Chapter 1

THE RISING OF THE TIDE - A STUDY OF MARSH RESTORATION

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The focus of this paper is on the restoration by Caltrans of a portion of the Hoffman Marsh, an intertidal salt marsh in Richmond, California (Figure 1). In my analysis of the Hoffman Marsh restoration project, I set out to monitor the water quality before and after the restoration work, and to keep a photographic record of the visual changes in the marsh. The parameters of water quality I have measured are dissolved oxygen, pH, turbidity, temperature, and conductivity. I intended to use these data, as well as data from the studies of Darrin Craig, Ellen Hay, and Jim Machado in this report, to answer the question of how the value of this marsh as a habitat would be altered as a result of the restoration work.

Unfortunately, the restoration project has not been completed as scheduled (by the end of January, 1985), and the final completion date is unknown at this time. In view of this unforeseen interruption, my report will instead present baseline data to which others can refer in the future either when studying water quality in marshes in general or in continuing to monitor this marsh. I will make a comparative analysis of the habitat before work began and as it stands now, in its uncompleted state.

Background

In the past fill has been placed in the San Francisco Bay solely on the basis of economic considerations, generally at the expense of the environment. Surrounded now almost entirely by landfill and roadways, the Hoffman Marsh offers a prime example of the strangling effect unchecked development has had upon the wetlands of the San Francisco Bay. Mudflats, commonly adjacent to a full tidal marsh ecosystem (Josselyn, 1983), have been replaced next to the Hoffman Marsh by landfill of little value to humans or wildlife, as the fill is contaminated with high concentrations of lead from the dumping of old vehicle batteries (Thomas, 1982). Today, however, many enforceable environmental checks and balances exist, such as San Francisco Bay Conservation and Development Commission (BCDC) policy, aimed both at preventing any such damage to the environment in the future, as well as repairing the harmful actions of the past.

Caltrans is performing restoration work on part of the Hoffman Marsh as mitigation for wetlands which will be lost to fill during improvements to state highway 17 (to be I-180). The filled areas involve 510 square feet of tidal area in BCDC jurisdiction (BCDC, 1983a) and 0.8 acres of low-quality non-tidal marsh (Caltrans, 1981) outside BCDC jurisdiction. This mitigation is required in order to comply with a number of state and federal policies regarding wetlands protection, including the McAteer-Petris Act and Federal Executive Order 11990, Protection of Wetlands. Such projects in the San Francisco Bay require approval from a number of agencies and ultimately permits from BCDC and the U.S. Army Corps of Engineers. Compliance with these policies requires that no alternative upland location for the fill exists, that the minimum fill necessary be placed, and that public benefits of the fill clearly exceed public detriments. Compensation for the fill must be in a manner that will result in the improvement or creation of ecologically sound marshes (BCDC, 1979). Caltrans, therefore, must choose a wetlands restoration site considered to have the potential to become a productive ecosystem.

Study Area

The Hoffman Marsh is located on the eastern shore of central San Francisco Bay, in the southernmost part of the City of Richmond (Figure 1). The marsh, about one kilometer in length, varies in width from 100 m to 175 m (Caltrans, 1981). A channel, which is the only tidal inlet into the marsh, runs west from the midpoint of the marsh to the bay. The 40-acre Hoffman Marsh (Figure 2), called the "entire marsh" in this report, is divided into two portions by a dike containing a sewer pipe owned

