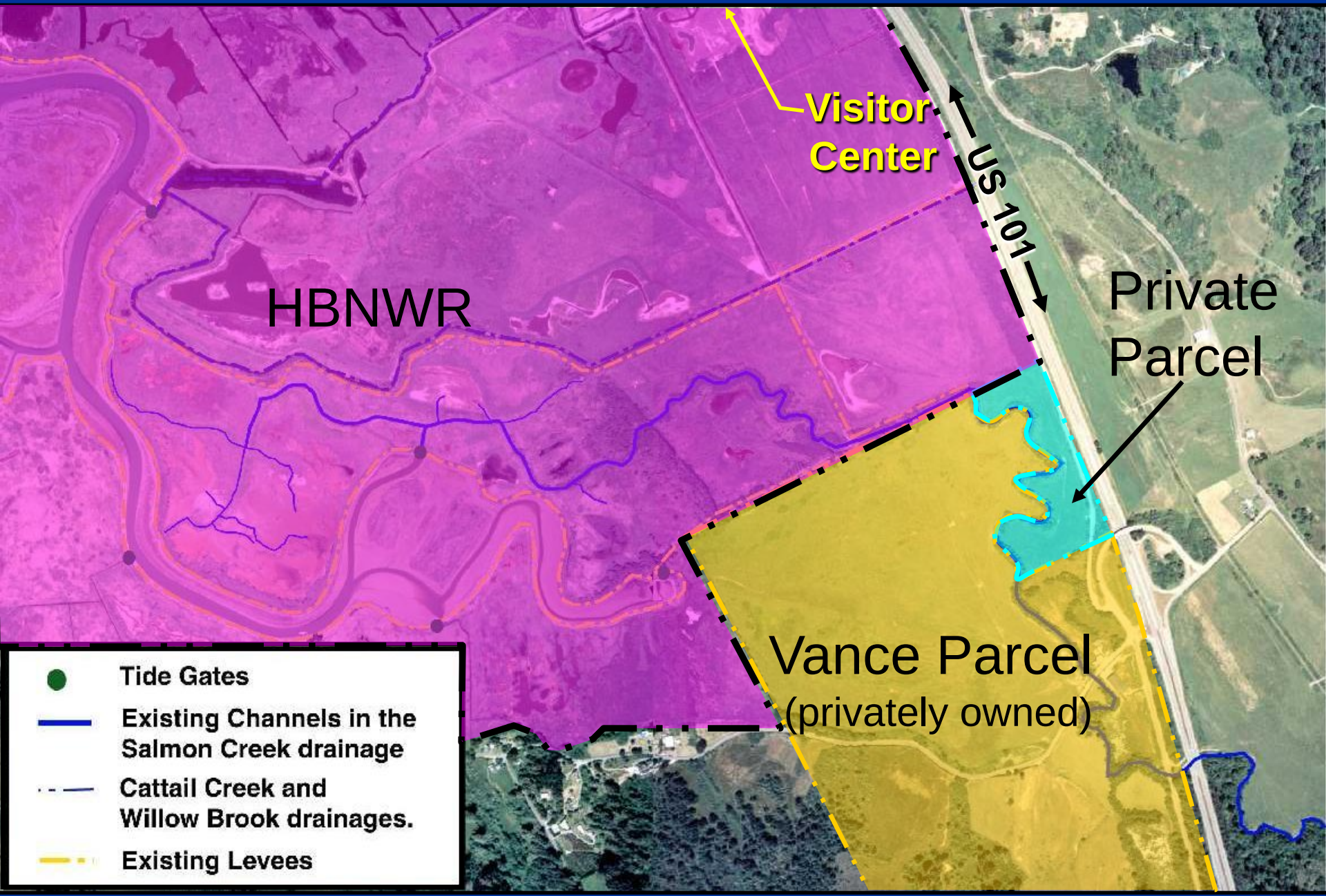
Species: coho, chinook, steelhead, cuttroat trout

Timeline of Salmon Creek

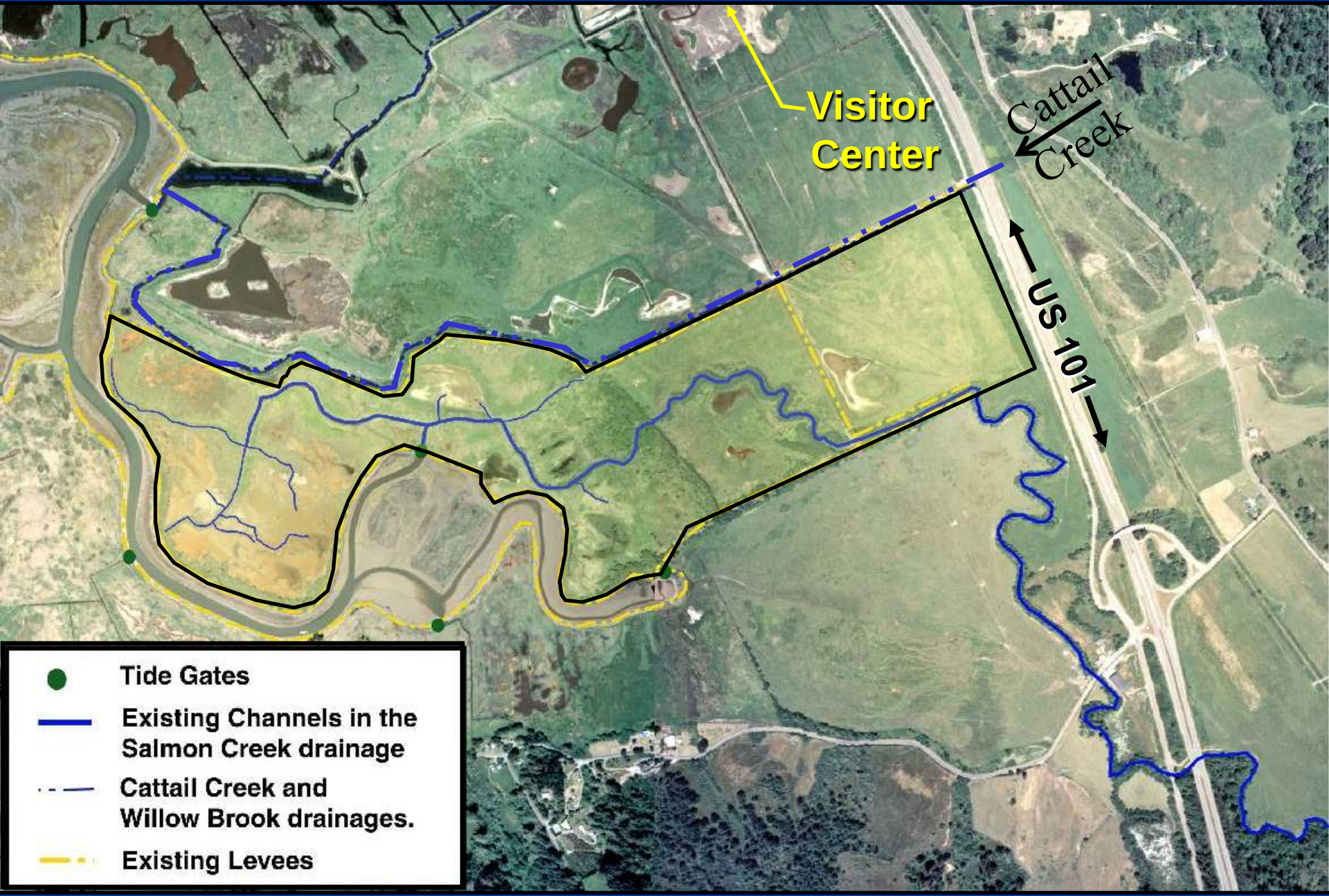
- **Pre-1850:** Wiyot Tribe maintains seasonal fishing village at Salmon Creek Delta. (Pop. ~1,000)
- **1856:** First timber mill and harvest in Salmon Creek watershed, by 1900 much of the basin was logged
- **1883:** Hookton channel first dredged for barging timber
- **1900:** Conversion of saltmarsh to agricultural lands by Z. Russ and Sons Company; Salmon creek channelized, tidegates and diversion structures constructed
- **1971:** Refuge created. Enhancement projects include; creation of freshwater ponds, construction of 2,500 ft of meandering stream, tree planting, installation of "fish door" in tide gate


College of the Redwoods
US 101
Visitor Center
Historic Channel of Salmon Creek
Tidegates

