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Physical Processes: Inundation, Datums, Salinity, Channel Geometry

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INTRODUCTION

Physical Processes are included in the IRWM Pilot Project for two primary reasons:

First, the status of tidal marshes and the consequences of restoration and other activities are strongly reflected in hydraulic, topographic, and edaphic (soil) variables. These variables, in turn, exert a strong influence on and are modified by a variety of biological variables such as vegetation colonization. Thus, changes in marsh form, function, and extent are often reflected in the distribution of water and sediment.

Second, interpretation of the distribution, abundance, and habits of living organisms that utilize tidal marshes generally requires knowledge of the spatial and temporal variations in physical parameters. Physical processes, in combination with landscape ecology processes, form the overarching conceptual model for IRWM. The conceptual model describes inundation, the estuarine salinity gradient and sediment supply as the fundamental external processes that drive tidal marsh evolution and development and abiotic and biotic variability.

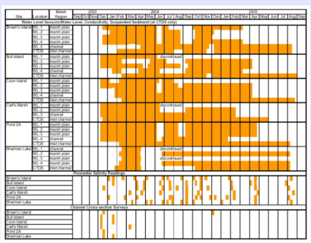

Table 1. Physical Processes data collection timeline.

TIDAL DATUMS

A critical factor driving the IRWM conceptual model is the role of tidal inundation in the evolution of a marsh. The tidal datum relates the tide heights to marsh plain elevations. Relative heights of tides and marsh plains are a critical ecological determinant. The San Francisco Estuary has mixed, semi-diurnal tides, meaning twice-daily tides with differing elevations for successive low and high tides. The five tide levels of most interest to the IRWM team:

- Mean Higher High Water (MHHW) – the average elevation of all higher high tides
- Mean High Water (MHW) – the average elevation of all high tides
- Mean Tide Level (MTL) – the average elevation of all tides
- Mean Low Water (MLW) – the average elevation of all low tides
- Mean Lower Low Water (MLLW) – the average elevation of all lower low tides

Datum	Port Chicago (ft NAVD)	BrI CTDS channel at inlet (ft NAVD)	# Tides	BrI WL-5 channel at head (ft NAVD)	# Tides
MHHW	6.01	5.87	136	5.96	127
MHW	5.51	5.38	272	5.49	253
MTL	3.68	3.89	**272**	3.93	**253**
MLW	1.84	2.22	271	2.16	253
MLLW	1.10	1.57	136	1.43	127
MLLW - MHHW range	4.91	4.30		4.59	

Table 2. Preliminary tidal datum at Browns

Datum	Richmond NOS Station (ft-NAVD)	Coon CTDS Channel Inlet (ft-NAVD)	#Tides
MHHW	6.20	6.62	199
MHW	5.57	6.05	399
MLW	1.11	1.11	200
MLLW	-0.01	0.2	111
MLLW-MHHW range	6.21	6.42	

Table 3. Preliminary tidal datum at Coon

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TIDAL INUNDATION: DEPTH, DURATION, AND FREQUENCY

Tidal inundation regime is defined as the frequency, duration and depth of water reaching the plain of estuarine tidal marshes. Inundation regime exerts significant control across the marsh plain in the chemical and physical properties of marsh soils with accompanying changes in the biological community.

Water surface elevation (WSE) time series data were collected at 12-minute intervals at three to six locations within each marsh. Water level stations are located on the marsh plain and in each "main" tidal channel, at the inlet and headward ends. This data enables calculating the tidal datum at each site and calculating inundations.

The Physical Processes Team and the Plant Team are conducting integrated analyses examining the influence of inundation regimes and plant community distribution and composition. Initial analyses are examining the following:

- How often did the tide reach the marsh plain?
- What was the duration for each period of inundation?
- How often did water levels exceed a given depth?
- What was the duration of each period of inundation at a given depth?
- What was the duration between inundation events?

Figure 1. Telemetry station providing real-time data from CTDS channel moorings

Inundation regimes can vary drastically over short distances within marshes in large part controlled by the local tidal datum, marsh plain elevations, drainage characteristics, and vegetation. Plant surveys and topographic surveys at the IRWM sites informed the development of site specific elevation range "bins" - these site-wide standardized elevation bins facilitated comparing inundation metrics between water level stations.

Initial analyses include:

- Synoptic time series water level comparisons by station
- Water surface elevation differences between channel stations
- Tidal attenuation across marsh plain stations
- Inundation and exposure metrics, focusing on per event durations and depths and event frequencies

Further analyses will allow for an evaluation of the feasibility and practicality of using selected inundation metrics as an additional predictive tool in wetland restoration design and management.

