CALFED BAY-DELTA PROGRAM
TECHNICAL SERVICES BRANCH

WORKING DRAFT

Preliminary Cattail Evapotranspiration Estimates in the Sacramento-San Joaquin Delta

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BAY-DELTA
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Introduction

A primary objective of the CALFED Bay-Delta Program involves improving and increasing natural habitats as well as improving ecological functions in the Bay-Delta to support populations of valuable plant and animal species. Development and management of native habitat in the Delta is currently under consideration as a component of the alternative solutions. Variations in vegetative species (and consequently vegetative consumptive use) are expected upon implementation of the proposed restoration of native habitat. This report was developed in response to stakeholder concerns regarding potential changes in the water balance and supply allocation with respect to the Bay-Delta resulting from such variations in vegetative composition. Accordingly, a comparative analysis was performed on the primary component of water use – vegetative consumptive use. The predominant existing land use in the proposed restoration area is agriculture. This memorandum presents estimates of evapotranspiration rates for cattail vegetation and a "representative" agricultural crop mix intended to depict baseline conditions.

Although this analysis was developed with assistance from appropriate subject matter experts, it is important to note that the cattail evapotranspiration estimates presented herein reflect only one primary data source and a series of critical assumptions. Scientific methods exist that are specifically designed to estimate evapotranspiration rates of native vegetation and wetland habitat; however very little data exist that quantify consumptive use of native vegetation in the Bay-Delta. Lastly, this analysis does not address potential water supply impacts (which may not be proportional to changes in evapotranspiration). Estimation of water supply impacts involves several additional parameters including (but not limited to): "irrigation efficiency", system operations, habitat locations, tailwater quality, and habitat "crop mix". Consideration of these parameters is beyond the scope of this analysis.

Assumptions and Methodology

Representative Agricultural Evapotranspiration Rate

Agricultural evapotranspiration rates were developed in order to provide a baseline for comparison to native vegetation evapotranspiration estimates. A single evapotranspiration rate was developed based on a "representative" existing agricultural crop mix in the Delta. Given the uncertainty in the precise locations and configurations of the proposed restoration, it was assumed that this representative Et rate would adequately represent existing conditions. Table 1 illustrates the method that was used to develop the representative crop mix.

A representative crop mix[1] was developed based on the mix shown in the first column of Table 1. It was assumed that restoration would not replace existing native vegetation, riparian vegetation, or urban land uses. Therefore, an adjusted crop mix was developed by factoring these existing land uses out of the mix (see Table 1). These areas were distributed proportionally among the agricultural crops.

Published evapotranspiration estimates[2] for the crops listed in Table 1 were then applied to each respective crop. The annual evapotranspiration rates were then weighted based on the relative percentage of the adjusted total cropped area. Lastly, the weighted annual evapotranspiration rates were summed to comprise a representative annual evapotranspiration rate that can be directly compared with the cattail evapotranspiration estimates discussed below. The resulting representative evapotranspiration rate is 34.6 inches (2.9 feet) per acre per year.

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1 Non-critical water year crop mix was taken from *Estimation of Delta Island Diversions and Return Flows*, CA DWR, February 1995.

2 The annual evapotranspiration estimates are presented in *Review of Delta Crop Coefficients*, CA DWR, May 1997; Norman MacGillivray and George Sato

Table 1
Development of Representative Agricultural Evapotranspiration Rate

CROP TYPE	TOTAL CROPPED AREA (%) [1]	ADJUSTED TOTAL CROPPED AREA (%) [2]	ANNUAL EVAPOTRANSPIRATION (INCHES/ACRE) [3]	WEIGHTED ANNUAL EVAPOTRANSPIRATION (INCHES/ACRE) [4]
Native Vegetation	17	0.0	N/A	N/A
Water Surface	7.5	9.8	57.1	5.6
Dry Grass	0.8	1.0	22.8	0.2
Riparian Vegetation	1.3	0.0	N/A	N/A
Corn	18	23.6	31.8	7.5
Vineyards	0.6	0.8	33.6	0.3
Orchards	3.5	4.6	40.2	1.8
Tomatoes	6.1	8.0	33.9	2.7
Truck	4.3	5.6	32	1.8
Rice	0.2	0.3	50.1	0.1
Grain	14.2	18.6	23.7	4.4
Sugar Beets	3.7	4.8	26.4	1.3
Safflower	3.2	4.2	28.1	1.2
Field	4.1	5.4	29.9	1.6
Alfalfa	5.4	7.1	46.1	3.3
Pasture	4.6	6.0	46.1	2.8
Urban	5.3	0.0	N/A	N/A
TOTAL REPRESENTATIVE ANNUAL EVAPOTRASPIRATION RATE (Inches/Acre)				**34.6**

(1) Non-critical water year crop mix was taken from *Estimation of Delta Island Diversions and Return Flows;* CA DWR, February 1995.

