DFG 5

State of California
THE RESOURCES AGENCY
Department of Fish and Game
Bay-Delta Project

Testimony on the Suisun Marsh for the State Water Resource Control Board's Bay-Delta Hearing

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THE SUISUN MARSH

Introduction

The Suisun Marsh (Marsh), located in southern Solano County, south of Fairfield and just west of the confluence of the Sacramento and San Joaquin rivers, is composed of 87,000 acres of managed and tidal marshlands, intertidal bays and sloughs. It is the largest contiguous brackish water marsh in the nation, supporting over 200 species of birds, 36 species of mammals, seven species of threatened or endangered wildlife and six species of candidate or listed plants. It is best known for its waterfowl resources and is a major wintering area for ducks and geese of the Pacific Flyway.

Marsh plants provide the major source of waterfowl food, and their distribution and productivity are controlled by several environmental factors, including soil water salinity and length of submergence.

Currently, bay salinity and marsh management practices both affect the vegetative composition of the Marsh. Future increases in diversions of fresh water upstream of the Marsh could result in substantial increases in the salinity of tidal bays and sloughs in the Marsh especially in dryer years. The use of highly saline waters for marsh management purposes would reduce the productivity of important waterfowl food plants thereby severely reducing the holding capacity of the Marsh, especially for wintering waterfowl.

In recognition of the Marsh's outstanding wildlife values and specific water quality and management requirements to maintain these values the State Water Resources Control Board (SWRCB) issued Decision 1485 (D-1485). This decision outlined water quality standards for selected control stations in the Marsh and mandated that the California Department of Water Resources (DWR) and U.S. Bureau of Reclamation (USBR) prepare a plan to implement these standards. DWR subsequently prepared the Plan of Protection for the Suisun Marsh (Plan). The Plan includes a description of physical facilities that DWR anticipated would be needed to meet the water quality standards in D-1485 and a plan to monitor compliance with these standards. The Plan was developed with the assistance of the Suisun Marsh Technical Committee which includes representatives of DWR, California Department of Fish and Game (DFG), USBR, U. S. Fish & Wildlife Service (USFWS), and with the participation of the U. S. Soil Conservation Service (SCS), Suisun Resource Conservation District (SRCD), SWRCB, San Francisco Bay Conservation and Development Commission (BCDC), Regional Water Quality Control Board, Fairfield-Suisun Sewer District and U.S. Corps of Engineers.

DWR, DFG, USBR and SRCD have since entered into a contract titled the Suisun Marsh Preservation Agreement (Agreement) which clearly defines the responsibilities of DWR and USBR to provide the required facilities and water quality to protect the Marsh. The areed upon water quality differs in some respects from that provided for in D-1485. The Agreement also outlines the responsibilities of SRCD to oversee landowner compliance with their individual ownership management plans.

This testimony includes data presented at the original D-1485 hearings that the SWRCB found useful in defining the permanent water quality standards established in that decision. It also describes how the proposed modifications to D-1485 water quality standards will impact the Marsh, outlines the mitigation proposed for impacts due to the construction of the water delivery facilities and impacts on the channel islands from upstream diversions, and summarizes protection measures adopted for the endangered salt marsh harvest mouse.

Importance of the Suisun Marsh to Waterfowl

The value of the Suisun Marsh to waterfowl has been well documented in the literature. Significant points related to its importance include the following: (1) the 57,310 acres of marshland constitute approximately 12 per cent of California's remaining wetlands; (2) average monthly fall and winter waterfowl populations within the last 10 years have varied between 78,000 and 178,000 birds (Table 1). These populations consisted principally of northern pintail (Anas acuta), American wigeon (Anas americana), mallard (Anas platyrhynchos), Northern shoveler (Anas clypeata), and green-winged teal (Anas crecca). It is important to note that poor breeding success due to drought conditions on the northern breeding grounds for the last five years have resulted in fewer waterfowl using the Marsh. From 1967

TABLE 1

Mean Monthly Waterfowl Use of Suisun Marsh from October 1977 Through December 1986 1/

	Oct.	Nov.	Dec.	Jan.
Pintail	61,200	126,200	124,700	67,000
Mallard	3,000	8,400	7,900	16,100
Total Waterfowl	78,200	169,500	178,000	125,300
% of State Total	3.3%	5.6%	4.5%	3.9%

1/ Data from California Department of Fish and Game aerial waterfowl surveys.

through 1976 waterfowl use varied between 314,000 and 374,000. (3) because of its permanency, the Marsh provides particularly critical habitat when few other areas are flooded in the early fall or under drought conditions. In 1974, for example, 1,128,035 ducks or approximately 28 per cent of the statewide waterfowl population was concentrated in the Marsh at the time of the October inventory; (4) it is a major wintering site for pintail, California's most numerous duck; and (5) it supports an average breeding population of about 2,400 pairs annually of primarily mallards, godwall and cinnamon teal. This is expected to increase as additional nesting and brood habitat is developed.

The first duck clubs in the Marsh were organized around 1880. With the general decline of agricultural efforts in the 1930's, private duck club activities increased and presently constitute the major land use of the area. There are between 150 and 160 duck hunting clubs varying in size from 30 to over 1,000 acres.