Property Boundaries within Salmon Creek Delta

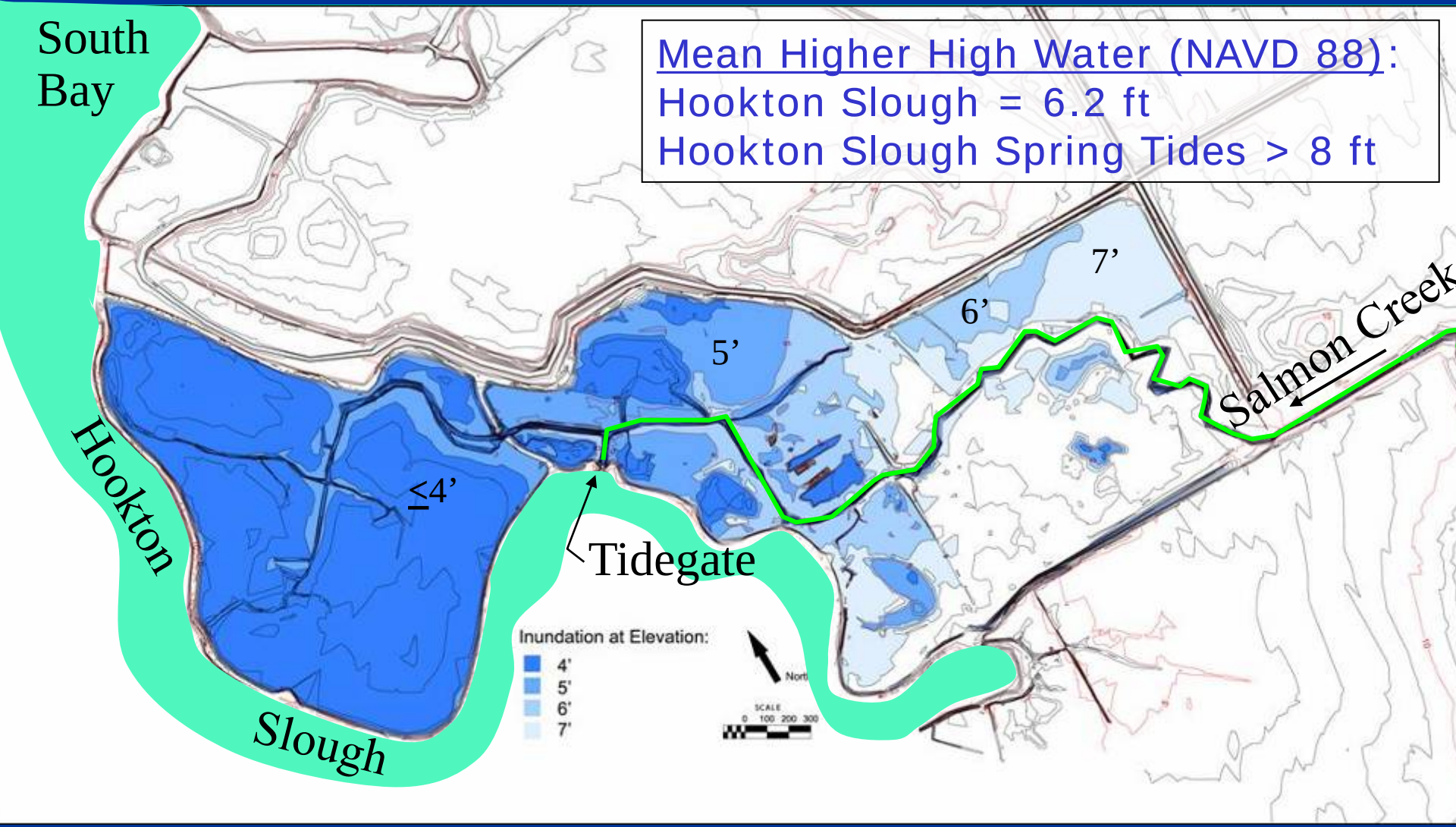


Focus Area for Salmon Creek Estuary Enhancement

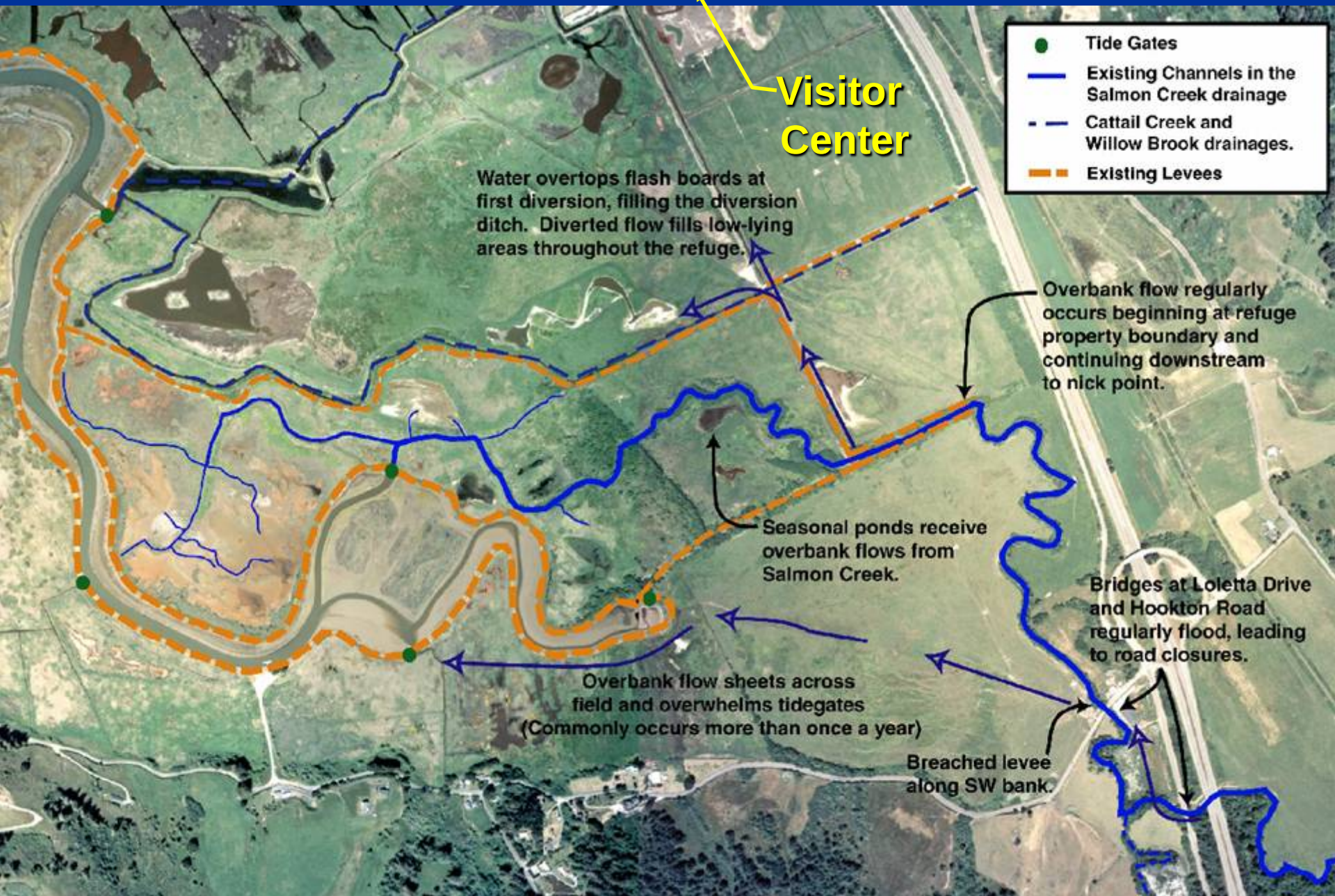


Ground Elevations

Salmon Creek – Humboldt Bay

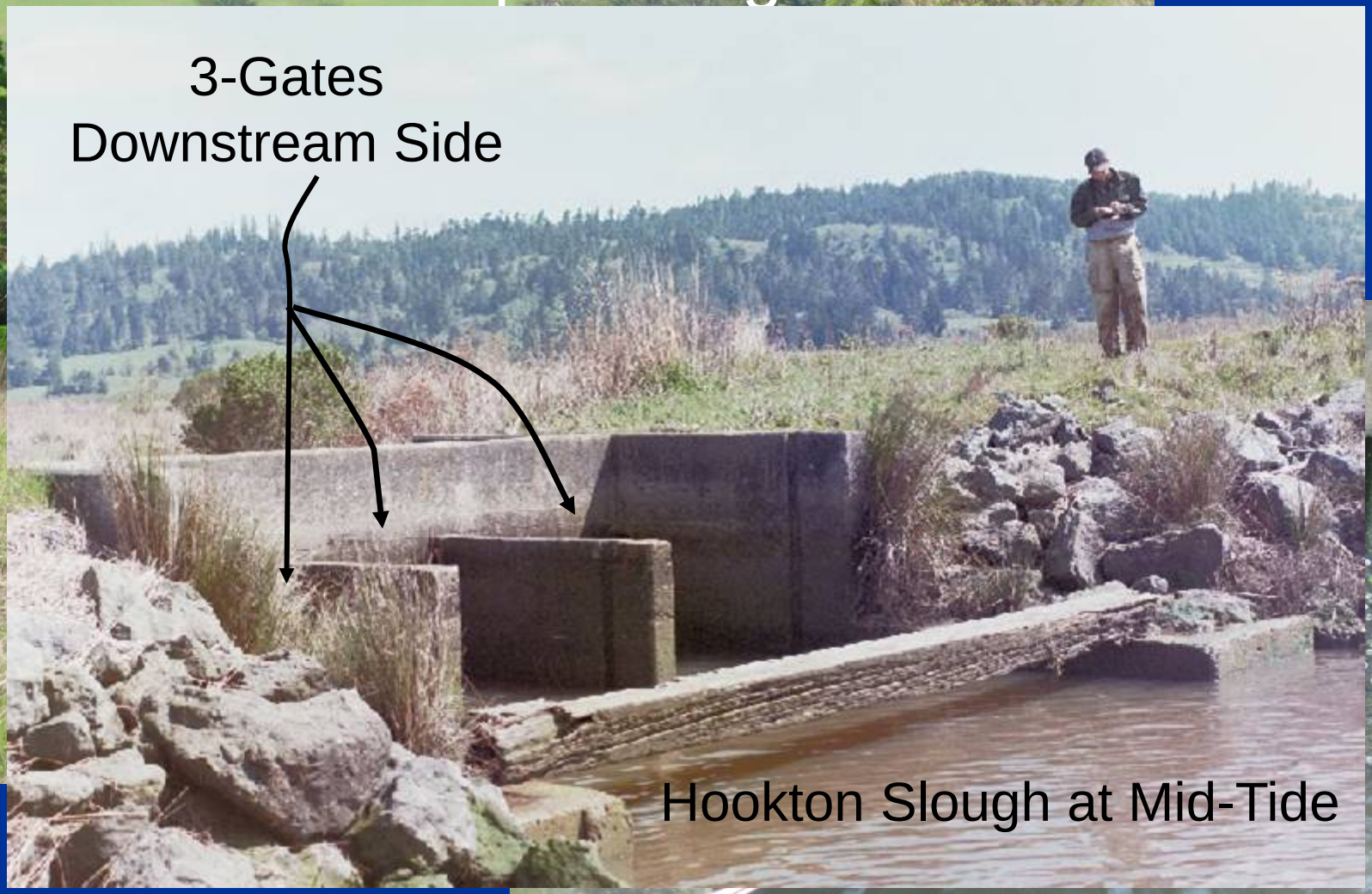


Pre-Project Hydrologic Conditions

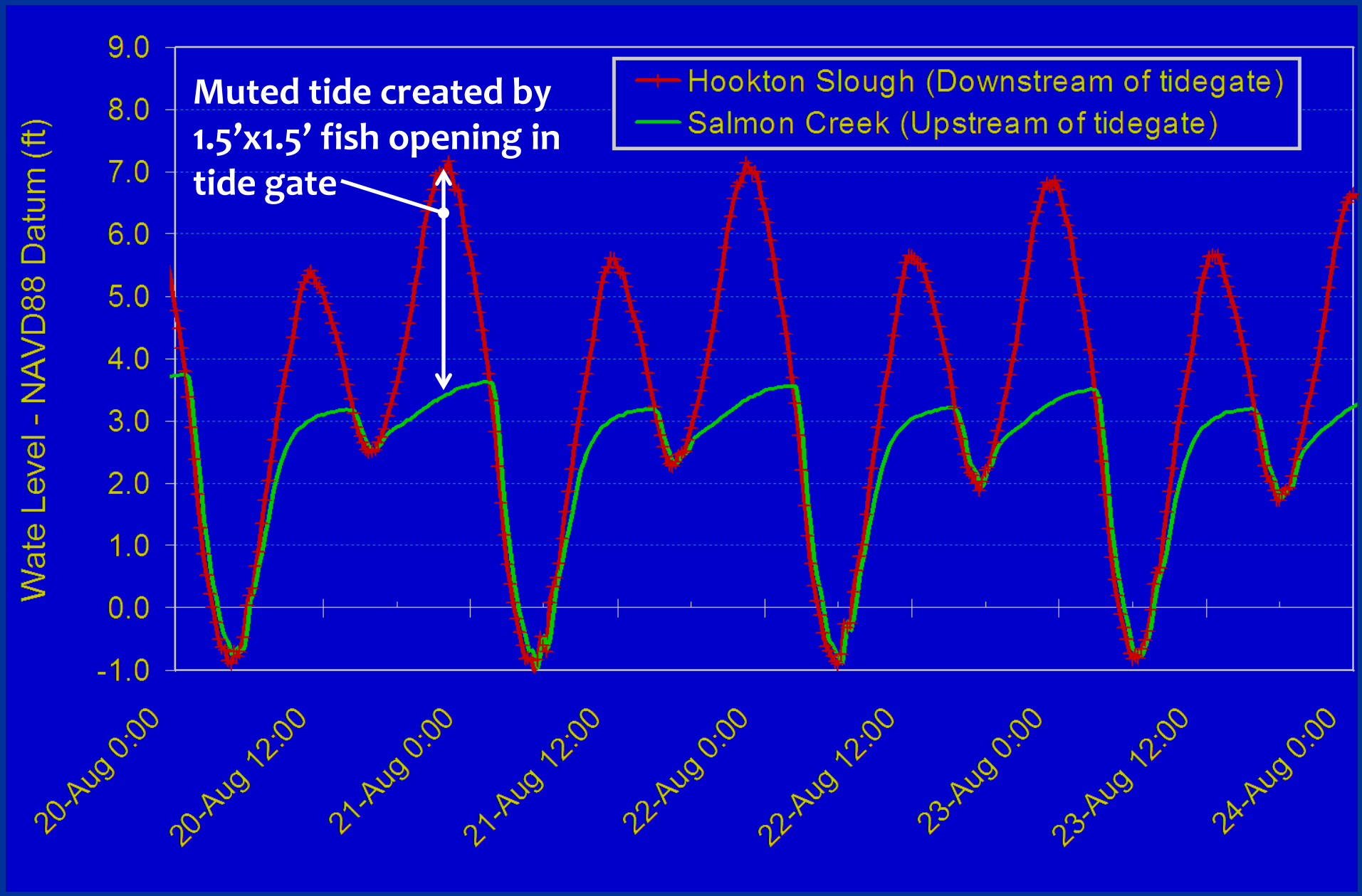


Channel Avulsions

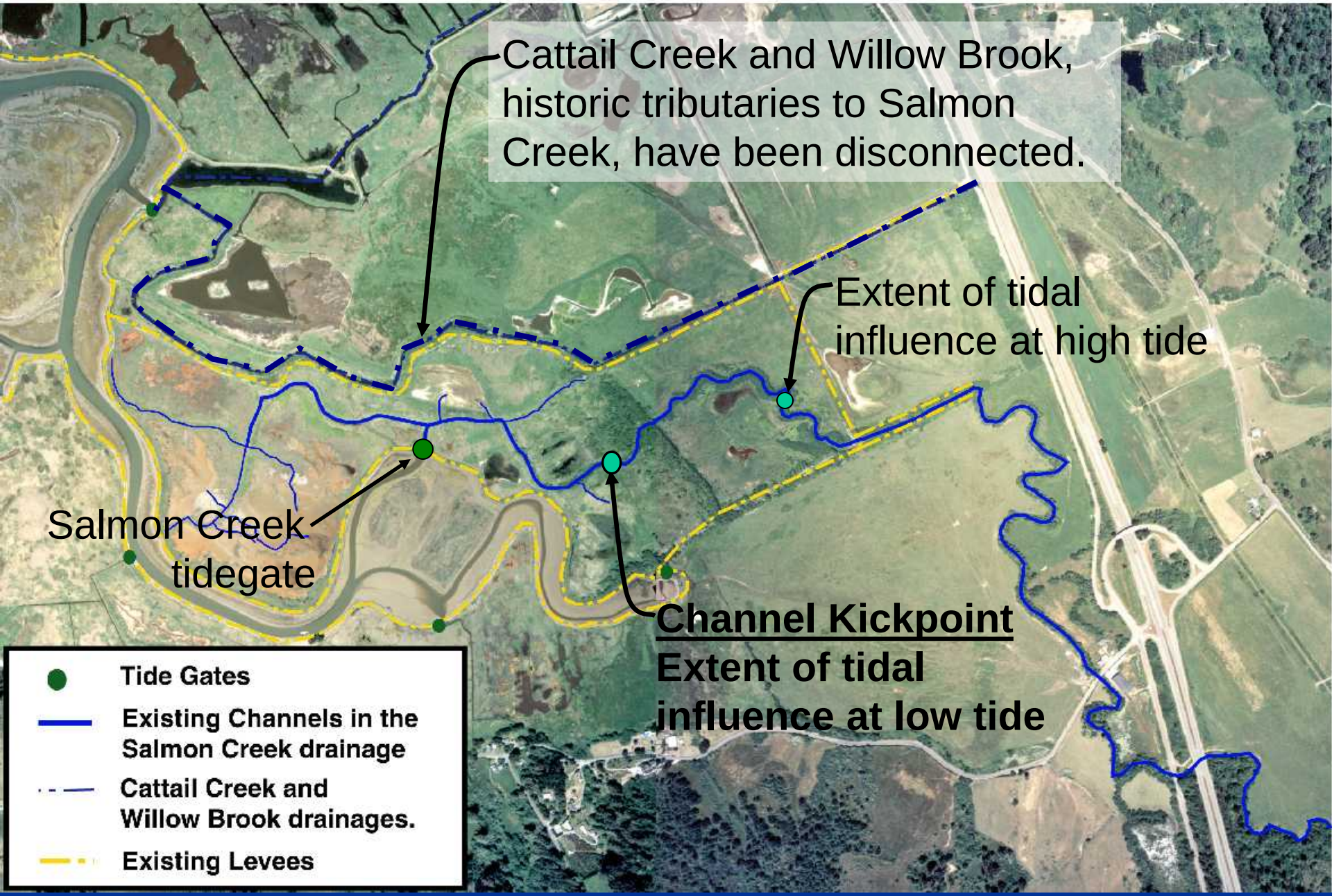
Salmon Creek Tidegate
Partial Barrier to Spawining Salmonids



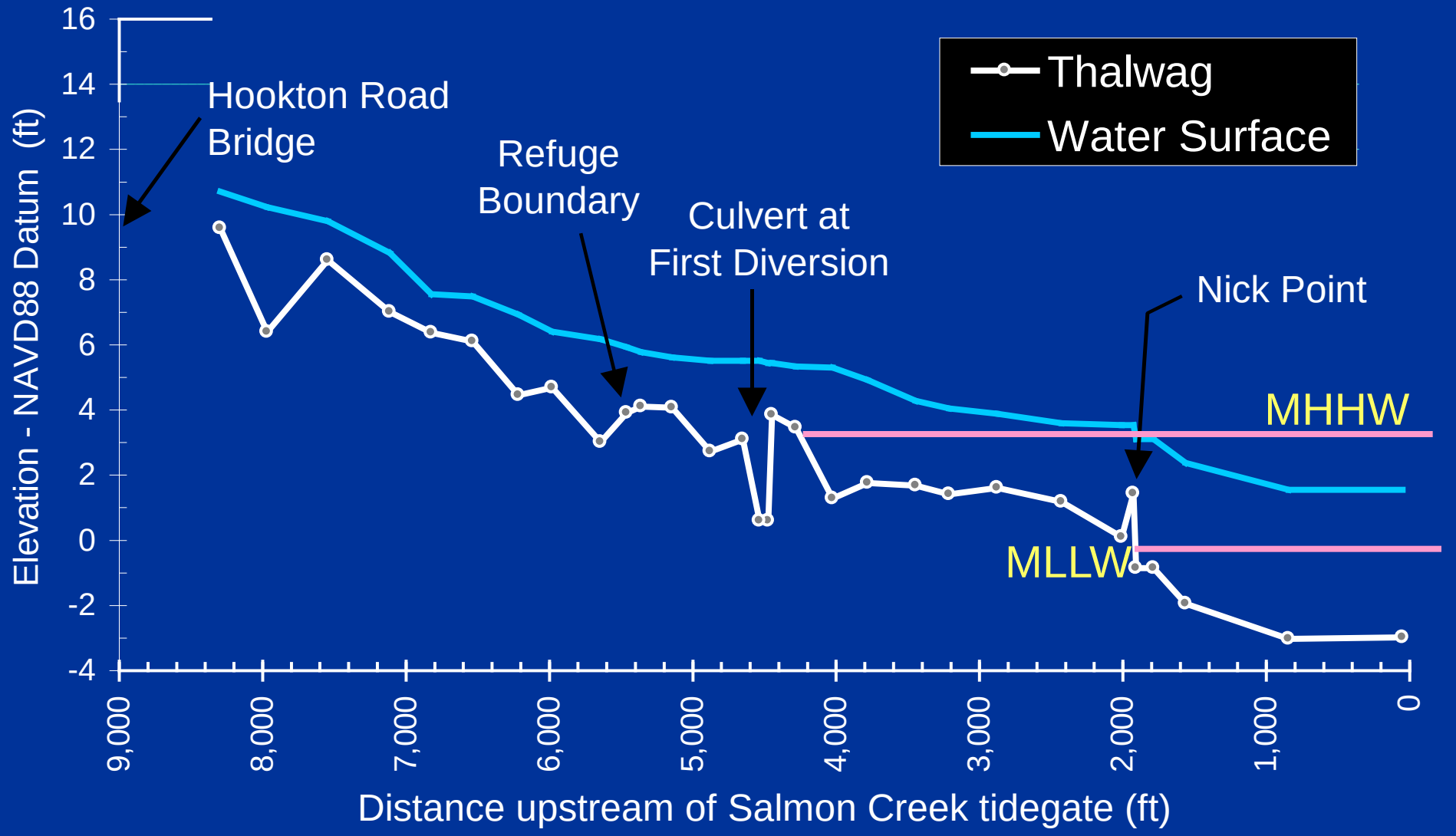
Pre Project Tide Cycles
Upstream and Downstream of the Salmon Creek Tide Gate



Salmon Creek Delta - Existing Conditions



Profile – Existing Channel



Surveyed May, 2002

Project Goals and Objectives

Enhance the diversity of the Salmon Creek Estuary while working within the physical constraints and multi-species management objectives of the Refuge