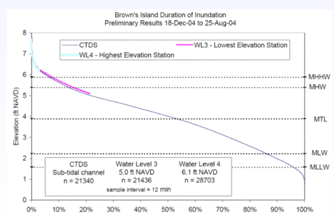


Figure 2. Percent time inundated vs. elevation Brown's Island

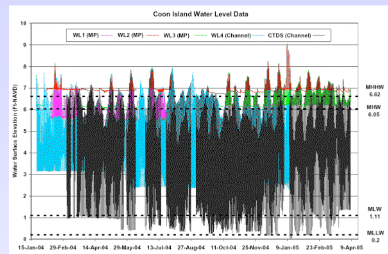


Figure 3. Water level time series data, all stations, Coon Island

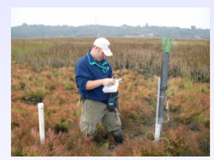


Figure 4. Downloading data from a marsh plain water level monitoring station

Station	Event Type	Period of Records: From (date)	To (date)	Event (count)	Day (count)	Per-Event Duration: min (day)	mean (day)	median (day)	max (day)	Event Frequency: min (day^{-1})	mean (day^{-1})	max (day^{-1})
Lowest elevation marsh plain station (partial data set)												
BrI-WL-3	**Inundation**	2/29/04 6:24	5/19/04 4:12	102	79	0.02	0.14	0.15	0.26	0.00	1.24	2.00
BrI-WL-3	**depth>1.0ft**	3/1/04 9:36	5/19/04 2:36	31	78	0.01	0.08	0.07	0.16	0.00	0.40	1.00
BrI-WL-3	**dry**	2/28/04 10:36	5/19/04 23:36	103	80	0.24	0.63	0.45	5.72			
Highest elevation marsh plain station (partial data set)												
BrL-WL-4	**Inundation**	2/28/04 18:36	5/19/04 4:00	4	80	0.13	0.16	0.17	0.18	0.00	0.04	1.00
BrL-WL-4	**depth>1.0ft**	NA	NA	0								
BrL-WL-4	**dry**	2/28/04 18:36	5/19/04 4:00	5	80	0.81	15.93	0.86	66.32			

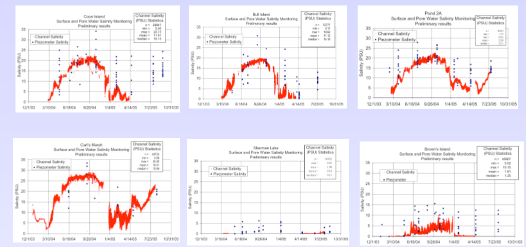
Brown's Island Inundation Regime - Depth, Duration, and Frequency

Notes:
1) BrI-WL-3 elevation is 5.0 ft NAVD, or - 0.9 ft relative to local MHHW
2) BrI-WL-4 elevation is 6.1 ft NAVD, or + 0.2 ft relative to local MHHW

Table 4. Inundation Regimes, Brown's Island

Initial results from Browns Island highlight that a relatively small change in local marsh plain elevation between two sites (1.1 ft) can have a dramatic effect on tidal datum inundation regimes. The maximum duration between inundation events (dry marsh plain) shows the most dramatic change between WL-3 and WL-4: 5.72 versus 66.32 days, respectively, during the data period evaluated. Figure 2 displays the duration of inundation at the Brown's Island CTDS, WL3 (the lowest elevation station), and WL4 (the highest elevation station).

SURFACE WATER AND MARSH PLAIN PORE WATER SALINITY



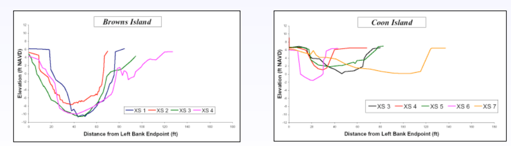
Figures 5 – 10. Surface Water and Marsh Plain Pore Water Salinity Graphs for all Six IRWM Study Sites

Salinity fundamentally influences tidal marsh structure, function, and process. It affects the distribution and abundance of marsh vegetation, influences ecological interactions, affects sedimentation, and affects site use by invertebrates, amphibians, reptiles, mammals, fish and birds. Continuous inlet channel surface water salinity monitoring and periodic marsh plain pore water salinity monitoring are conducted at each IRWM site.

Preliminary results of surface water salinity and marsh plain pore water salinity monitoring are shown above in Figures 5-10. The estuarine salinity gradient is evident across the six IRWM sites, with decreasing salinity values observed from the western-most site (Carl's Marsh) to the eastern sites (Brown's Island and Sherman Lake) in the west Delta. A secondary estuarine salinity gradient is apparent along the Napa River, with decreasing salinities from Bull (northern), Coon Island (middle) and Pond 2A (southern).

CROSS-SECTION MORPHOLOGY

Channel cross-section surveys were performed at each of the six IRMW sites. Hydrographic surveys at four to seven channels per site provided channel dimensions. Elevations (Ft-NAVD) are based upon site-wide surveys conducted using RTK-GPS and onsite benchmarks established during IRWM. Channel complexity varies significantly amongst sites. Below are cross-section profiles from Browns Island (western Delta) and Coon Island (Napa River).



Figures 11 - 12. Browns Island and Coon Island Channel Cross-Sections

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