In 1931 the State acquired the 1,880 acre Joice Island as a waterfowl refuge. Major waterfowl crop depredation problems developed in the Central Valley during the late 1940's, and as a part of relief measures, the 8,560 acre Grizzly Island Wildlife Area was acquired in 1950. Both state areas also provide hunting for unattached sportsmen. There are now approximately 13,000 acres of State owned lands in the Marsh with plans to acquire up to 2,500 additional acres over the next 10 years.

Vegetative Composition of the Suisun Marsh

During 1959 a major effort was undertaken by DFG to inventory the vegetation of the Suisun Marsh (George et al 1963). That survey identified 177 plant species, of which 15 species covered areas greater than one per cent of the total marsh acreage. Three plant species comprised over 56 per cent of the Marsh's vegetation. Pickleweed (Salicornia virginica) comprised 25.6 per cent, saltgrass (Distichlis spicata) 24.4 per cent, and alkali bulrush (Scirpus robustus) 6.3 per cent. Twelve other plants, individually accounted for 1 to 5 per cent of the Marsh and together covered about 28 per cent. The remaining 162 species of plants collectively contributed a little over 16 percent of the total ground cover.

Subsequent vegetative surveys were conducted in 1973, 1978 and 1981 (Table 2). Significant changes in the composition of alkali bulrush occurred between 1978 and 1981, with an increase of at least 106 percent. This increase can be attributed to the implementation of marsh management practices that favored alkali bulrush. The most notable difference between the 1973 survey and 1978 is the significant increase in pickleweed. This increase reflected the changes in vegetation composition caused by the drought. By 1981 this trend had been reversed and pickleweed abundance returned to the pre-drought levels of 1973.

TABLE 2

Distribution of Habitat Classes
1973, 1978, and 1981

Habitat Classification	1973	1978	1981
Pickleweed	5,256.6 ha	7,281.3 ha	5,157.6 ha
Alkali bulrush	2,766.1	2,841.4	5,701.3
Olney bulrush	96.3	28.7	19.3
Cattails & Tules	3,739	2,589.2	2,814.2
Brass buttons	773.8	786.3	1,541.2
Fat hen	1,601	794.4	179.8
Salt grass	2,264.7	2,295	1,799.4
Baltic rush	230.3	286.1	56.7
Low-land purslane	1/	1/	8.9
Annuals	1,604.6	2,466.2	10,683.9
Bare ground	237.1	269.1	1,583.4
Water 2/	924.7	422.1	1,581.4
Miscelaneous	104.4	255.8	615.2
Crops	1,676.6	1,323	3/
Total	21,275.2 ha (52,571 A)	21,608.6 ha (53,395 A)	31,742.3 ha 4/ (78,435.3 A)

1/ Not measured.
2/ Classified as Ponds (P) in 1973 and 1978 surveys.
3/ Included in Annuals and Miscellaneous.
4/ Survey area was defined differently than in 1973 and 1978 surveys. Larger areas of annuals were included as a by-product of standardizing survey area boundaries by using major roads.

Waterfowl Food Habits

A collection of 1,409 gizzards was obtained from the five most abundant duck species in the Suisun Marsh (George et al, 1963). The collection spanned the months of August, September, October and December 1960 and January 1961. Analysis of that data revealed that 35 plants out of 177 species recorded in the Marsh were used as food. The method used to assess the relative value of food plants employed two factors, use and selection. The use factor was determined by multiplying the per cent of gizzards containing portions of a given plant (per cent frequency of occurrence) by the per cent of the total gizzard contents that plant consitituted (per cent volume). The selection factor was calculated by dividing the use value of a given plant by the relative abundance of that plant in the Marsh. The monthly use and selection values for each plant were determined by combining the respective monthly values of each plant for each of five duck species and adjusting the results to reflect the relative abundance of each duck species. Thus the calculated importance of various food plants relates to the entire waterfowl population and not just a single species. Pintails were estimated to be about 7 times more abundant in the Suisun Marsh than any other duck so it follows that plants utilized by this species were weighted proportionately higher than plants favored by other ducks.

Six plants, representing about 60 per cent of the total marsh plant cover, received the greatest overall use: alkali bulrush, brass buttons (Cotula coronopifolia), pickleweed, saltgrass, fat-hen (Atriplex patula) and Italian ryegrass (Lolium multiflorum). Of that group, alkali bulrush, fat-hen and brass buttons were highly selected by the entire waterfowl population.

A subsequent food habits survey conducted in the fall of 1971 and the winter of 1972 revealed that the use of alkali bulrush and fat-hen had nearly doubled (Rollins 1973). The use of brass buttons had decreased slightly. The increase in use of alkali bulrush and fat-hen probably reflected the increased abundance of these plants.

Alkali bulrush received higher seasonal use in 1960-61 than any other waterfowl food plant recorded (Figure 1). It was the only plant that received a continuous high level of use by the overall waterfowl population throughout the fall and winter. In 1960 and 1971 it was the major food of an estimated 88 percent of the wintering ducks which included pintails, mallard, shovelers, and greenwinged teal, yet in 1960 it represented only 6.3 per cent of the marsh vegetation and in 1973, 13 per cent. The high selection of this plant, as indicated by the high use/abundance ratio, is influenced strongly by three factors: (1) nearly all of the areas where alkali bulrush grows are flooded for most of the winter, thereby making it easily accessible, (2) under favorable conditions, the plant produces large quantities of seed and (3) its seeds are resistant to decay and persist for several years.