(2) Native Vegetation, Riparian Vegetation, and Urban land use were removed from the crop mix and the respective percentages were distributed into the remaining crops proportionately.

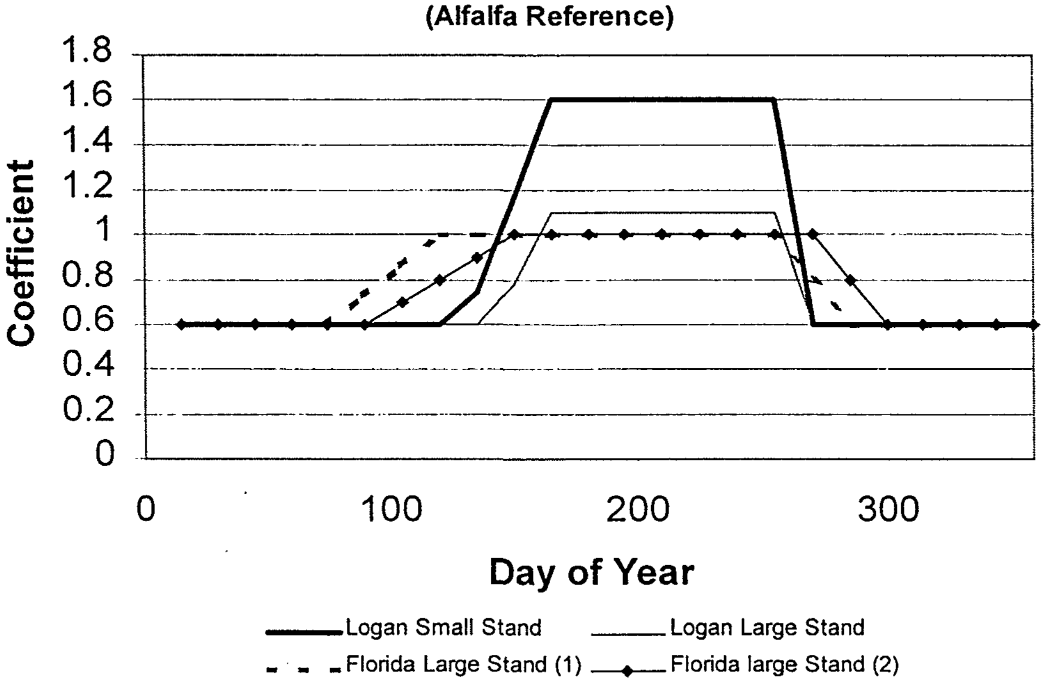
(3) Values based normal year Et as presented in *Review of Delta Crop Coefficients;* CA DWR; May 1997. Values include non-growing season precipitation where non-growing season Et = precipitation not to exceed Eto.

(4) Et rates weighted by the respective cropped areas.

Cattail Evapotranspiration Estimates

Cattail evapotranspiration rates were based on existing research data, input from several subject matter experts, and several critical assumptions. Cover coefficients[3,4] that were developed in two locations – Logan Utah and Florida were incorporated into this study. The cover coefficients developed in Logan Utah were evaluated for two crop configurations. Small "patchy" stands of vegetation (small stands) and large expanses of vegetation (large stands) were evaluated. Similarly, data from two large stands of cattail vegetation in Florida were also considered in this analysis. The original cover coefficients are presented graphically in Figure 1 (also see Appendix A for more details).