1. Improve fish passage into Salmon Creek
2. Create estuarine diversity (an ecotone) extending into the Upper Refuge
3. Create stable channel size for increased tidal prism
4. Improve floodplain connectivity & drainage
5. Reduce fish stranding
6. Create off-channel ponds and marshes suitable for salmonids and other estuarine fish
7. Raise subsided land to reestablish native saltmarsh

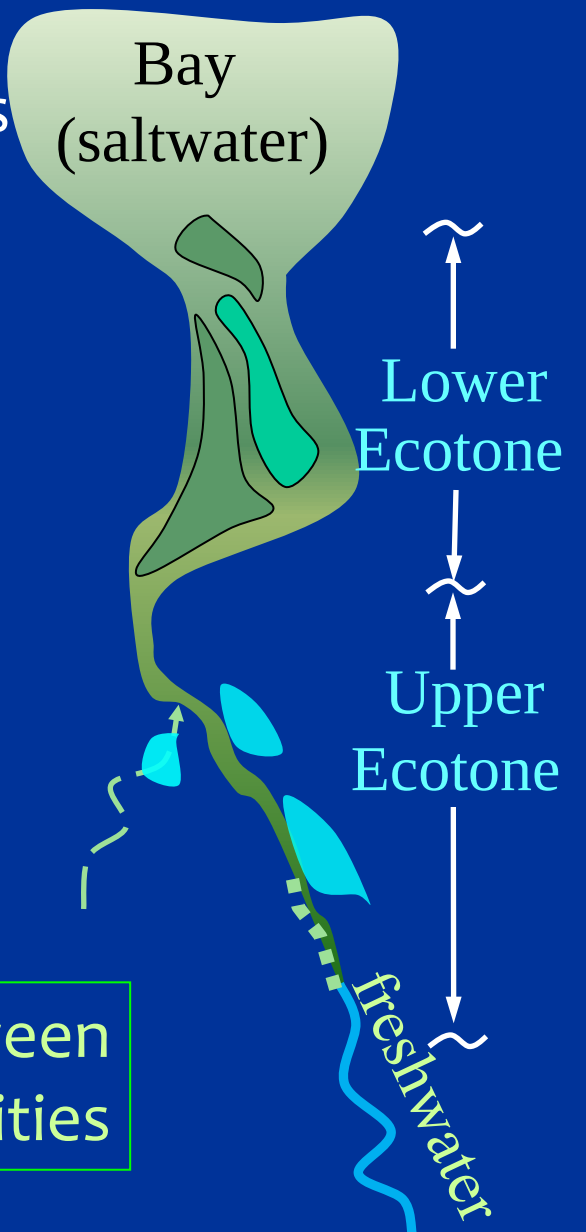
Expanding the Freshwater-Saltwater Ecotone

Lower ecotone consists of multiple channels

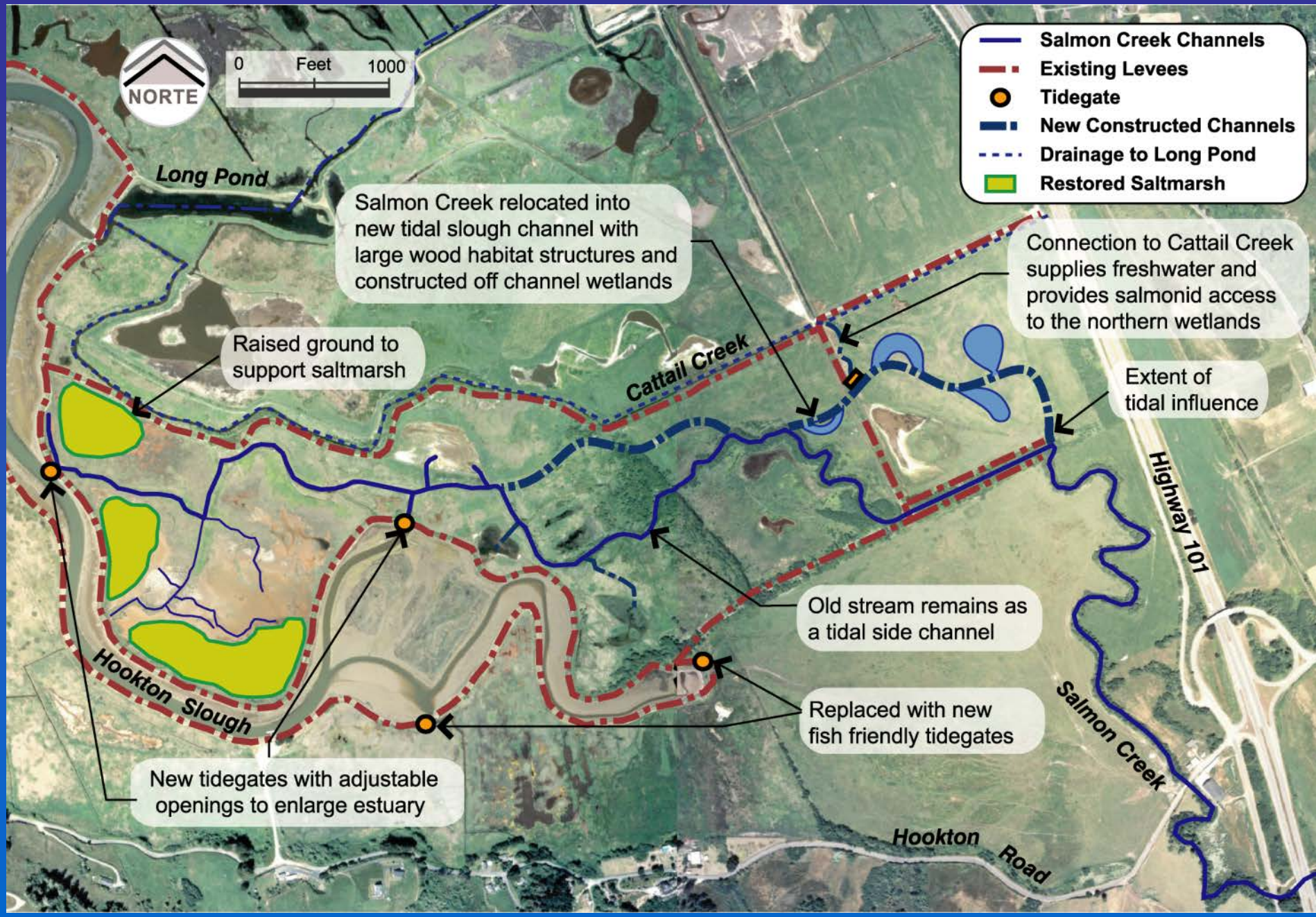
- Fresh-saltwater interface at high flows
- Continuous tidal influence (below MLLW)

Upper ecotone consists of single channel with off-channel wetlands

- Brackish at low flows
- Influenced during higher tides and higher flows.