Brass buttons was second in overall use in 1960, though it constituted only 2.1 per cent of the marsh vegetation. Waterfowl use of the seeds from this plant occurs almost entirely in August and September. The tendency of the small seeds to windrow in mats

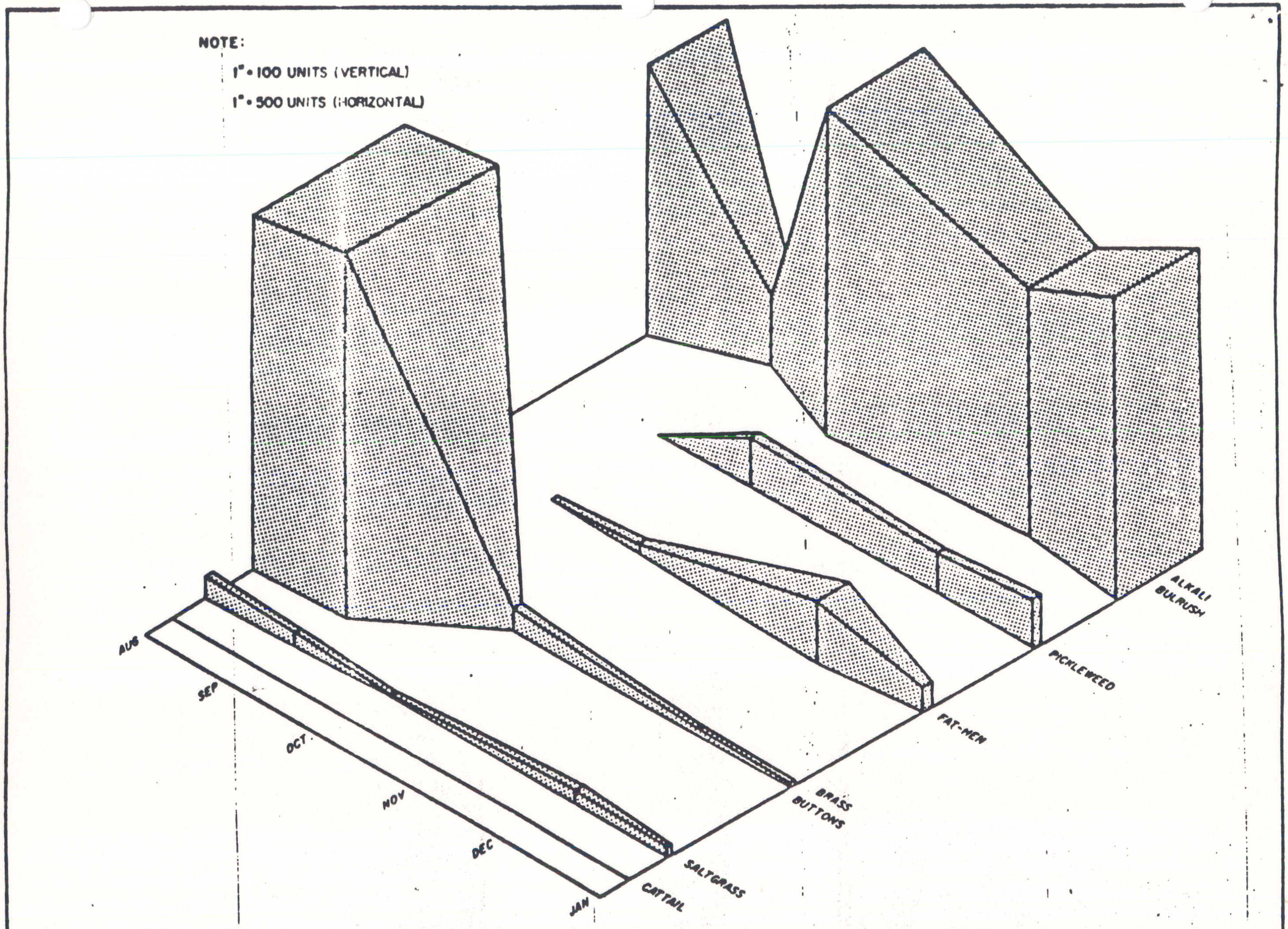

FIGURE 1. Overall Waterfowl Use and Selection of Important Marsh Plants in 1960 and 1961 (Mall 1969).

at the pond margins immediately following flooding make the plant an especially attractive food source. Waterfowl feed heavily on the leafage of this plant in the winter from mid-December until their spring departure. The winter use of brass buttons is not reflected on Figure 1 since the vegetative fragments are Figure 1 unidentifiable in gizzard contents. Field observations of feeding waterfowl have identified this pattern of use.

Fat-hen was third in use in the fall of 1960 and second in 1971. Waterfowl use of this plant doubled between the 1960 and 1971 surveys. The use of fat-hen occurs mainly in November and December. Two factors appear to be responsible for this use pattern. First, access to fat-hen stands, normally located on the higher areas of ponds, is greatest during November and December when pond water levels peak. Second, approximately one month of inundation is required before the seed heads have rotted sufficiently to release the seeds. Since alkali bulrush seeds persist longer in the gizzard than fat hen seeds, fat hen may have been under represented in these past surveys. Consequently its value to waterfowl may be greater than at first indicated.