Figure 1
Cattail Cover Coefficients[4]
(Alfalfa Reference)



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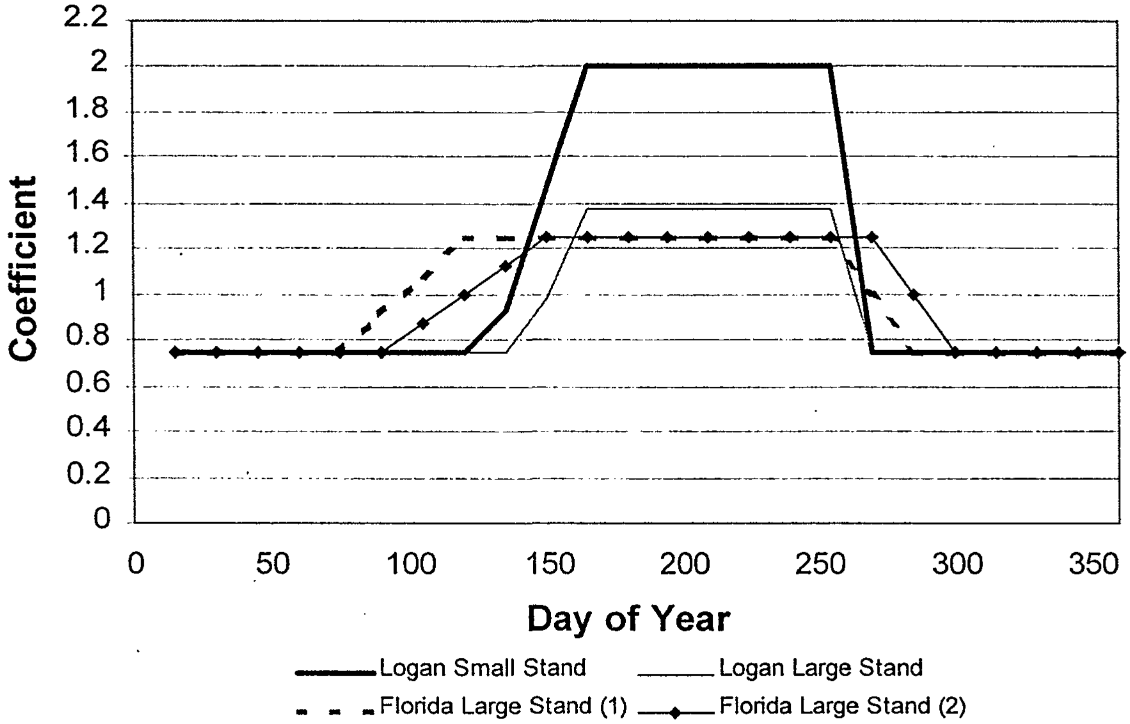
3 In this report, the cover coefficient is synonymous with the crop coefficient that is used for agricultural crops. It is defined as the ratio of cattail evapotranspiration to the grass reference Et or Eto.

4 *Predicting Evapotranspiration Demand for Wetlands;* Dr. Richard Allen, Utah State University, March 1998

The primary logic behind evaluating two different crop configurations is the "clothes-line" effect[5]. This approach may provide "bookends" with respect to the size and continuity of the vegetative stands.

The original cover coefficients were developed based on an alfalfa reference crop. Hence, an adjustment was necessary to convert the coefficients to a grass reference as grass reference is routinely applied (and better established) in the Bay-Delta region. As such, the original coefficients were increased by a factor of 1.25. The adjusted cover coefficients are presented graphically in Figure 2.

Figure 2
Adjusted Cover Coefficients
(Grass Reference)



5 For further details see Appendix A – *Predicting Evapotranspiration Demand for Wetlands;* Dr. Richard Allen, Utah State University, March 1998