Ecotone – Zone of gradual transition between two distinct ecological communities

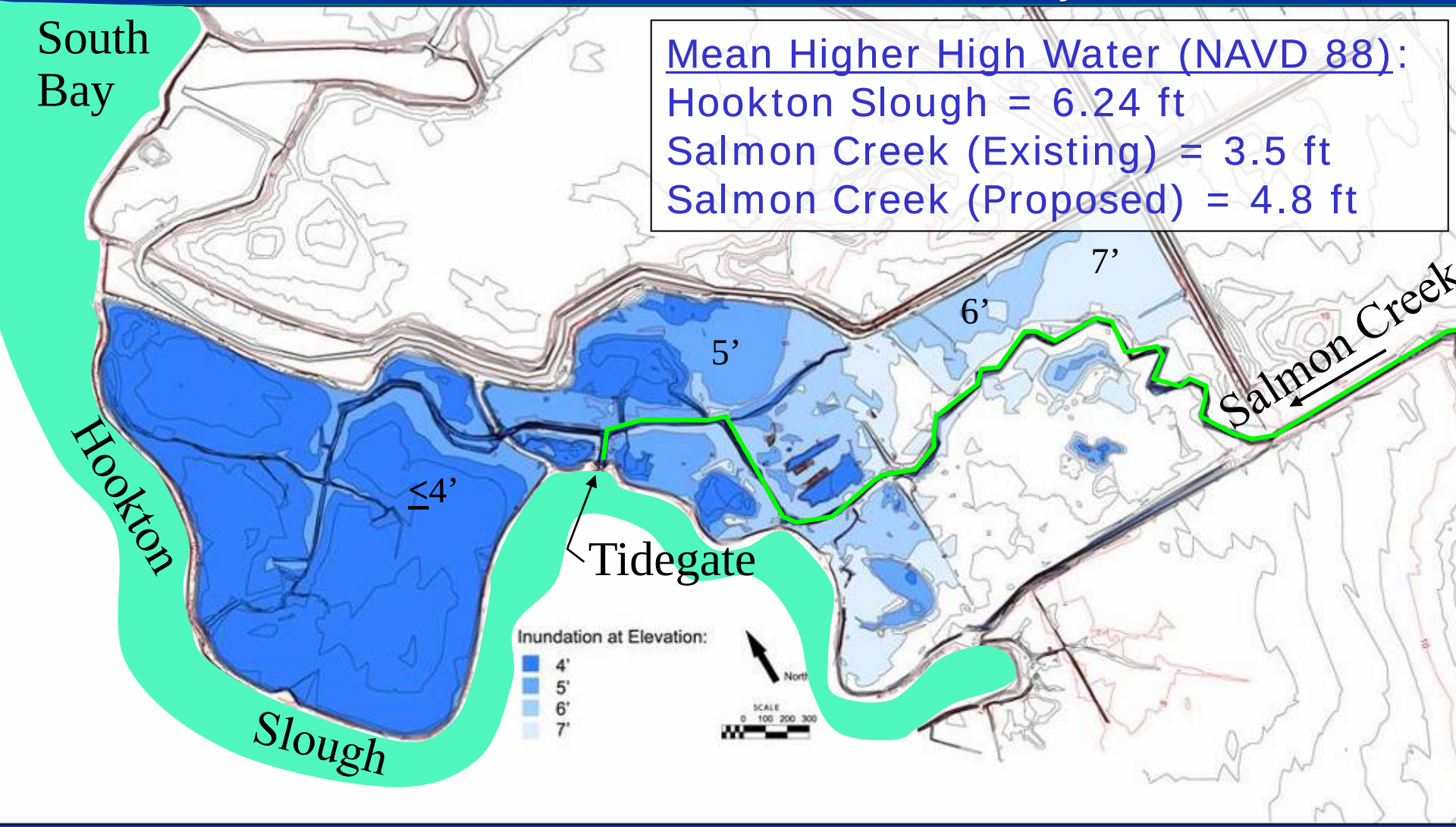

NORTE
0 Feet 1000
Salmon Creek Channels
Existing Levees
Tidegate
New Constructed Channels
Drainage to Long Pond
Restored Saltmarsh
Long Pond
Salmon Creek relocated into new tidal slough channel with large wood habitat structures and constructed off channel wetlands
Connection to Cattail Creek supplies freshwater and provides salmonid access to the northern wetlands
Raised ground to support saltmarsh
Cattail Creek
Extent of tidal influence
Highway 101
Old stream remains as a tidal side channel
Hookton Slough
Replaced with new fish friendly tidegates
Salmon Creek
New tidegates with adjustable openings to enlarge estuary
Hookton Road

Phase 1: Salmon Creek Tide Gate Design Objectives

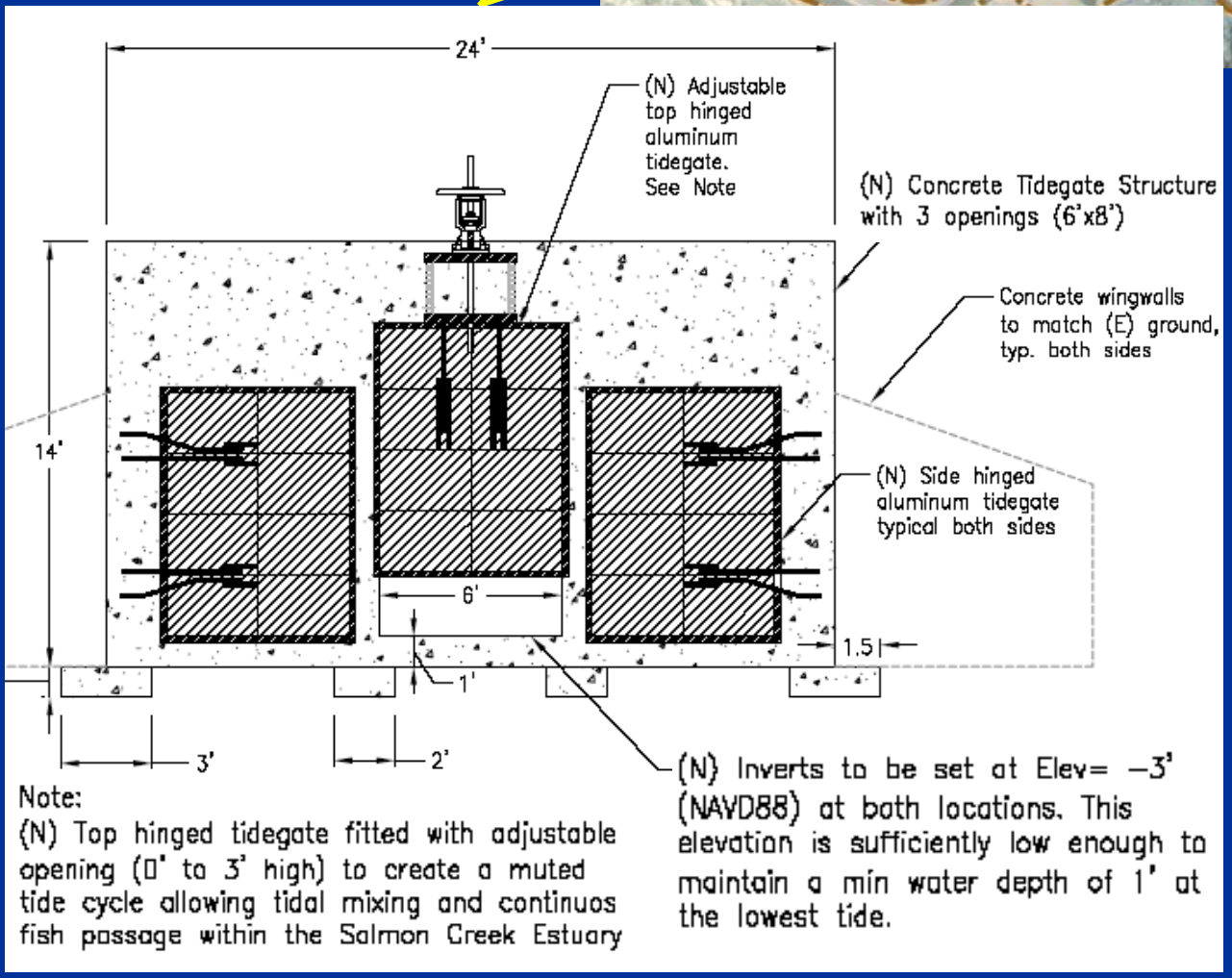
1. **Minimum 30-year design life**
2. **Provides uninterrupted passage in/out of Salmon Creek for Adult Salmon/Steelhead**
3. **Gates sized to drain floodwaters similar to ungated system at 2-year flood**
4. **Allows for a muted tide that can:**
   - Support a complex estuarine ecotone on the Refuge (marine to freshwater)
   - Protects Northern Refuge and off-Refuge infrastructure from tidal flooding
   - Adaptable to sea-level rise over design life
     - ❖ *Target: Highest Tide = 5.5 feet*