In the 1960 study, pickleweed ranked third in overall use, but received a very low overall selection value. It was, however, the most important and selected food of American wigeon. Wigeon selected and fed heavily upon pickleweed throughout the winter.

The use of pickleweed by other species of ducks appears to be mainly the result of incidental ingestion, and the low selection values indicate avoidance of pickleweed. This hypothesis is supported by the following: (1) pickleweed was abundant, since it represented nearly 26 per cent of the marsh vegetation in 1959; (2) it was present in ponds and easily available; (3) it was often found in association with highly selected plants such as alkali bulrush, brass buttons, and fat-hen; and, (4) the average seasonal volumes of pickleweed material found in all duck species, except American wigeon, were small (approximately 6 per cent).

Although saltgrass was the most abundant plant in the Marsh, providing 24 per cent of the ground cover in 1959, it received a very low selection value. While this is partly because most saltgrass grows on upland soils not normally flooded and therefore not readily accessible to ducks, low selection also reflected avoidance of this plant by most duck species. The only exception was shovelers which seemed to prefer it over most other plant foods.

Many plants found at higher elevations in the Marsh are selected by waterfowl when available. Frequently however, because of their more "upland" location, waterfowl access to them is dependent largely upon high water levels. Fat-hen is a good example. Use peaked in December at the same time that pond levels were at a maximum and began dropping off in January as water levels receded. Proper marsh management techniques on areas with good drainage capabilities are now being used to encourage plants such as fat-hen, while allowing for subsequent shallow flooding to make this plant available to waterfowl at any time during the fall and winter.

Recent research on the food habits of wintering pintail has demonstrated the importance of invertebrates such as insects

(Connelly et al. 1980). Invertebrates ingested by waterfowl in the late winter and early spring provide the much needed protein to prepare waterfowl for the return migration to the northern breeding grounds. The dense complex structure of a diverse assemblage of marsh plants such as those described above provides an ideal substrate, when flooded, for large populations of invertebrates. This research indicates that the importance of maintaining a diverse association of brackish marsh vegetation may go beyond simply providing optimum levels of seed production.

Soil Factors Affecting Marsh Plants

Of the seven soil and water factors investigated during a two year study, in the Suisun Marsh by DFG (Mall 1969), the length of soil submergence and the concentration of salts in the root zone had the greatest influence on the presence and abundance of a given plant species.

Length of Submergence

Presence of water in the Marsh is a seasonal variable. Except for levee overtopping during high runoff conditions, and limited tidal flooding of the Marsh, it is almost completely controlled through the use of tide gates.

Except for a limited number of participants in an early flooding program, most duck club operators do not flood their lands before the first of October in compliance with mosquito abatement regulations. Flooding of the state-managed waterfowl areas and private lands in the early flooding program begins in early September. This early flooding provides badly needed resting and feeding areas and helps to minimize crop depredation in the Central Valley.

Maximum water depth on clubs in the Marsh, averaging 12 to 18 inches, is normally reached in late November and December. In anticipation of heavy rains, and the end of waterfowl season in January, many duck club managers begin lowering water levels in December. Following the end of waterfowl season the depth and duration of flooding varies from area to area. Generally, in an effort to leach out accumulated soil salts; clubs are drained, reflooded and then drained within 30 to 60 days of the end of waterfowl season. Many times this process is followed by a second flood and drain cycle depending on the resulting vegetative composition desired.

Hinde (1954), Chapman (1960) and Adams (1963) have all provided evidence that in tidal salt marshes one of the major factors controlling the vertical distribution of vegetation is the extent of tidal inundation to which these plants are subjected. The resulting distribution is rigid enough in such marshes to produce definite patterns or zones of vegetation. The vertical patterns in the Marsh are more diffuse than in tidal marshes because the land manager can and does alter the length and depth of submergence to achieve the goals outlined in the management plan for the ownership.

Marsh plants can be divided into two groups based on their tolerance to flooding: (1) the upper marsh flora which includes Baltic rush, saltgrass and fat-hen, and (2) the lower marsh flora which includes brass-buttons, pickleweed, alkali bulrush and narrowleaf cattail.

Soil Water Salinity

The second factor controlling plant distribution and growth in the Marsh, and the variable predicted to increase in the future, is soil water salinity. The importance of salinity in regulating plant growth has been well documented (Magestad 1945: U. S. Salinity Lab. 1954; Chapman 1960).

Soil water salinity in the Marsh varies with the season. Maximum levels in the root zone (0 to 12 inches) are recorded in September when soil moisture is at its lowest and the amount of salt is at its highest. With flooding in the fall, soil water salinity is substantially reduced and remains fairly stable until draining and flooding for leaching further reduces soil water salinity through about mid-May.

With the exception of the late summer period, concentrations in the second and third foot of soil are usually much higher and less variable than the first foot. The mean soil water salinity within the the third foot appears to change only slightly throughout the season.

Effects of Submergence Duration and Soil Water Salinity on Alkali Bulrush and Fat-Hen

Alkali Bulrush

The seed of alkali bulrush is the most important waterfowl food item in the Marsh, and interest is centered in the yield of this plant and its relation to seasonal soil water salinity. This relationship was determined by comparing September yields from square meter quadrats of alkali bulrush with soil-water salinities in the first foot of soil for each of the preceding 12 months at each quadrat. This analysis was based on the assumption that end of growing season seed yields are the result of past growth site conditions. A regression analysis revealed that May soil water salinity had the greatest influence on seed production (Mall 1969).