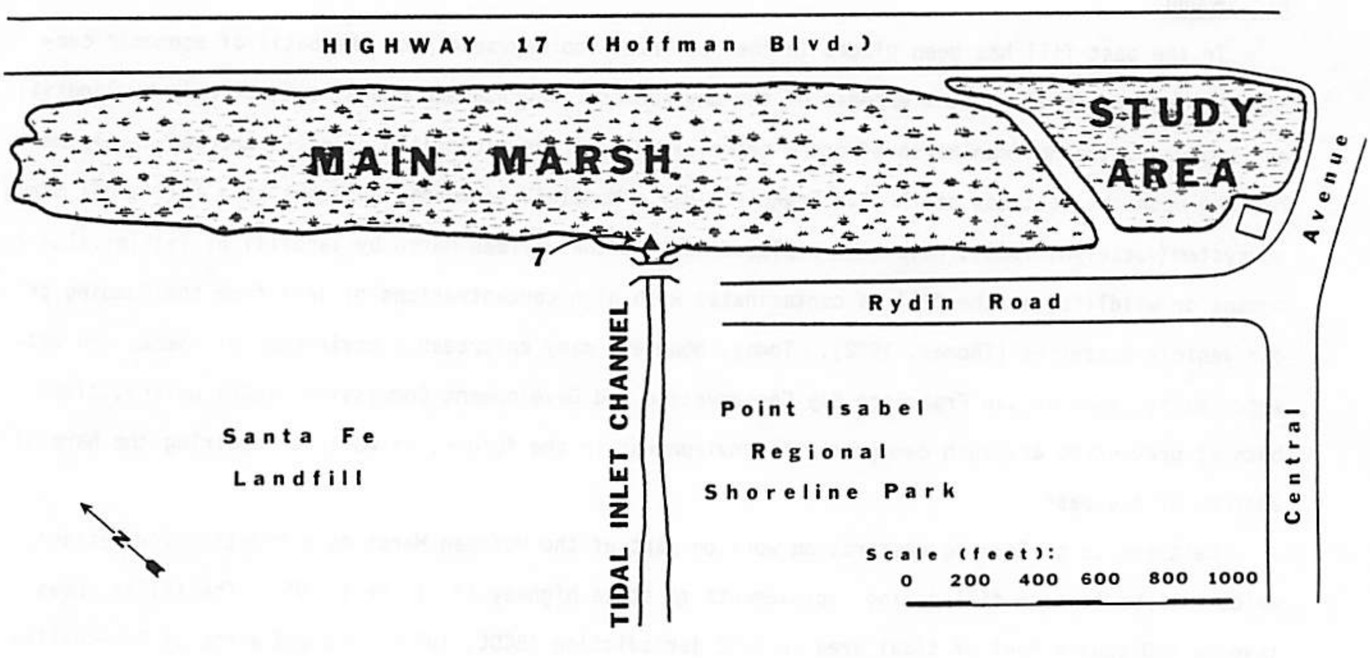

Figure 2. The Entire Hoffman Marsh, Showing Marsh Features and Neighboring Land.
Source: Adapted from URS (1973).

by Stege Sanitation District. A northern 32-acre healthy portion, defined here as the "main marsh," and a southern 7.5-acre unhealthy portion, the study area, make up the entire marsh. During storms, fresh water enters the main marsh through a storm drain (Rust Drain) from the east, and a single 24" culvert through the dike and a network of channels provide limited tidal exchange to the southern 7.5-acre study area.

The Hoffman Marsh is a mature salt marsh, characterized by a surface lying predominantly above the mean high water mark and a complete cover of established vegetation, particularly pickleweed (Salicornia virginica) and cordgrass (Spartina foliosa). A larger number of plant species, including some upland species, have been found than are characteristic of typical marshes, suggesting that the entire marsh should be considered a residual salt marsh (URS, 1973). Distinguishing the study area from the main marsh is the absence of cordgrass in the study area (URS, 1973).

The southern portion of Hoffman Marsh is a valuable site for restoration, as the entire marsh and nearby mudflats form the only existing stand of marsh vegetation for a five mile stretch of East Bay shoreline, and such wetlands habitats are especially rare in this region of the San Francisco Bay (URS, 1973). The restoration plan chosen was considered ecologically sound, and "would result in a net improvement in both the natural and human environments" (Caltrans, 1981, p. 136). This project is mostly "bonus," or extra, mitigation, because the 7.5-acre mitigation site offsets only 0.81 acres of fill. The plan consisted of installing three new culverts beneath a sewer pipe in the dike (A, B, and C, Figure 3), deepening most of the existing channels, and dredging some additional channels. The goal Caltrans sought to achieve was to enhance nutrient transfer and tidal flushing in the degraded area (Caltrans, 1981).