Inundation at Varying Tidal Elevations

Salmon Creek – Humboldt Bay

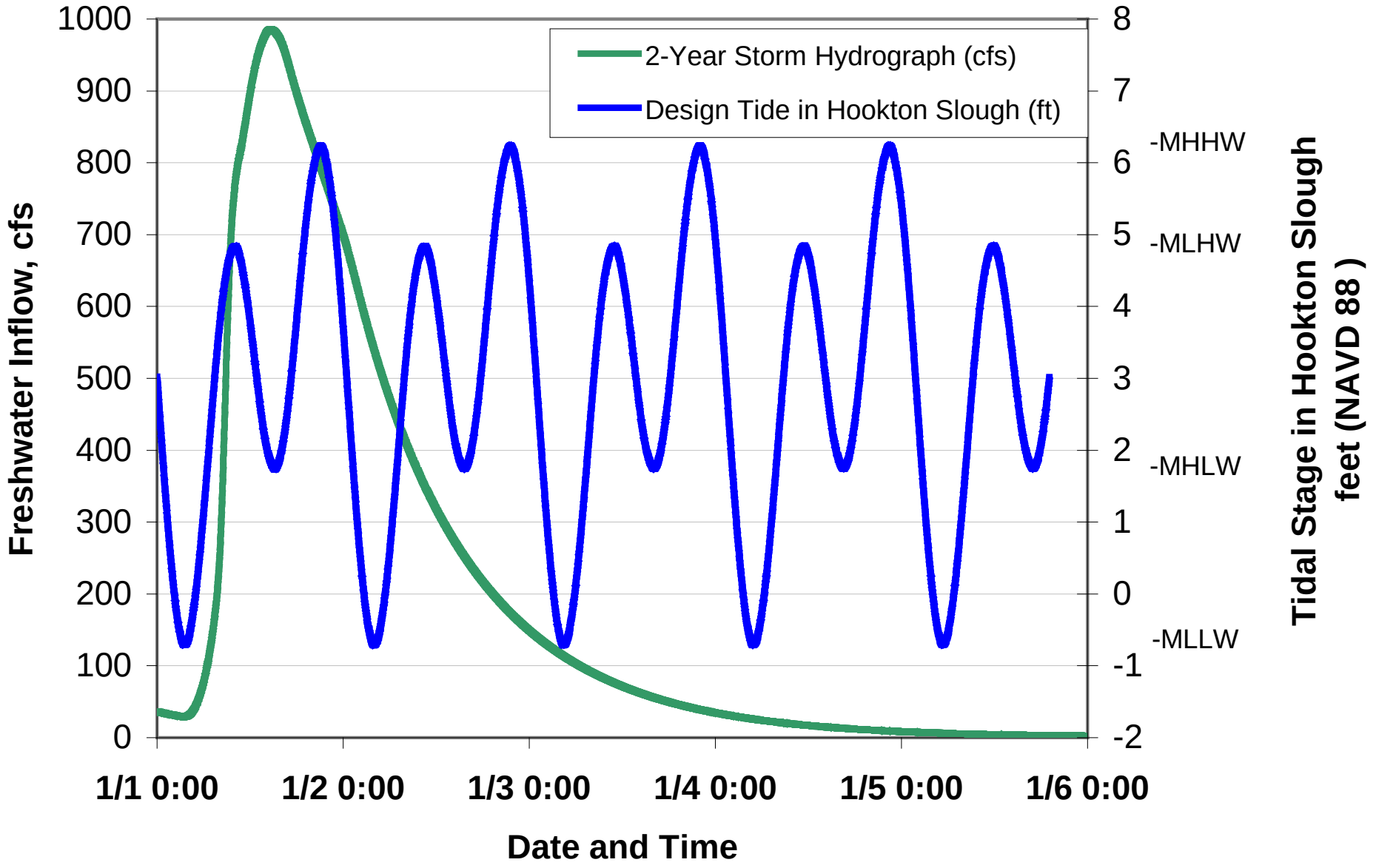


Tide Gate Design



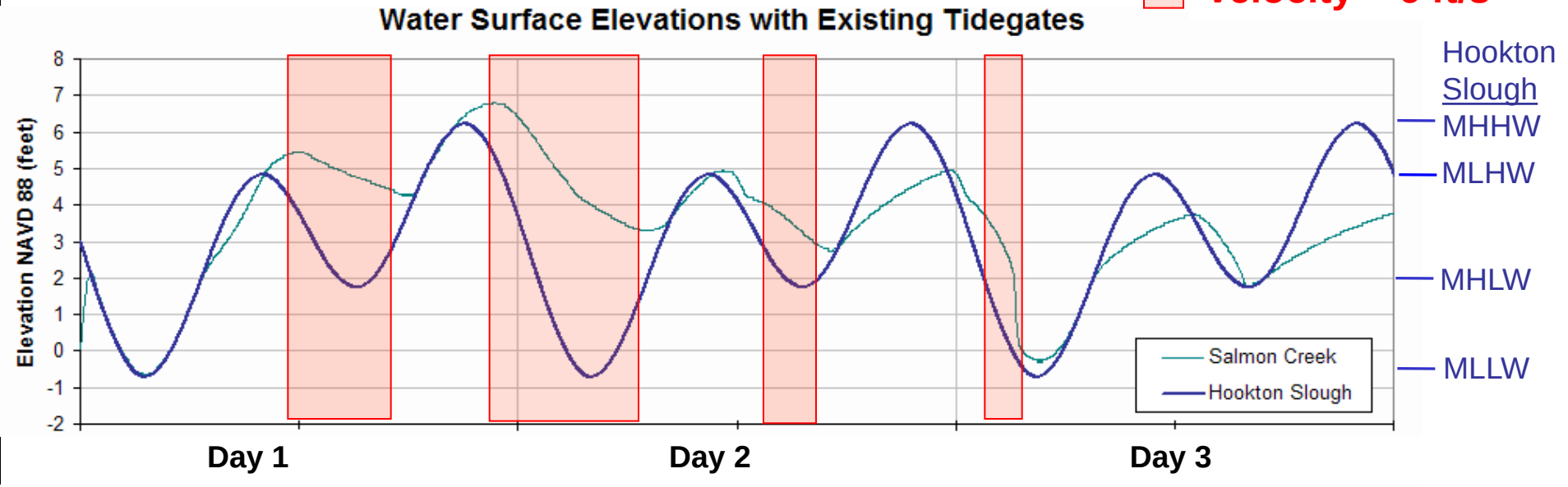
Note:
(N) Top hinged tidegate fitted with adjustable opening (0' to 3' high) to create a muted tide cycle allowing tidal mixing and continuos fish passage within the Salmon Creek Estuary

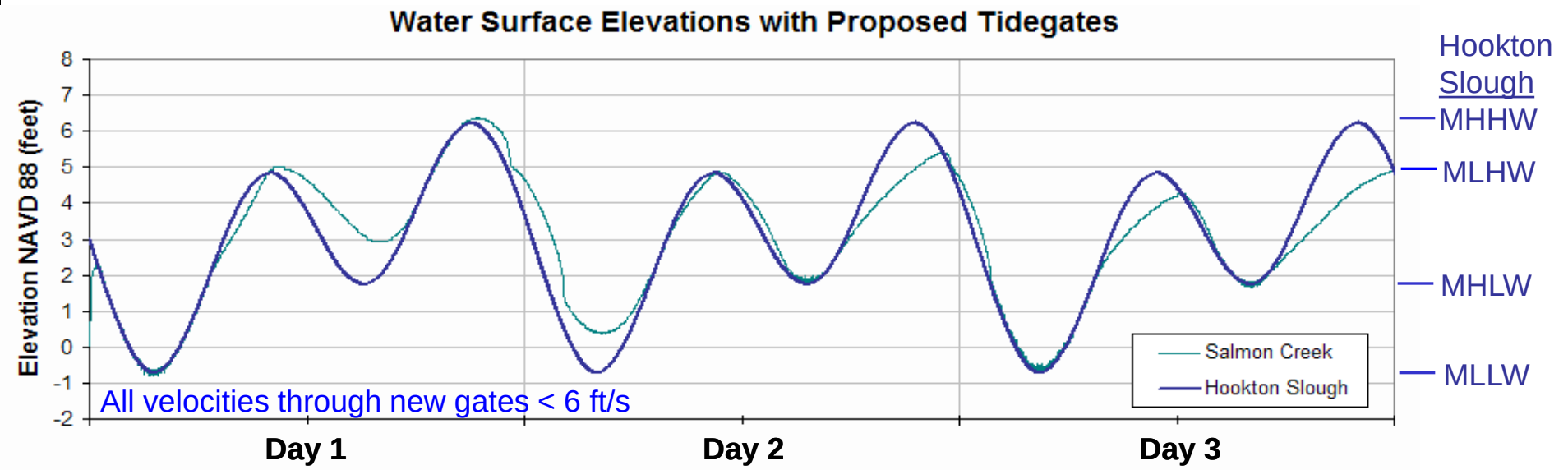
Design Events: 2-Year Peak Flow Hydrograph and Design Hookton Tides



Predicted Water Surface Elevations at Tidegates during 2-yr 24-hr storm event

Velocity > 6 ft/s





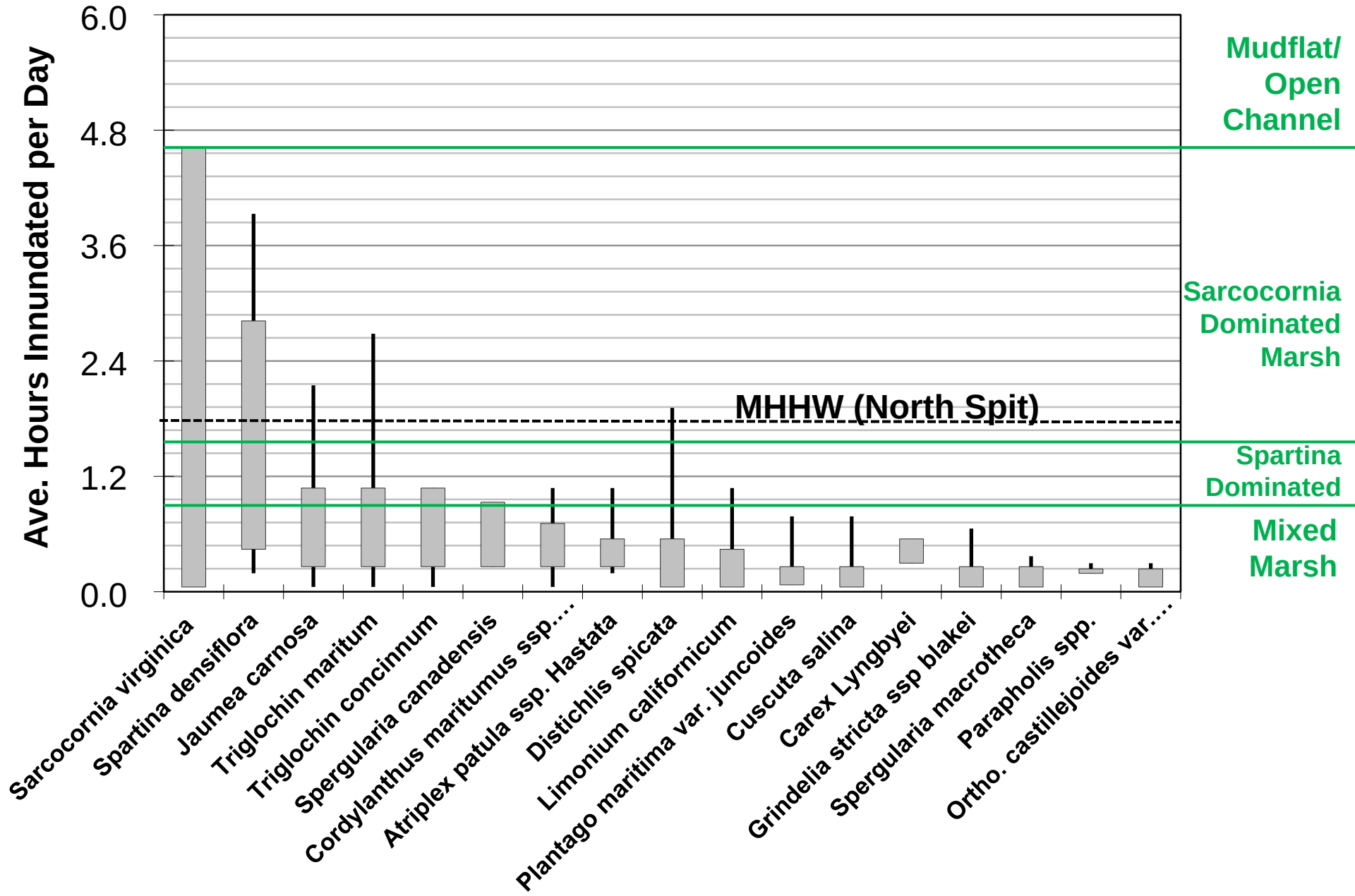
Salmon Creek Muted Tide Gates (constructed 2008)

Phase 2: Salmon Creek Channel, Pond, Marsh Habitat Design Objectives

1. **Construct geomorphically stable features for the muted tide condition**
2. **Maintain fresh/low saline waters in upper ecotone (near Refuge boundary) at winter baseflow conditions**
   - Design Salmon Creek Estuary for 130 AF tidal prism (tidal exchange between MLLW and MHHW)
   - Use excavated spoils to raise subsided lands, recreate native salt marsh and maintain tidal prism
3. **Construct side-channel and off-channel ponds suitable for overwintering salmonids (approximately 3 acres)**
   - Use sills at pond inlets/outlet to maintain a "pool" at low tide and control tidal exchange/salinity in ponds
   - Include large wood cover structures

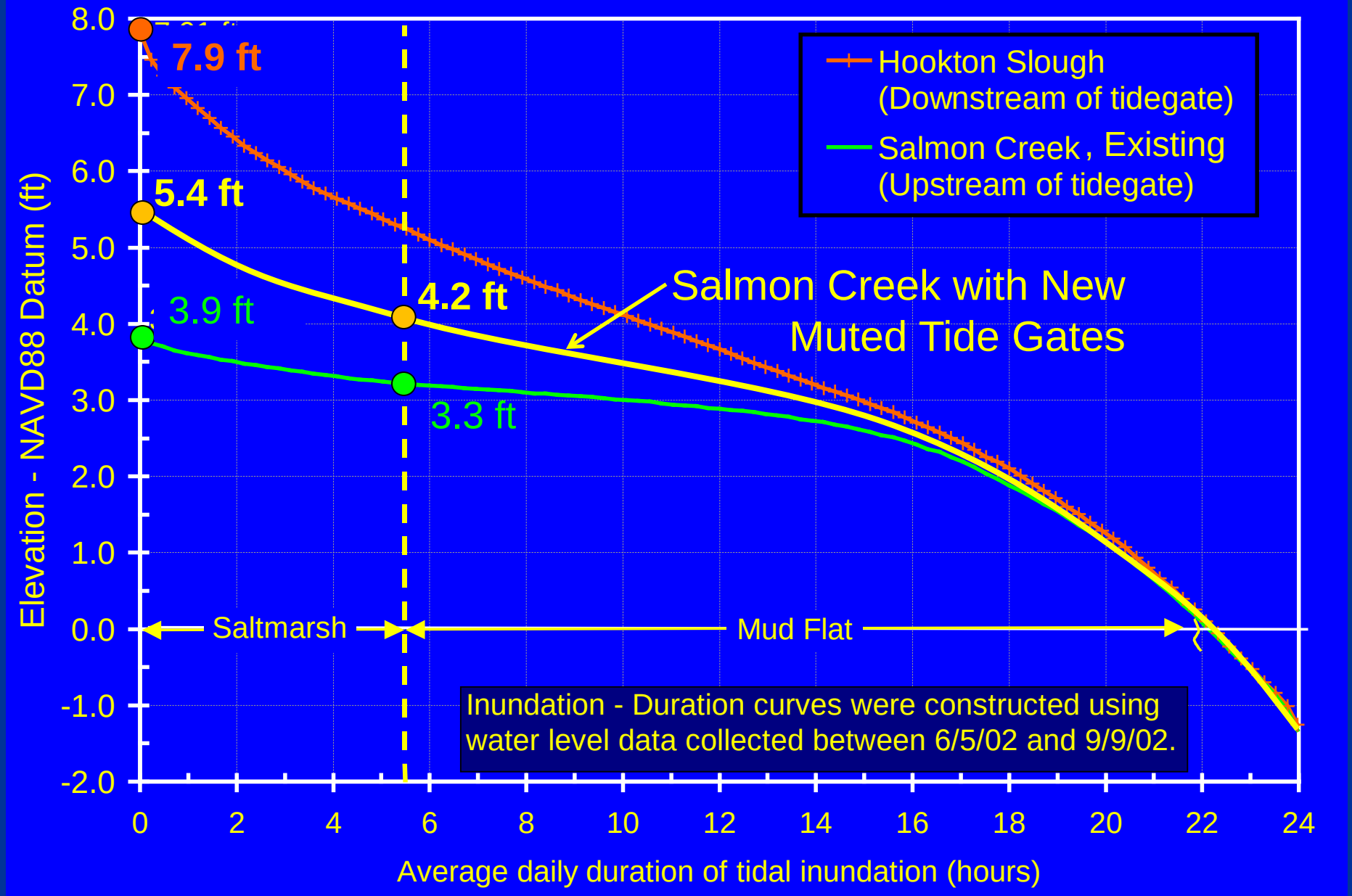
Salmon Creek Overflow

Spoils from channel excavation used to raise subsided land and restore salt marsh.