An analysis was made of the affect of May soil water salinity and length of soil submergence on resulting seed production (Figure 2). It was determined that the most suitable soil water salinity at that time was found to be about 14.1 EC (9 ppt TDS). Seed production at or above 80 per cent of maximum was attained within a salinity range of 10.9 to 14.8 EC (7 to 9.5 ppt TDS). When soil water salinity exceeded 18.8 EC (12.0 ppt TDS) during May, seed production was significantly reduced. Length of soil submergence provided an added benefit to increased productivity of alkali bulrush (Figure 2). This benefit, however, does not occur if the alkali bulrush is continually flooded. Interspecific

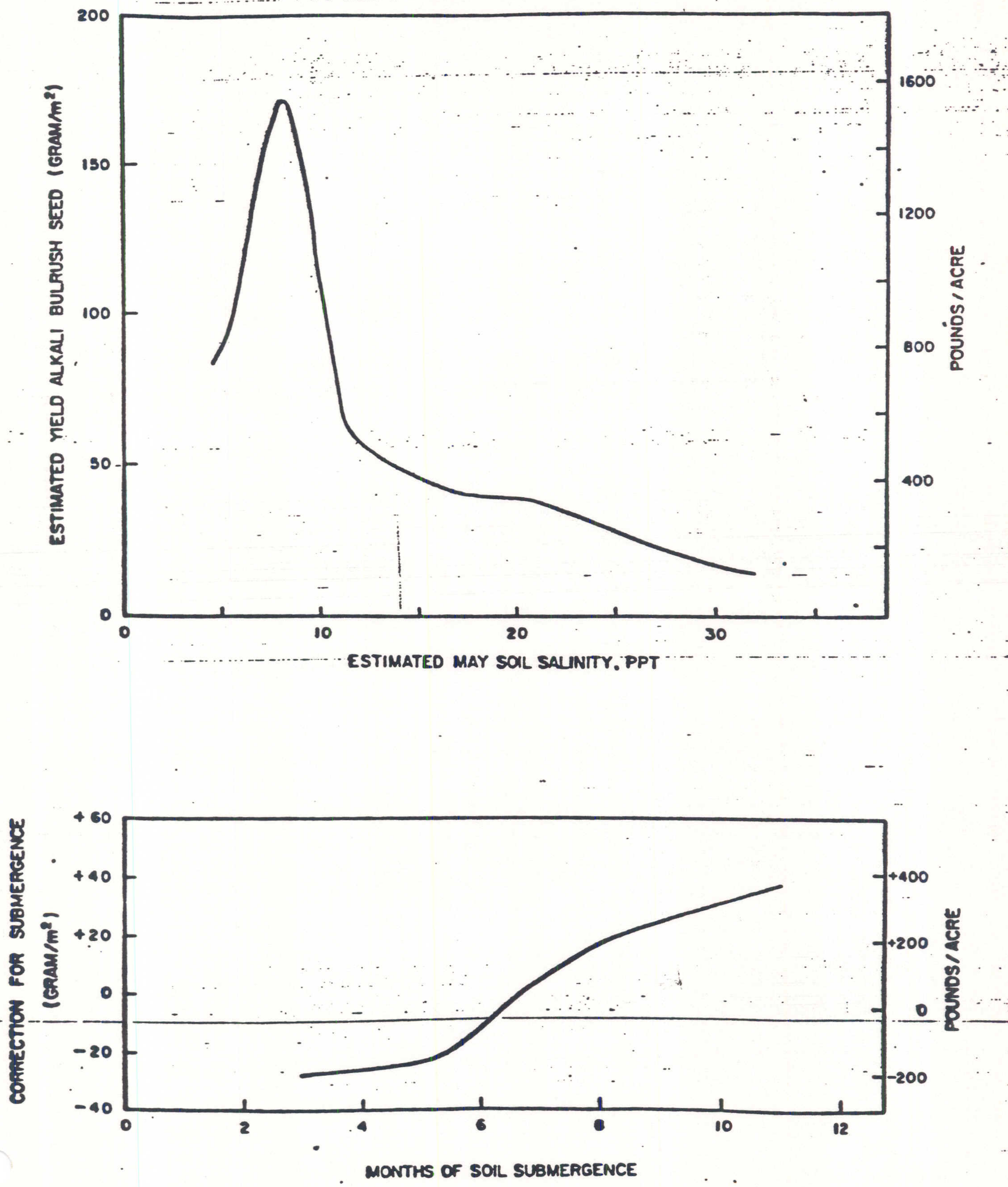

FIGURE 2. The Relationship of Alkali Bulrush Seed Yield to May Soil Water Salinity and Length of Soil Submergence (Mall 1969).

competition with cattails, for example, will result and seed production will be reduced.

The reduction in seed production from stands on soils with soil water salinities below 14.1 EC (9 ppt TDS) was primarily related to the influence of interspecific competition and not the effect of lowered salinity, because the ratio of seed weight to plant weight remained high in all instances of low salinities. Results from greenhouse cultures of alkali bulrush by Kaushik (1963), indicated better growth at low soil water salinities, but as is often the case, optimum levels which have been recorded under controlled laboratory conditions are not optimum in the natural environment because competition introduces additional effects.