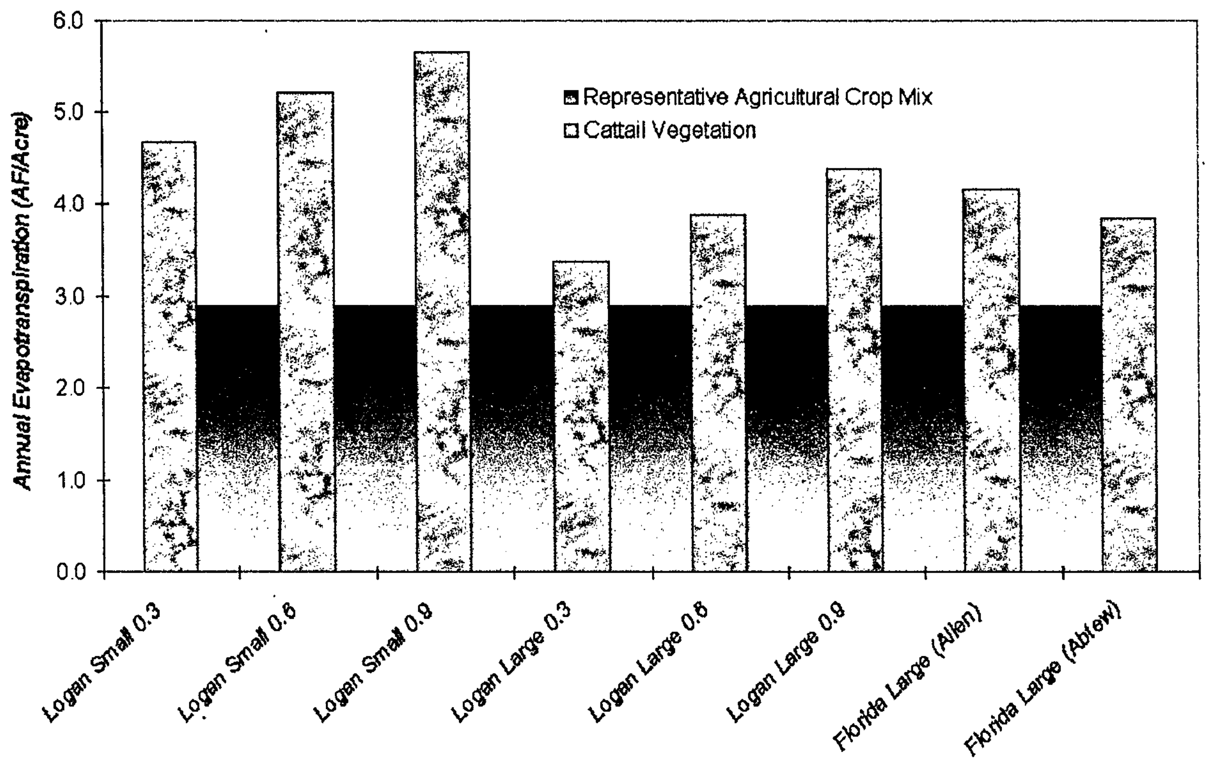
To more accurately reflect the Delta conditions with respect the seasonality of climate, an additional adjustment was made to the cover coefficients that were measured in Logan Utah. Data collected in Utah shows no measurable evapotranspiration during fall, winter, and early spring. This would not be the case in the Sacramento-San Joaquin Delta however. Therefore a range of evapotranspiration estimates were developed with the coefficients for this period ranging from 0.3 to 0.9. A range of evapotranspiration estimates was subsequently derived from this data. The results are presented in the next section.

Summary of Results

Based on the data and assumptions detailed in this memorandum, land use conversions from the existing representative crop mix to cattail vegetation may increase the evapotranspiration rate by as little as 17%[6] or as much as 95%[7] (or 0.5 feet/acre to 3 feet/acre), respectively. Figure 3 presents the results graphically. Lastly, the development of the cattail Et estimates is documented in Table 2.

Figure 3

Representative Agricultural Crop Mix Vs Cattail Evapotranspiration Rates



6 Contiguous cropping with a dormant cover coefficient of 0.3.
7 Small patchy configurations with a dormant cover coefficient of 0.9.

Table 2

Development of Cattail Evapotranspiration Comparison

Cattail Configuration	$Kc_{Dormant}$	Annual Evapotranspiration (AF/Acre)	Increase in Annual Evapotranspiraiton (AF/Acre) [1]	% Difference (AF/Acre)
Small Stand - Logan				
	0.3	4.7	1.8	61.2
	0.6	5.2	2.3	79.5
	0.9	5.7	2.8	95.2
Large Stand - Logan				
	0.3	3.4	0.5	16.5
	0.6	3.9	1.0	34.0
	0.9	4.4	1.5	51.4
Large Stand - Florida (Allen)				
	N/A	4.2	1.3	43.4
Large Stand - Florida (Abtew)				
	N/A	3.8	0.9	32.4

(1) Based on annual evapotranspiration estimate for existing "representative" crop mix in the Delta of 2.9 AF/Acre.

References

Allen, Dr. Richard; Associate Professor of Biological and Irrigation Engineering, Utah State University, *Predicting Evapotranspiration Demands For Wetlands;* March 1998

CA Department of Water Resources, *Estimation of Delta Island Diversions and Return Flows*; February 1995.

MacGillivray, Norman and Sato, George; CA DWR, *Review of Delta Crop Coefficients*; May 1997

MacGillivray, Norman and Sato, George; CA DWR, *Evaluation of Et-Grass* (Et_0) *in the Delta*; October 1994