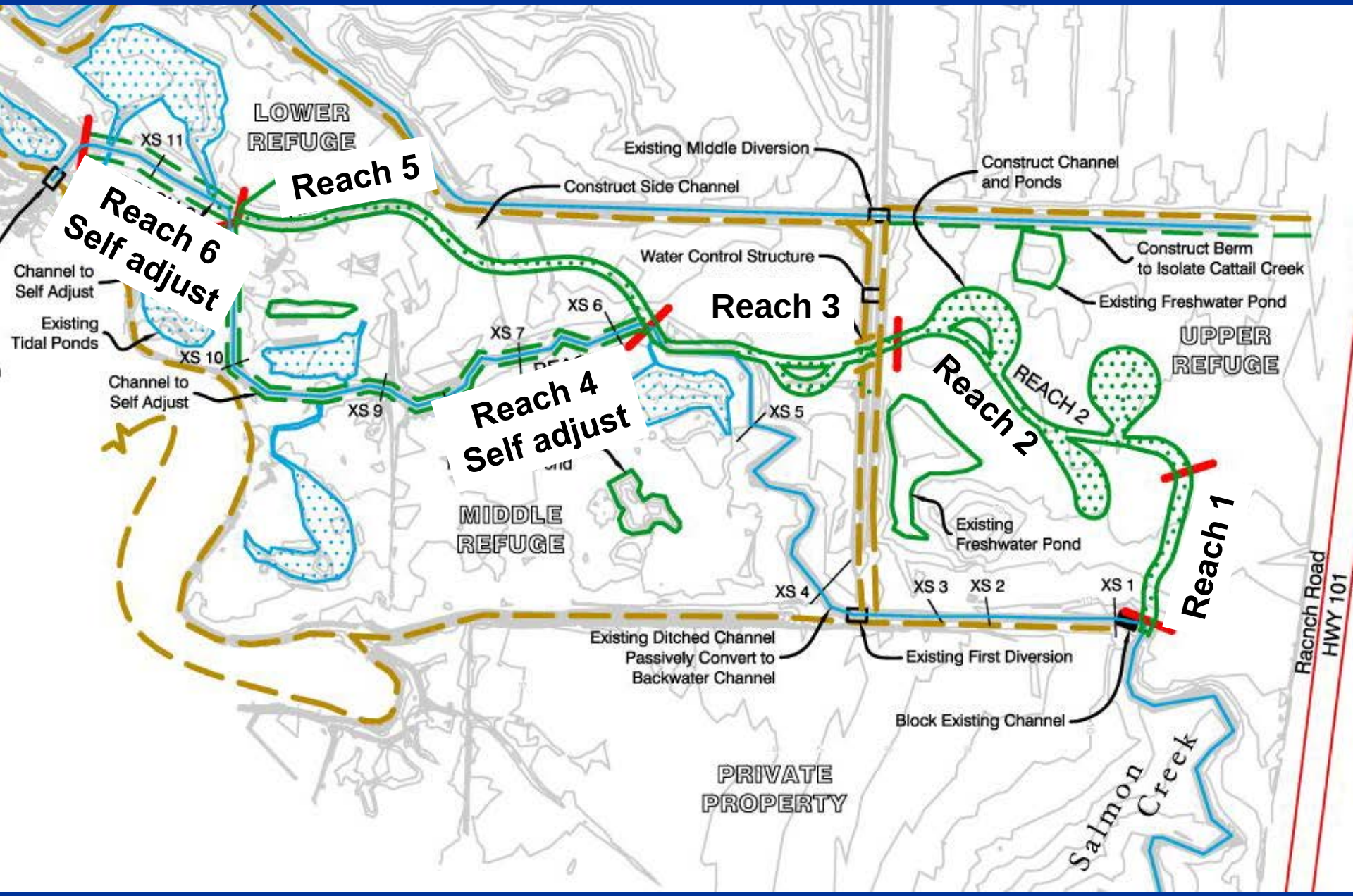
Based on Vegetation-Elevation Data from Eicher (1987) and NOAA Tide Records from North Spit (1993-2010). Adapted from Conor Shea, USFWS.

Duration of Saltmarsh-Mud Flat Inundation in Hookton Slough Upstream and Downstream of Salmon Creek Tidegate



Salt Marsh Vegetation Recruitment -Salmon Creek Overflow

Salmon Creek Tidal Channel Design

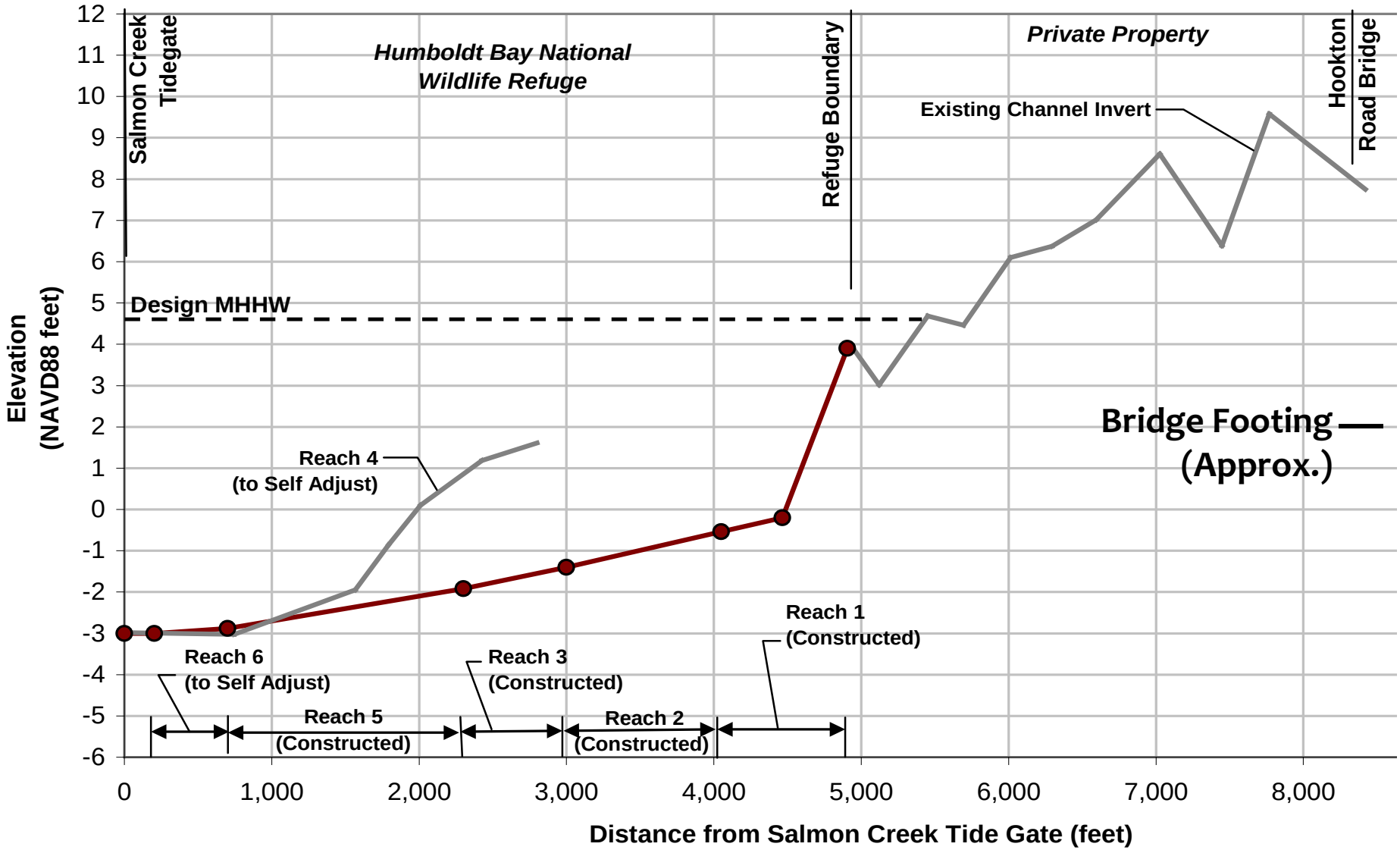


Salmon Creek Tidal Channel Design

Reach	Reach Length	Channel Type	Top Width at MHHW	Channel Depth	Contributing Tidal Prism (MHHW-MLLW)
1	805 ft	Temporary Grade Control	18 ft	8.2 ft	**1.2 AF**
2	950 ft	Construct Slough	25 ft	8.3 ft	**6.9 AF**
3	925 ft	Construct Slough	31 ft	8.8 ft	**9.6 AF**
4	2,100 ft	Self-Adjust Slough	22 ft (15 ft)*	7.4 ft (7.3 ft)*	**3.3 AF**
5	1,525 ft	Construct Slough	36 ft	8.2 ft	**14.1 AF**
6	700 ft	Self-Adjust Slough	52 ft (32 ft)*	8.1 ft (7.9 ft)*	**21.1 AF**
Overflow Area		Marsh/Mud-flats/Sloughs	-	-	**80 AF (105 AF)***