The length of soil submergence accounted for important variations in seed yield and appeared to reduce the effect of high soil water salinities. Less than 8 months submergence reduced yield and longer periods, short of continuous submergence, increased yield. However, May soil water salinity at or above 39.1 EC (25 ppt TDS) are probably completely precludes alkali bulrush seed production regardless of the length of soil submergence.

A germination study of alkali bulrush seed conducted by DFG further indicated the importance of relatively fresh soil water conditions during the spring[1/]. Results indicated that as the

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1/ California Department of Fish and Game, unpublished data by Glenn Rollins on alkali bulrush seed germination rates.

soil water salinity increased, the rate of seed germination declined. This relationship has been found by other researchers during similar studies (Kaushik 1963 and Taylor 1939). Rollins found that May soil water salinities of approximately 14.1 EC (9 ppt TDS) resulted in a germination rate of 60% (Figure 3). At 23.4 EC (15 ppt TDS) virtually no germination occurred.

Fat-Hen

Dominant stands of fat-hen occur on soils where submergence ranges from 0-5 months. Three months appears to be the optimum length of flooding. The plant is a subdominant on sites submerged longer than 5 months. Delay or absence of seed germination is a primary response to prolonged submergence. Recommended management provides for only one leach cycle following the duck season so that ponds will be dry by mid-March to allow for seed germination of this important annual food plant.

During the early spring, when fat-hen seeds are germinating, soil water salinities are at a minimum in the root zone. Established fat-hen plants withstand high summertime salt concentrations. By July, when many fat-hen stands are growing actively, the mean soil water salinity may reach 53.1 EC (34 ppt TDS). Seed weights in excess of 3,600 lbs/acre have been recorded in the Chadbourne Slough area (Miller 1975). Little specific data is available on optimum soil water salinities for germination, seedling development and seed production. Monitoring data is now being collected that will provide this information.

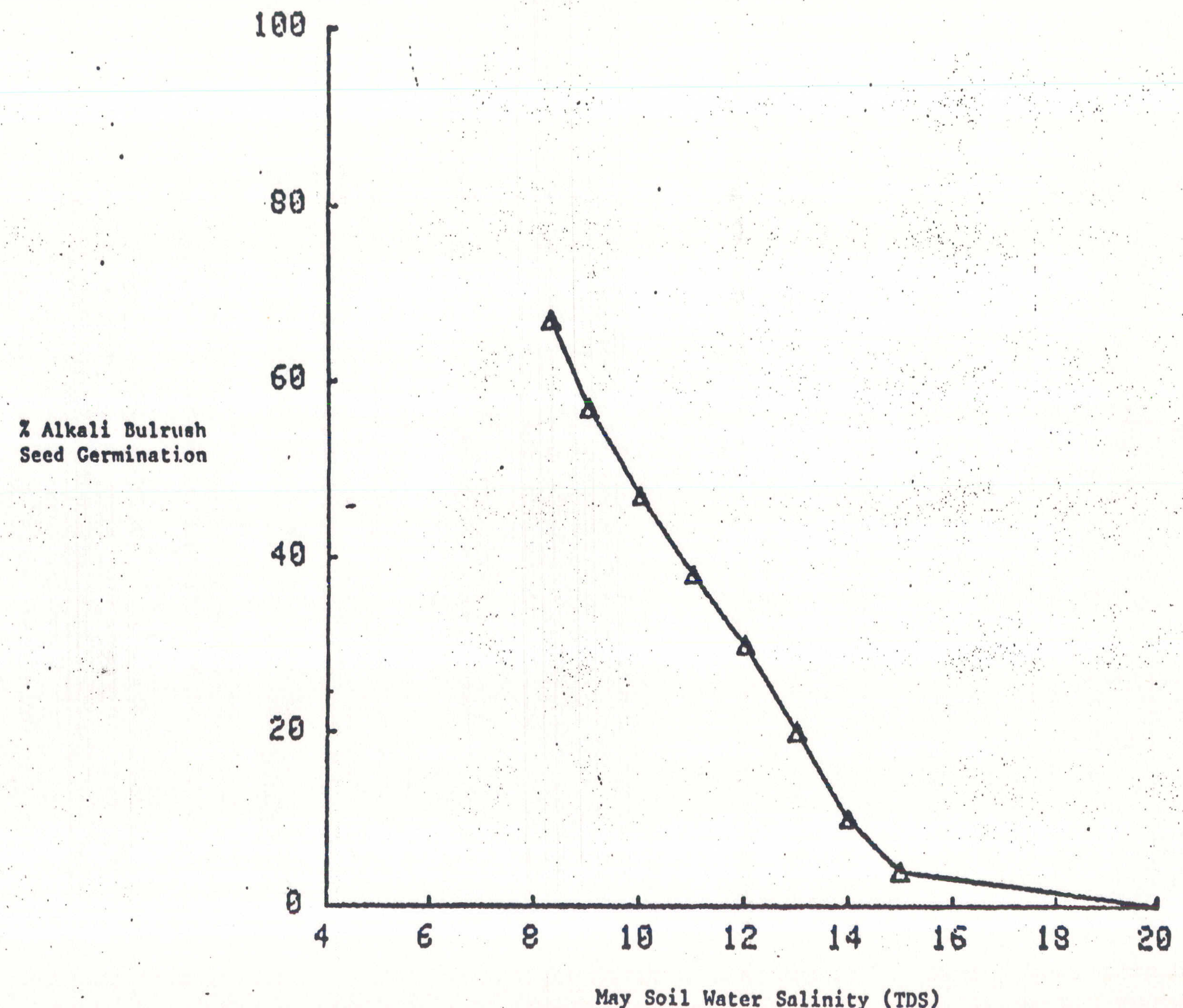

FIGURE 3. Relationship of Alkali Bulrush Seed Germination to May Soil Water Salinity

The Affect of Applied Water Salinity on Soil Water Salinity

Salts that affect the distribution and seed production of marsh plants are introduced into the soil column primarily by the waters applied to the Marsh each fall.