Had the design process of the restoration been more thorough, the contractor would have been able to complete the work by the end of January, 1985 and some conclusions regarding the restoration work could have been drawn in this paper. However, it was impossible to install the new culverts without causing damage to the overlying sewer pipe and leaking sewage into the marsh, due to the extremely old and decrepit sewer pipe. The problem arose only after the new and deepened channels had been dug, and the existing culvert had been cleaned out because the condition of the sewer pipe had never been investigated. This oversight brought the entire restoration project to a halt, and the remainder of the project is currently being reengineered, with the cost of installing the additional culverts estimated to be between $80,000 and $200,000, a significant amount when compared to the original cost estimate of $25,000. In addition, there is a risk of serious environmental damage associated with the possible solutions. Caltrans has therefore proposed to install the culverts in five or ten years, at the time when Stege Sanitation District can afford to replace its sewer pipe (Kuntz, personal communication, 1/31/85).

Past Work

When Caltrans began to consider improvements to state highway 17, they contracted with URS Research Company to study the Hoffman Marsh. URS focused on an inventory of the terrestrial and marine biota, and discussed impacts and mitigation possibilities for widening the freeway (URS, 1973). Caltrans then compiled an environmental impact statement for the Hoffman Corridor (Caltrans, 1981). Included in this report were possible mitigation projects for the Hoffman Marsh, many based on the URS study.

No water quality studies have been done on the Hoffman Marsh, but several studies along the East Bay shoreline are applicable, including past UC Berkeley Environmental Sciences Reports (Oddi, 1982; Jeung, 1982; Altamirano, 1983; Imlay, 1983). Objectives for water quality in the Bay designed to meet the needs of various shoreline uses have been drawn up by the Regional Water Quality Control Board (RWQCB, 1982). A number of informative works regarding wetlands restoration are available (e.g., Josselyn, 1982, 1983; BCDC, 1983b; Eliot, 1985).