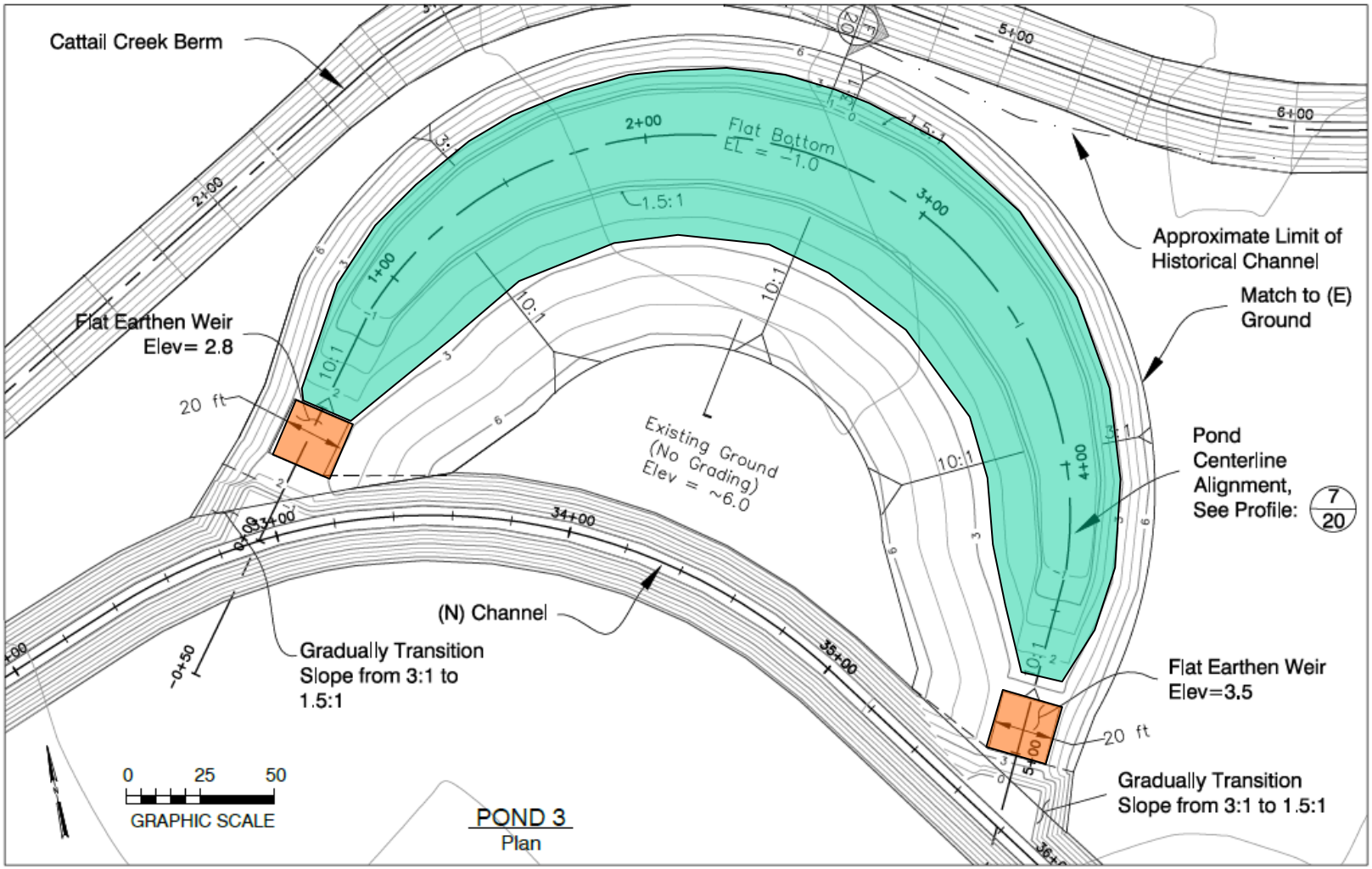
* Existing conditions in parenthesis

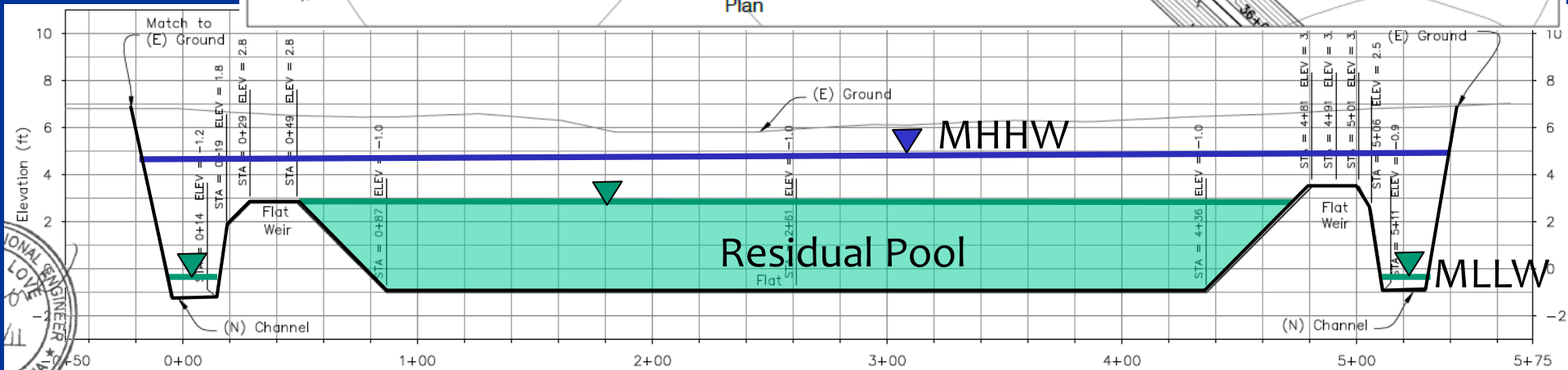
Salmon Creek Tidal Channel Design



Off-Channel & Side-Channel Ponds (Constructed 2011)

Salmon Creek Pond 3 Design





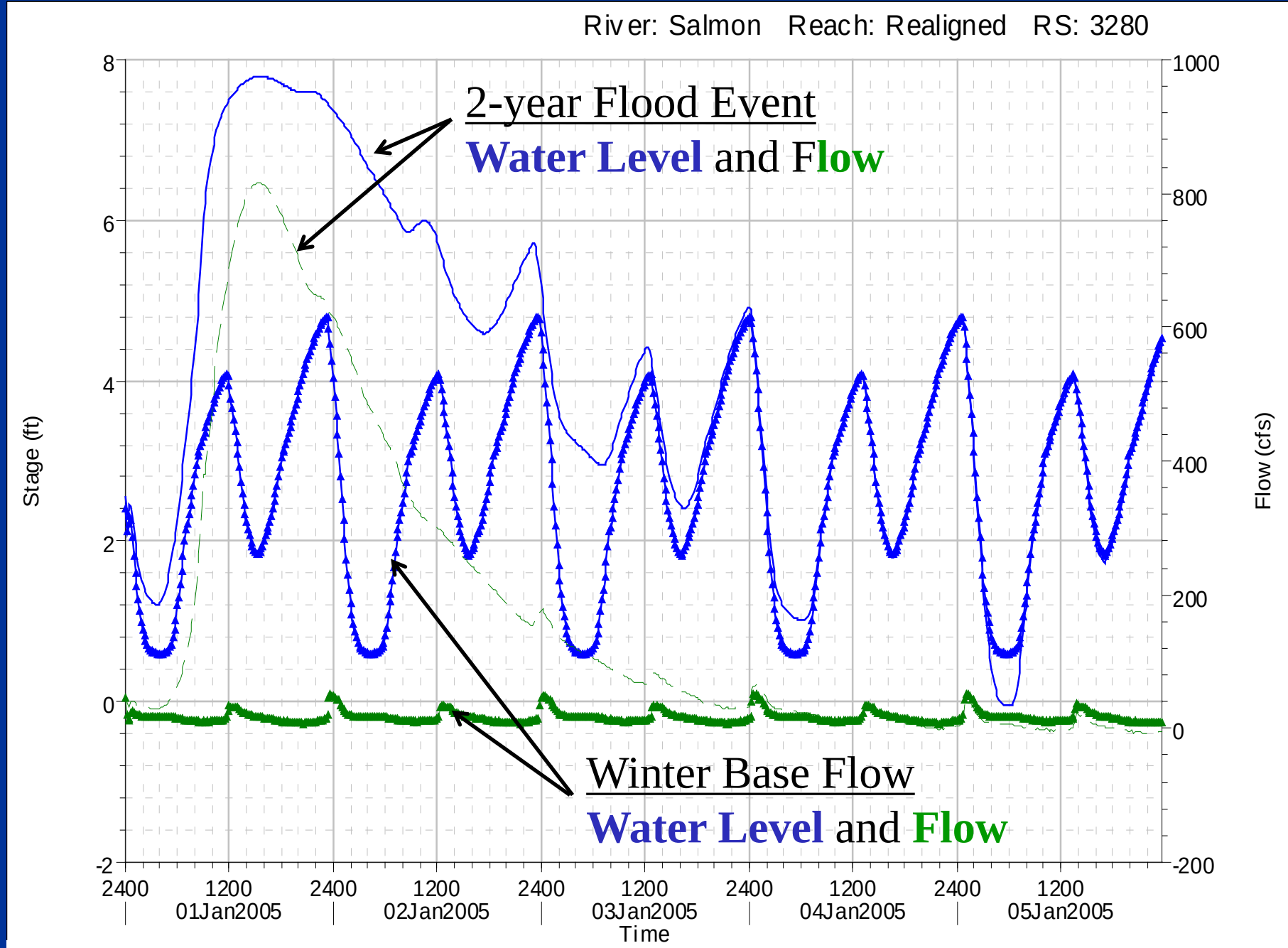
Off-Channel & Side-Channel Pond Dimensions

Pond Number	Pond Outfall Station	Outfall Weir Elevation (NAVD 88)	Tidal Prism from Pond	Residual Pool Depth
1	40+30	2.5 feet	**1.4 AF**	3.5 feet
2	38+25	3.0 feet	**0.6 AF**	3.0 feet
3	35+75 Upstream	3.5 feet	**1.5 AF**	3.8 feet
	33+00 Downstream	2.8 feet		
4	29+75 Upstream	3.0 feet	**0.35 AF**	5.0 feet
	27+50 Downstream	3.5 feet		

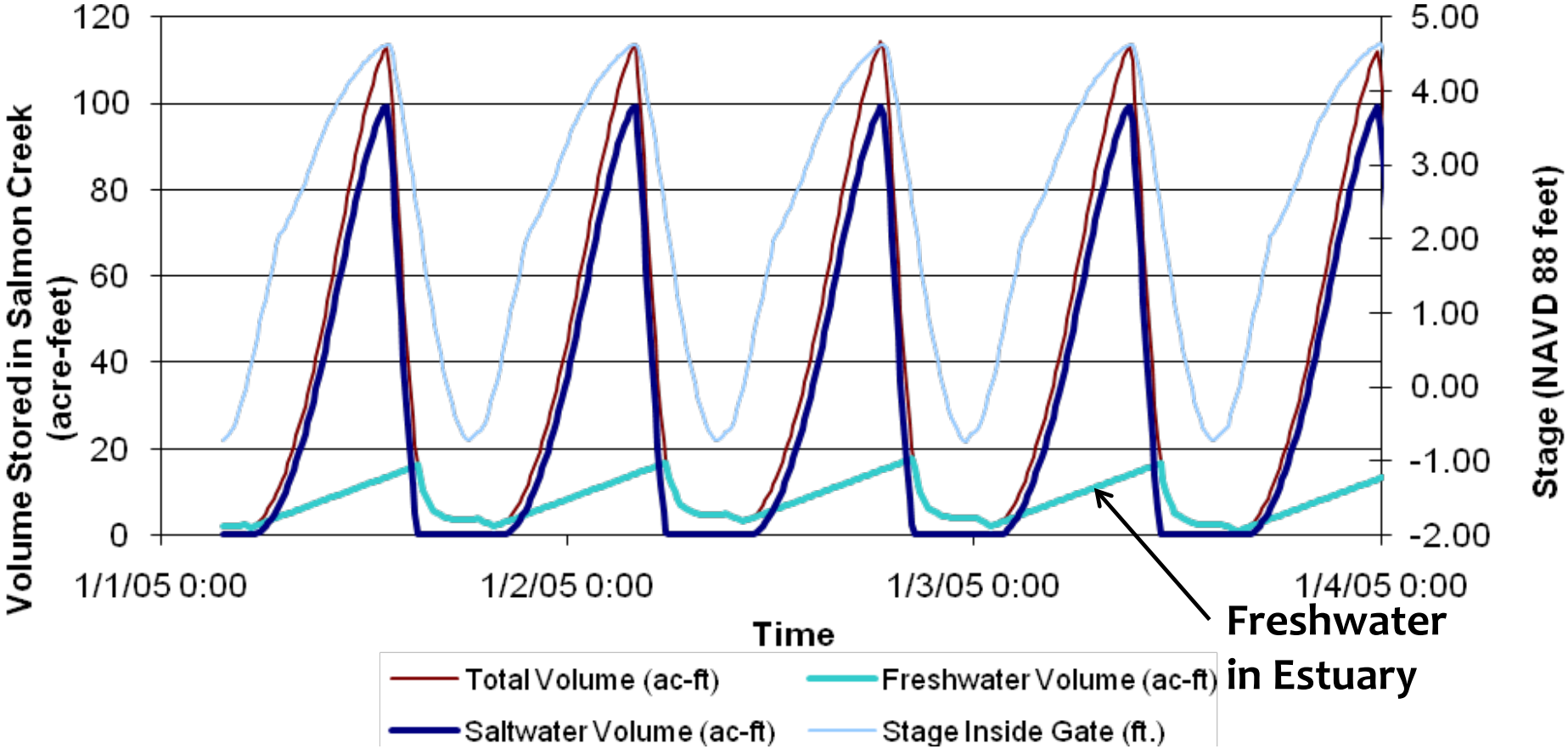
Side Channel (Pond 4) Confluence with Salmon Creek

Unsteady HEC-RAS Model of Proposed Project

Model Predicted Channel Conditions near Pond 3



Salinity Mass Balance Analysis between MLLW-MHHW at Winter Baseflow (15 cfs)



Conclusion: Freshwater dominated to Pond 3 During Moderate Winter Baseflow Conditions