A study by the DFG (Rollins 1973) was undertaken to determine the relationship between applied water salinity and the resulting soil water salinity. An analysis of the results of water management on four private duck clubs and the results of an infiltrometer study on the Joice Island Wildlife Area were used to more clearly define this relationship. Rollins found that applying a relatively low salinity water in a series of flood and drain cycles resulted in significant reductions in soil water salinity ranging from 50 to 77% in the first foot of soil and 28 to 63% in the second foot. He also found that applications of high salinity water of approximately 31 EC (20 ppt TDS) resulted in significant increases in soil water salinity in the first and second foot of soil. Based on this work and previous research by the University of California[1/] regarding the relative efficiency of soil water salinity reduction through leaching, a table was prepared that depicts the applied water salinities required each month to achieve the soil water salinities necessary to assure adequate alkali bulrush seed production and germination (Table 3). These applied water salinities were those adopted by the SWRCB in its Decision 1485.

1/ University of California, Unpublished Data from the Delta Salinity and Nutrient Status Study (1973-75).

TABLE 3. Salinity of Applied Water Required to Achieve an Average of 90 Percent of Maximum Alkali Bulrush Seed Production and 60 Percent Seed Germination.

	Applied Water Salinity		Soil Water Salinity		Ratio of Soil Water Salinity to Applied Water Salinity
	EC (mmhos)	PPT TDS	EC (mmhos)	PPT TDS	
Oct	18.8	12[1/]	50.0	32	2:1
Nov	15.6	10[2/]	37.5	24	2:1
Dec	15.6	10	31.2	20	2:1
Jan	12.5	8	25.0	16	2:1
Feb	7.8	5	15.6	10	2:1
Mar	7.8	5	14.1	9	1.8:1
Apr	10.9	7	14.1	9	1.3:1
May	10.9	7	14.1	9	1.3:1

1/ The salinity of water applied in October dissolves surface salts and is increased by 4 ppt TDS, hence the 32 ppt TDS in the soil.

2/ The salinity of water applied in November is increased by 2 ppt TDS due to residual surface salts, hence the 24 ppt TDS in the soil.

It is important to note that the results of leaching accomplished by the application of the water in Table 3 was, by itself, not adequate to produce the desired waterfowl food production. Instead, it was concluded that a combination of improved management practices, improved drainage and control facilities, and a supply of adequate quality water would all be necessary to achieve the desired soil water conditions for waterfowl food plants.

The Affect of Water Management on Soil Water Salinity

Two main management strategies were devised to produce alkali bulrush and fat-hen respectively (Rollins 1981). A third strategy was also developed to grow watergrass (Echinochloa crusgalli) in areas of the Marsh which have low spring and summer soil water salinities. The first two strategies require two leach cycles and a final drain by June for alkali bulrush, and one leach cycle and final drain by mid-March for fat hen. The third strategy for water grass provides for no leach cycle but requires several irrigations during the summer months.

Impacts on Alkali Bulrush of Modifying Present D-1485 Permanent Marsh Standards and Providing for Deficiencies

The proposed modifications of the D-1485 permanent standards include a minor technical correction in the current permanent standards for November, the relocation of some Control Stations and the addition of "Deficiency Period". The first change would allow for an EC of 16.5 instead of 15.5 in November of all years. This modification will more accurately reflect the salinities expected in November as DWR and USBR reduce salinities from 19.0 in October to 15.6 in December. This modification will also result in a significant reduction in outflow needs with a predicted negligible effect on waterfowl food production. The increase of EC in applied water will not significantly add to the Marsh's salt load, especially since this water is generally being used for circulation in already flooded ponds and not for leaching purposes. The water applied during the months starting in December are proposed to remain the same as those in D-1485 (Table 4).

A more significant change in the original D-1485 standards is proposed, which provides for a relaxation in salinity standards for the months of January through May during a defined "Deficiency Period". A "Deficiency Period" is defined in the Agreement as a critical year following a dry or critical year, a dry year following a year in which the Four Basin Index was less than 11.35 or the second consecutive dry year following a critical year. Therefore, a "Deficiency Period" will not occur during the first dry or critical year. The salinities proposed for these "Deficiency Standards" utilize past research on the effects of soil water salinity on alkali bulrush seed production survival and competitive ability (Mall 1969, Rollins 1973 and 1981, and Pearcy

TABLE 4

Proposed Suisun Marsh Standards

Month	Normal Standards	Deficiency Standards[1/]
October	19.0	19.0
November	16.5	16.5
December	15.5	15.6
January	12.5	15.6
February	8.0	15.6
March	8.0	15.6
April	11.0	14.0
May	11.0	12.5