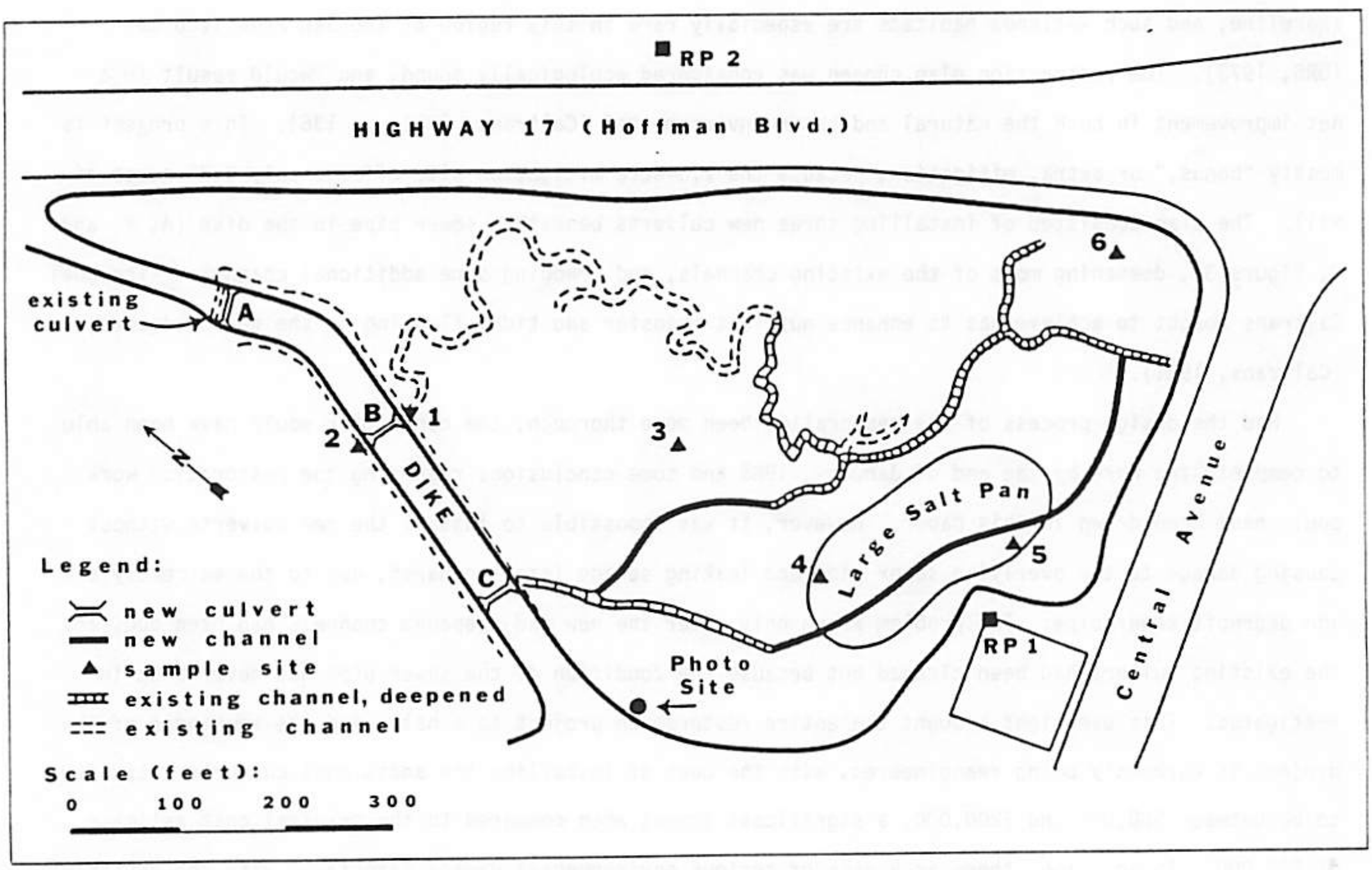

Figure 3. Hoffman Marsh Study Area, showing Restoration Features and Sample Sites.
Source: Adapted from Caltrans (1984).

Sampling Methods

Water samples were collected on two separate days, one dry day (10/25/84) and one day during a rainfall (11/2/84) (Table 1). The sampling sites were chosen to show conditions representative of both salt pan and channel water quality in the study area (sites 1, 3-6, Figure 3), and to compare conditions with the main marsh (site 2, Figure 3). A reference site was also chosen (site 7, Figure 2) in order to represent the nature of the bay water entering the marsh. Refer to Table 2 for precise site locations.

Rainfall:	
10/25/84:	no rain for 8 days prior to sampling; season total rainfall = 2.36"
11/02/84:	0.35" rainfall day of sampling; season total rainfall = 2.85"
Tides (Golden Gate):	
10/25/84:	ebb, 6.5' at 12:28 pm, -1.1' at 6:51 pm.
11/02/84:	flow, 2.4' at 1:33 pm, 4.6' at 7:05 pm.

Table 1. Rainfall and Tide Conditions on Sampling Days.

Sampling procedures common to all the tests follow Standard Methods (APHA, 1975) except as noted. I collected grab or catch samples of water from both open channels and salt pans containing still water. Open channel samples were collected as far out from the edge as I could reach and 10-30 cm below the surface, and all the bottles were capped under water.

Site	RP 1	RP 2
1	158^{0} E of N	80^{0} E of N
2	155^{0} E of N	82^{0} E of N
3	166^{0} E of N	47^{0} E of N
4	155^{0} E of N	33^{0} E of N
5	123^{0} W of N	16^{0} E of N
6	112^{0} W of N	12^{0} W of N

Reference Point 1 (RP 1): Northest corner of building in southwest corner of study area.

Reference Point 2 (RP 2): Northwest corner of 2-storey cement building immediately east of highway 17.

Table 2. Site Locations with Respect to Compass Reference Points.

Salt pan water samples were collected in one of two ways. Where depth permitted, the sample bottle was submerged and capped underwater. Where the water was too shallow for this method, a smaller bottle was used to pour water into the sample bottle until the sample bottle overflowed.

Testing Methods

Dissolved oxygen: Samples were collected in 300 ml glass BOD bottles. The samples were analyzed using the Winkler or iodometric method, with the azide modification to account for the presence of nitrite (APHA, 1975). The samples were treated immediately in the field with 2 ml $MnSo_4$ and 2 ml alkali-iodide-azide reagent in order to preserve the oxygen in the sample. I performed the remainder of the procedure within two or three hours after collecting the sample, following exactly the procedure in Standard Methods (APHA, 1975).