20 In-Channel Large Wood Structures

20 In-Channel Large Wood Structures

Deflector Logs to force local scour around Pond Mouths

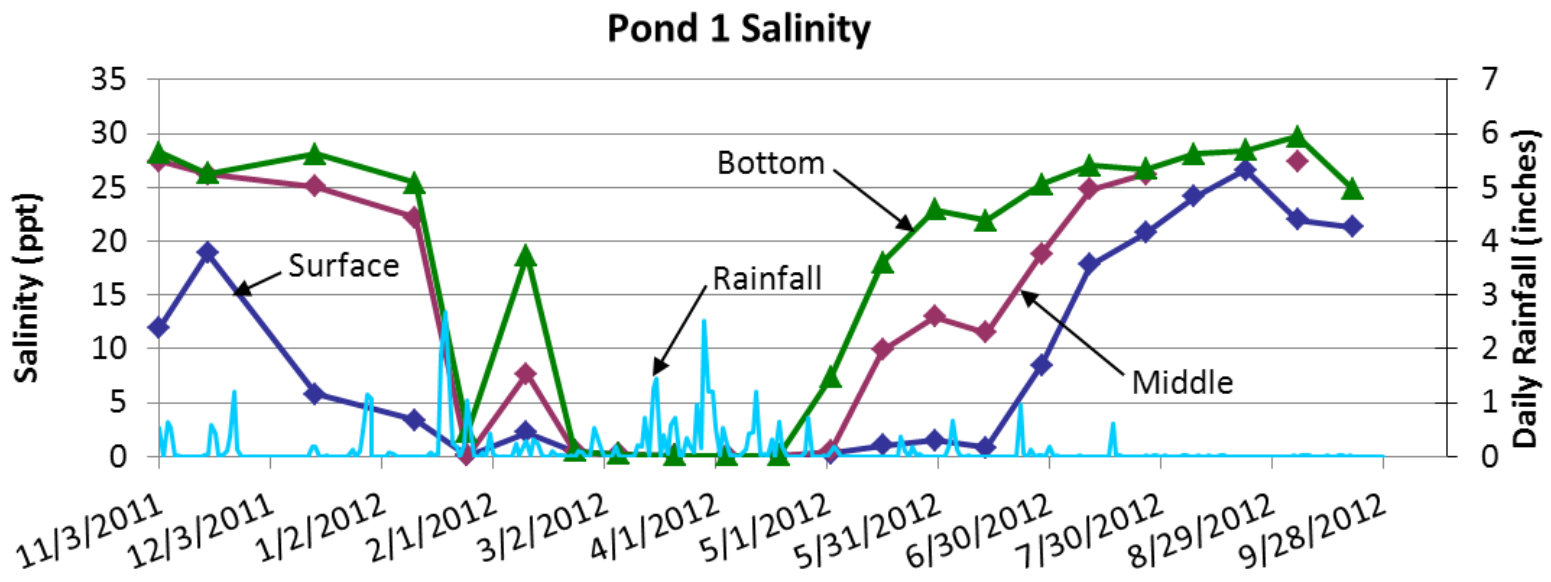
12 Complex Wood Cover Structures in the 4 Ponds

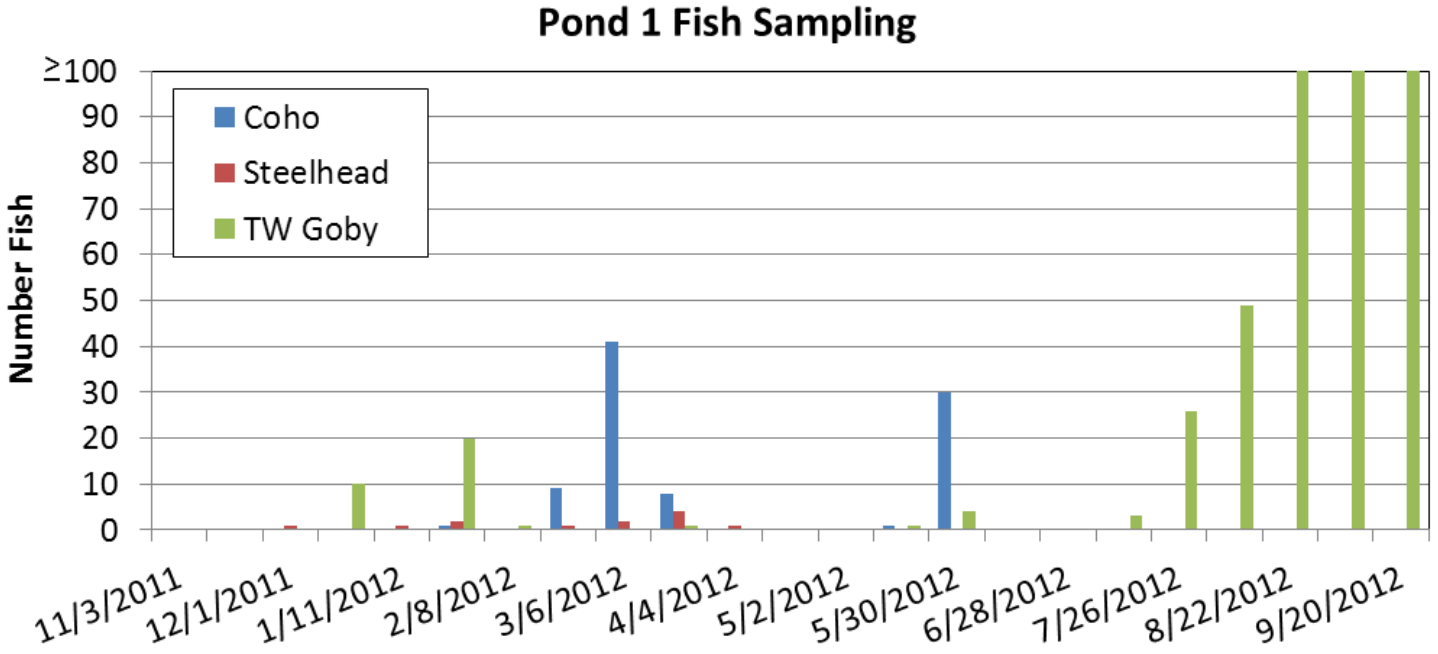
Logs Anchored together and cabled to 2-Ton Rocks. Each log required one 2-Ton Rock to counter buoyancy

Large Wood Structures at Low Tide

Large Log Jam to Create Low-Flow Blockage at Upstream end of Old Channel

Salinity & Fish Monitoring (from Mike Wallace, CDFG)





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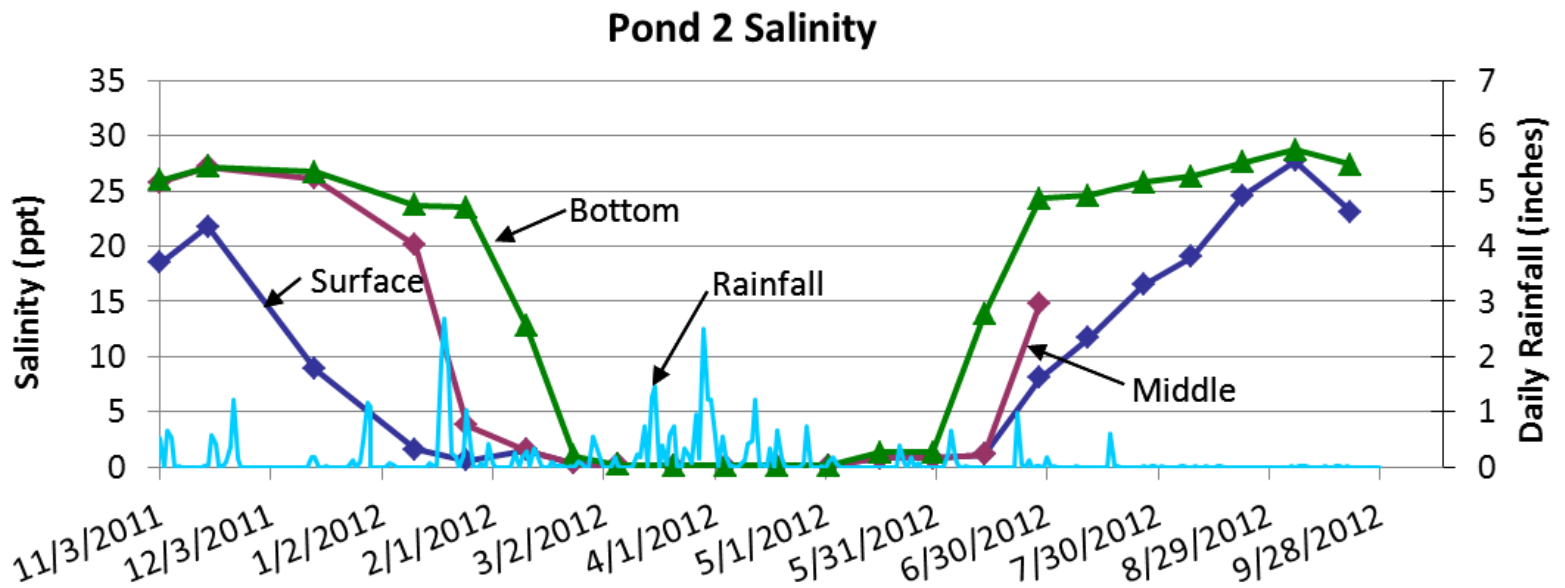

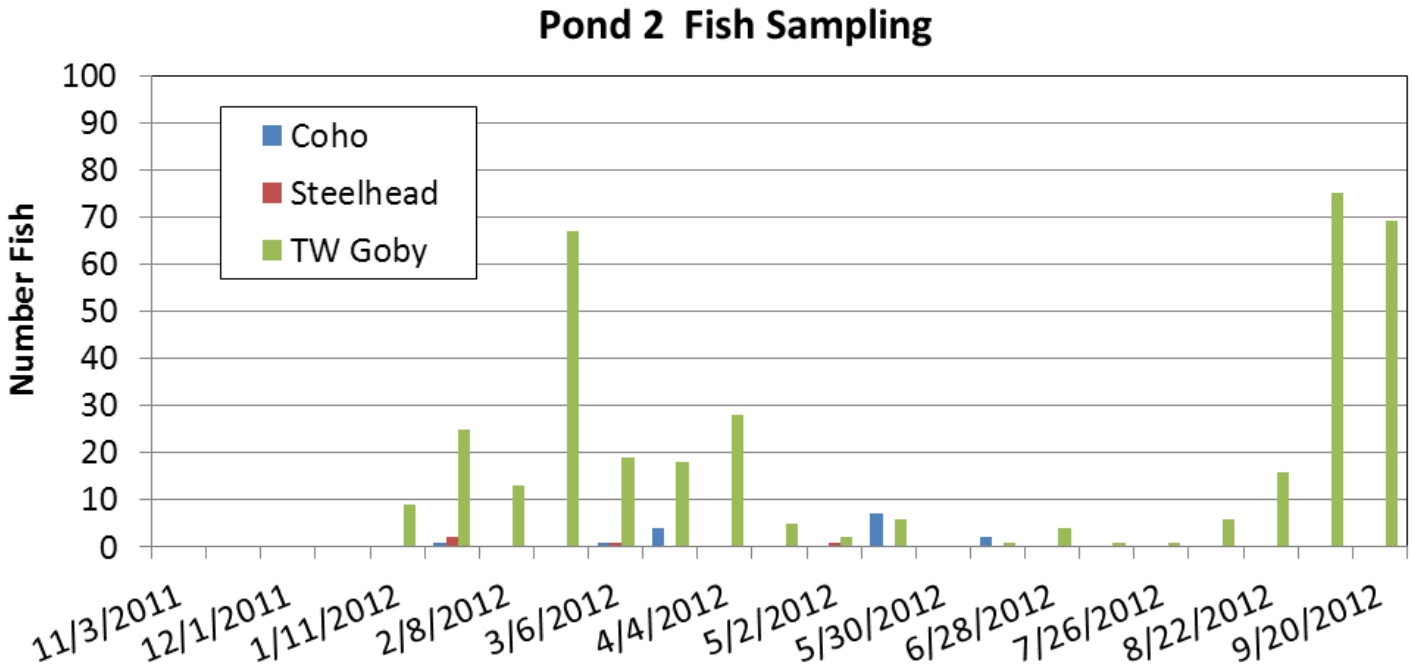

Past, On-Going, and Future Monitoring Efforts

- **Pre and post tide gate replacement monitoring cross-sections**
- **Pre and post tide gate replacement water level monitoring**
- **Ongoing fish and water quality sampling (CDFG)**
- **As-built surveys of channel and ponds**

- **Follow-up survey of ponds (2013)**
- **Monumented channel cross-sections for future monitoring (2013)**
- **Time-lapse photos & video of ponds and channel**
- **Detailed monitoring of salinity in ponds and channel (tentative)**

Questions?