1/ Mean monthly high tide electrical conductivity in mmhos/cm.

et al. 1982). Table 4 contains the "Deficiency Standards" agreed to by the parties to the Suisun Marsh Preservation Agreement. These applied water salinities will result in soil water salinities significantly different than those calculated for the normal standards. Leach ratios determined by Rollins (1973) were modified to reflect the lower leaching efficiencies with the higher salinity water. The resulting soil water salinities are tabulated in Table 5 and compared to the salinities expected with the normal standards. Because these standards will eventually apply to all salinity Control Stations , including the west side stations, and because there is a natural salinity gradient from west to east with the west being more saline, there will be significantly lower salinity water available in the eastern Marsh. Computer model results based on DWR's Marsh model verified this and indicated that nearly two thirds of the Marsh will still achieve alkali bulrush seed production equivalent to that expected for the existing D-1485 standards. Table 6 contains an analysis of the results of these model runs. While production will suffer in the remaining one third of the Marsh, alkali bulrush tubers will survive even after two consecutive years of deficiencies (Pearcy et al. 1982). However, significant pickleweed encroachment will result due to increased soil water salinities and reduced competition from alkali bulrush during the second year. A two year recovery period will be needed after the "Deficiency Period" to return to D-1485 levels of seed production (Pearcy et al. 1982). During this two year recovery period good

TABLE 5

Soil Water Salinities Expected with
Applied Water Salinities Proposed for
Normal Standards and Deficiency Standards

Month	Normal Standards[1/] Applied	Normal Standards[1/] Soil-Water	Deficiency Standards[1/] Applied	Deficiency Standards[1/] Soil-Water
Oct.	19	50.5	19	50.5
Nov.	16.5	39	16.5	39
Dec.	15.5	31	15.6	31
Jan.	12.5	25	15.6	31
Feb.	8.0	15.6	15.6	28
Mar.	8.0	14.1	15.6	28
Apr.	11.0	14.1	14	21
May	11.0	14.1	12.5	19

1/Mean monthly high tide electrical conductivity in mmhos/cm.

TABLE 6

Predicted Impacts of Deficiency Standards

on Alkali Bulrush Seed Production
in the Suisun Marsh[1/]

EC of Applied Water	% Seed Production/ % Germination	Approximate Acreage Receiving this Salinity	% of Marsh
Meets D-1485 Normal Standards	90/60	36,000	66%
11-14 EC	62/44	9,500	17%
14-22 EC	23/16	9,500	17%

1/ Based on predictions from DWR's and USBR's Saldiff runs on Suisun Marsh model.

club management and water quality equal to or fresher than the normal D-1485 standards will be required. DWR and USBR have agreed to operate the Suisun Marsh Salinity Control Gates to provide water qualities fresher than the standards as long as there is no significant impact on yield.

DWR has projected that the Marsh will experience a "Deficiency Period" in approximately 10 to 15 percent of future years. This projection is based partially on the fact that the "Deficiency Standards" will not apply to the Marsh in the first year that the SWP and CVP are actually experiencing deficiencies and takes into account a modification of the runoff projection for dry and critical years.

DFG feels that the level of impact resulting from the "Deficiency Standards" given the projected frequency of these impacts is acceptable since waterfowl food production in the Marsh will be substantially preserved and no significant mortality to alkali bulrush is expected, even in the most saline portions of the Marsh.

Mitigation for Construction Impacts and Impacts on the Channel Islands

DWR and USBR, in the Suisun Marsh Mitigation Agreement, have agreed to provide DFG with sufficient funds to acquire, develop, operate and maintain new wetlands in the Marsh to compensate for losses of wetlands due to the construction of the facilities proposed in the Plan of Protection and for the water quality impacts on the Channel Islands (Roe, Ryer, Freeman and Snag). Up to 438 acres of wetland will be impacted if all the facilities proposed are required and constructed. In addition, USBR and DWR proposes to mitigate for the impacts of upstream diversions on the Channel Islands instead of providing more costly facilities to provide these islands with water quality meeting the proposed standards. DFG originally calculated that 582 acres of optimally managed wetland would be needed to compensate for the loss of waterfowl food production on the Channel Islands. This estimate was further refined to reflect that over 20 percent of these islands were subject to direct tidal action because of deteriorated exterior levees. The revised total equalled 455 acres. The mitigation agreement, therefore, provides funds for up to 893 acres of new wetland.

Endangered Species Impacts and Conservation Measures

The water salinity standards and distribution facilities being proposed now by USBR and DWR along with the management practices prescibed in each duck club's individual ownership management plan were primarily directed toward the needs of wintering waterfowl. However, the environmental requirements of other wildlife species, particularly endangered species, were not overlooked. A biological assessment of the impacts of the Plan of Protection on the endangered salt marsh harvest mouse (mouse) was completed and a biological opinion issued by the USFWS Endangered

Species office. The opinion provided that 100 acres of the mitigation lands described previously would be developed as preferred mouse habitat. It also required that DFG identify 1,000 acres of its own lands to be set aside and managed specifically for the mouse. Efforts to implement this provision are now underway. A monitoring program was outlined that will provide information on the extent of preferred mouse habitat throughout the Marsh. This monitoring program has also begun.

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