Turbidity: The Nephelometric method of analysis (APHA, 1975) was used to determine the turbidity on a Hach Model 2100A Turbidimeter. The samples were stored overnight at $4^{o}C$. Turbidity is expressed in Nephelometric Turbidity Units (NTU).

pH and conductivity: Samples collected in 300 ml glass BOD bottles were used for both tests, using a Beckman Model 4500 Digital pH Meter and a YSI Model 31 Conductivity Bridge, respectively.

Significance of Water Quality Parameters

Dissolved oxygen is a general index of the health of a body of water, and plays a very significant role in wetlands water quality. Physical, chemical, and biochemical activities all affect DO levels in natural water (APHA, 1975). The standard for San Francisco Bay is 5.0 mg/l for tidal waters, although higher concentrations are recommended to protect sensitive aquatic forms (RWQCB, 1982). High levels of dissolved oxygen are especially important in waterfowl habitats in order to suppress the development of botulism organisms, particularly in shallow fringe areas (RWQCB, 1982).

pH is a measure of the hydrogen ion concentration in the body of water. The standard is a range of 6.5 - 8.5 (RWQCB, 1982). Since many activities are dependent on the pH, particularly biological activity (Sawyer and McCarty, 1978), the maintenance of the pH within the above range is essential to a healthy salt marsh.

Turbidity, caused by suspended matter such as clay, silt, finely-divided organic and inorganic matter, and plankton and other organisms, affects the extent to which light transmits through water (APHA, 1975). Sufficient penetration of sunlight is essential to maintain phytoplankton productivity. The standards state that waters shall be free of changes in turbidity that adversely affect beneficial uses (RWQCB, 1982).

Temperature is particularly important in dissolved oxygen determinations, as the oxygen solubility is a function of temperature (Sawyer and McCarty, 1978).

Conductivity is a measure of the ability of an aqueous solution to carry an electric current, and depends on total concentration of dissolved ionic species (i.e., salts) and temperature (APHA, 1975).

The conductivity of seawater is about 50,000 µmhos/cm (Hem, 1970).

Results

Table 3 presents the results of my water analysis. Dissolved oxygen (DO) ranges from a low of 3.98 mg/l at site 7 on the wet day (11/2/84) to a high of 9.63 mg/l at site 4 on the dry day (10/25/84). The dry day has an average DO level of 8.13 mg/l, whereas the wet day has an average DO level of 6.80 mg/l. Note also that DO levels at site 7, the reference site, are below the average on both test dates. The pH ranges from 7.05 at site 6 on the dry day to 8.65 at site 3 on the wet day. All of these values are basic (neutral water = pH 7, and below pH 7 is acidic). The turbidity was low on the dry day, ranging from 5.2 NTU at site 2 to 7.0 NTU at site 1, and much higher on the wet day, ranging from 12 NTU at sites 3 and 4 to 26 NTU at site 7. Water temperatures are essentially constant between the sites, but differed between sampling dates. Temperatures were 13° or 14° C on the dry day and 11° or 12° C on the wet day. With one exception, all the conductivities are close to that typical of seawater (50,000 µmhos/cm at site 6. The exception is site 7 on the wet day, where the value dropped to 16,100 µmhos/cm.

Site	Date	Rain	Time (pm)	Temperature (°C)	pH	Conductivity (umhos/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)
1	10/25/84	dry	2:40	14	7.96	48,900	7.0	8.88
	11/02/84	wet	-	-	-	-	-	-
2	10/25/84	dry	3:10	14	7.87	47,800	5.2	8.96
	11/02/84	wet	-	-	-	-	-	-
3	10/25/84	dry	3:40	13	7.67	44,800	5.7	7.27
	11/02/84	wet	2:40	12	*8.65	46,900	16	9.36
4	10/25/84	dry	3:50	14	7.99	51,600	-	9.63
	11/02/84	wet	2:50	11	7.95	46,400	12	5.90
5	10/25/84	dry	4:10	13	8.06	51,300	-	9.01
	11/02/84	wet	3:05	11	7.75	47,500	12	8.18
6	10/25/84	dry	4:25	13	7.05	49,500	-	5.63
	11/02/84	wet	3:15	12	7.77	51,800	17	*3.98
7	10/25/84	dry	4:55	14	7.84	45,700	-	7.52
	11/02/84	wet	3:35	11	7.75	16,100	26	6.58
Average	10/25/84	dry		14	7.78	48,500	6.0	8.13
	11/02/84	wet		11	7.97	41,700	17	6.80

* Exceeds RWQCB Standards

Table 3. Water Quality Data.

Discussion

Water Quality

In examining the water testing results, one must keep in mind that grab samples were taken, representing conditions at only one instant of time, rather than composite samples, which can show diurnal and seasonal variations. Hence, only limited interpretations of the results are possible. Samples taken on the dry day are more representative of the habitat water quality, as rainfall disturbs many processes.

Since dissolved oxygen (DO) levels represent a balance between biological decay and photosynthesis, two explanations for the lower DO levels on the wet day can be proposed. First, photosynthesis has likely decreased (less sun, colder water), thus less oxygen is produced. Second, one could speculate that rainwater, usually saturated with dissolved oxygen (Hem, 1970), may stir up the bottom of the salt pans or channels, exposing additional dead organic matter, which increases the biological oxygen demand (BOD). The DO results also indicate that physical processes, namely atmospheric oxygen exchange, do not play a significant role, as the DO levels decrease when the water temperature is lower, opposite to the laws of gas dissolution into water (Sawyer and McCarty, 1978). Site 7, the mouth of the tidal inlet channel to the entire marsh, has lower DO levels than most all other sites, indicating that net photosynthesis is occurring in the study area. Lastly, the main marsh channel (site 2) has a high DO level, the value being surpassed only by the large salt pan values. This indicates that more photosynthesis and/or less decay is occurring in the main marsh than in the study area, excluding the now-drained large salt pan.

The turbidity data suggest that less photosynthesis occurred during the rain, as higher turbidity values mean less light penetrates through the water (Sawyer and McCarty, 1978). Greater variation among sites on the wet day indicate that site comparisons of activities on the wet day might not be very valid. This further supports my hypothesis that the dry-day results are more indicative of habitat conditions. Lastly, note that site 7 on the rainy day has the highest turbidity of all the sites, probably due to the nearby storm drain that flows into the main marsh carrying in large amounts of suspended material with the storm water.

The conductivity data show no substantial change between the dry and wet days, except at site 7 which is influenced by the storm drain. This strongly indicates that there are no appreciable freshwater flows into the study area. The conductivity data also show that all portions of the Hoffman Marsh tested contain saltwater, verifying indeed that the entire marsh is a salt marsh.

All the pH values are within acceptable standards except that at site 3 on the wet day. Since so many factors influence pH, the most that can be said about the pH data is that the pH in the marsh does not impede the proper functioning of any physical, chemical or biological activity in the water. It is this variety of influences that has likely caused site 3 to be above the standard.

Habitat

The dramatic changes that have occurred in the marsh are shown in the photographs of the before-restoration and current condition of the study area (Figure 4). About three or four acres of the marsh study area are now a torn-up field of mud with isolated depressions full of water, and it appears that the elevation of portions of this western half of the study area has been raised. These two photographs would be useful for future evaluations of this marsh.

A factor that has had a major influence on the study area is the removal of the dredge spoils that were created by digging the new tidal channels. The BCDC permit to Caltrans stipulated removal of the dredge spoils, as dredge spoils constitute unnecessary fill in the Bay. This condition is required by the San Francisco Bay Plan policies on marshes and on fill (BCDC, 1979). Heavy equipment used to remove the dredge spoils from the study area, however, resulted in the tearing up of the marsh surface (see photos) to the apparent detriment of this marsh habitat. In an attempt to minimize the impact, the contractor was allowed to place the remaining spoils onto the marsh surface (Michalak, personal communication, 1/85). This activity has resulted in a rise in marsh elevation, particularly along the western side of the study area.

One of the most important factors governing diversity of a wetlands habitat is zonation patterns of vegetation, dictated primarily by frequency and extent of tidal inundation (Josselyn, 1983). The lower zone (roughly, up to MHW, Mean High Water) receives frequent inundation and consists primarily of cordgrass and other submergence-tolerant species; the middle zone (roughly, MHW to MHHW, Mean Higher High Water) is occasionally inundated and is dominated by pickleweed; and in the rarely-inundated upper zone (roughly, above MHHW), saltgrass and other upland and non-marsh species exist (Josselyn, 1983). Each zone, therefore, provides a unique wetlands habitat (Josselyn, 1983). In the study area, unlike in the main marsh, the cordgrass zone is absent (URS, 1973). This could be attributed to two causes: first, the average elevation of the study area is roughly one foot higher than the average in the main marsh (Cuneo, unpublished data); and second, the existing culvert acts as a barrier to free tidal action, limiting the extent of tidal inundation in the study area. The absence of the cordgrass zone and the presence of upper zone vegetation on slight rises throughout the study area are evidence of the already-limited habitat in the study area. Further limiting of the wetlands habitat value of the study area has been caused by the placing of some of the dredge spoils onto the marsh surface, resulting in the creation of additional upland zone habitat in the study area. These changes indicate the rapid acceleration of the succession of the study area habitat from a wetlands habitat to an upland habitat. Had the additional culverts been installed, as planned, the barrier to tidal action would likely have been lessened, resulting in a possible damping out of the effects of the dredge spoils, and thereby preventing the transition of portions of three or four acres of marsh to upland habitat.

Figure 4. The Hoffman Marsh Before Restoration Began (Top, 10/28/84) and After Restoration Commenced (Bottom, 2/9/85).

Pickleweed, the dominant salt marsh vegetation, should be a good indicator of marsh recovery, since it is a prolific species in locations where most competitors cannot survive. Regrowth occurs in the springtime via rhizome and seed propogation, but it is not uncommon, however, for full pickleweed recovery in a disturbed area to take more than one season (BCDC, 1983b). Recent observations show some isolated recovery of pickleweed in the mud-torn area, although a number of upland species have also been observed, including wild radish (Raphinus sativa), wild oats (Avena fatua), and other species (Faber, personal communication, 4/3/85). Invasion by upland species of what was once a predominantly pickleweed area indicates the loss of wetlands habitat, and is therefore not in the best interests of San Francisco Bay nor the public.

A dramatic change that has occurred in the study area is the destruction of the top layer of sediments throughout most of the mud-torn area. Loose loam to clay soils are best for marsh plant growth (BCDC, 1983b); such soils are like quicksand -- one sinks in when stepping directly on the soil. The entire marsh had such sediments. Now, however, the three or four acres of mud-torn sediments in the study area, which receive little or no tidal inundation and bake in the hot sun, have lost most of their water content and have become very compacted. The bulk densities of the sediments in the study area have been found to be as much as twice that of sediments in the main marsh (see Jim Machado's paper in this report). One can walk anywhere through this area and have no fear of sinking. Such clay soils, once compacted through evaporation, cannot revert to their original state, for water cannot easily penetrate the closely-packed clay particles (Sloan, personal communication, 4/85). Thus, reestablishment of vegetation could be hampered in the three- or four-acre impacted area.

A significant change in the study area habitat resulting from the restoration work is the draining of the large salt pan found in the southwest corner of the study area (Figure 3). Although the salt pan was thought to be an undesirable feature of the marsh, hence the plan to channel through it, two factors suggest that the pan played an important role. First, the dissolved oxygen data (Table 3) for sites 4 and 5, both in this salt pan, show the highest DO values of all the test sites on the dry day. Photosynthetic production by phytoplankton and benthic algae, major primary producers in water (Pomeroy, 1981), is an oxygen-producing activity, hence the DO levels found indicate either low oxygen demand and/or high photosynthetic productivity in this salt pan, relative to the other test sites. I would speculate that the latter cause is more likely, for reasons to follow, indicating that this salt pan was in fact a valuable habitat in its own right. Second, the high level of bird activity in this salt pan (discussed in Ellen Hay's paper in this report) suggests a plentiful food supply (perhaps due to the active photosynthesis). Both of these findings raise questions about the merits of eliminating this large salt pan.

A major concern in salt marshes anywhere is mosquito control. Because adult mosquitoes are identified as the carriers of diseases, such as malaria, their control is of great interest to the public.

Prime habitats for the breeding of the Aedes larvae include the following characteristics: (1) stagnant water; (2) pond height greater than 6.4 feet above MLLW (Mean Lower Low Water); and (3) pond area of less than 100 m^2 or a minimum 30% pond cover of emergent vegetation if considering a larger surface area (Balling and Resh, 1983). Application of these conditions to the study area both before restoration work began and after work commenced leads to the conclusion that a potential mosquito breeding habitat existed and still exists, as the marsh elevation is approximately 8.4 feet above MLLW (adapted from Cuneo, unpublished data), and a number of small salt pans exist. In addition, many small, isolated depressions in the mud-torn area that were created during restoration work have filled with rainwater, thereby providing additional mosquito habitat. Sampling for Aedes larvae is needed to confirm a mosquito problem. However, the presence of mosquitoes in the study area has been observed on more than one occasion, and particularly since restoration work began, perhaps due in part to the changing seasons.

The restoration project, in so far as it has been carried out, has indeed brought some improvements to at least part of the 7.5-acre study area. The existing culvert does provide somewhat better tidal exchange into the study area since the culvert has been daylighted, and the new and deepened channels are providing tidal circulation to previously-remote areas (Figure 3). The effects of the improvements are particularly noticeable at site 6, a small salt pan in the farthest southeast corner of the study area, as well as in much of the eastern half of the study area. Site 6 now receives tidal flushing with the very high tides, whereas flushing rarely occurred before restoration. The study area also appears to receive more extensive tidal inundation now, although inundation is still greater in the main marsh. Even though the entire restoration project has not been completed, it does appear that the goals of the project are being realized to some extent in parts, but not all, of the study area.

Conclusions and Recommendations

Rating the success of the Hoffman Marsh restoration project at this stage would be premature, for the course of nature takes time and can be very forgiving. But under the circumstances that have arisen as a result of the work performed, some evaluation is warranted. Ideally, this project could, and might still, have great success. But with the combination of spoils placed onto the marsh surface, compacted sediments, and absence of additional culverts to help tidal exchange into the study area, full restoration goals are not likely to be achieved in this marsh. Rather, if no corrective measures are taken, the outcome will be a net degradation of this wetlands habitat.

What can be done to rescue this marsh from its possible demise? One alternative is to require Caltrans to install the three additional culverts and remove all the spoils, regardless of the cost involved. But considering that the restoration project is essentially "bonus" mitigation, one can find little legal justification for this expensive alternative. Another alternative is simply to leave the degraded marsh as is and install the additional culverts when the sewer pipe is replaced by its owner in five or ten years. This alternative neglects the value of the marsh. A third alternative, which I strongly advocate, is requiring Caltrans to do the following: (1) reduce the elevation of the restoration area to its original height; (2) check the existing culvert often (monthly), and clean out as necessary; and (3) install the additional culverts at the time of sewer pipe replacement. This alternative would allow nature to take its course without so many impediments, and could result in near-achievement of restoration goals throughout the study area even before the new culverts are installed.

What has happened with the Hoffman Marsh restoration illustrates some of the problems of marsh restoration is mitigation, problems that more and more people are coming to recognize. It is evident, therefore, that reforms in the mitigation process are necessary. The State Coastal Conservancy, an agency active in wetlands restoration, has initiated some reform, including a "mitigation bank." But what else can be done? First, I feel that comprehensive, thorough, and professional planning is a necessity. Developers, often left to plan and implement restoration projects themselves with the responsible agency (BCDC or the U.S. Army Corps of Engineers) acting merely to review the project, often do not have the expertise or interest necessary for successful wetlands restoration. Second, expanding the mitigation bank concept could provide developers with habitats that have identified problems and potentials, thereby easing the burden on developers of searching for a suitable restoration site. Lastly, responsible agencies should be wary of accepting "bonus" mitigation, for they are tying their own hands when problems arise with approved projects.

Monitoring marsh restorations is a very important part of the restoration process. If the Hoffman Marsh had not been monitored, most of the detrimental results would not be documented, and this marsh might have become another unfortunate failure. What has happened with this restoration project should not be forgotten, for only by examining the successes and failures of marsh restoration as mitigation can the entire mitigation concept be improved.

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