Technical Memorandum

date July 22, 2009, revised November 30, 2009

to Anna Roche, SFPUC and Erika Lovejoy, MEA

from Barbara Leitner; Rachel Brush; Thomas Roberts, CWB; and Joyce Hsiao

subject Supporting Documentation for CEQA Impact Analysis of Vegetation/Habitat Impacts Due to Proposed Future Operations of Crystal Springs Reservoir under the Lower Crystal Springs Dam Improvements Project

Introduction

The objective of the Lower Crystal Springs Dam Improvements (LCSDI) project is to make structural improvements to Lower Crystal Springs Dam to comply with requirements of the California Department of Water Resources, Division of Safety of Dams to accommodate the probable maximum flood. These improvements would enable the SFPUC to restore use of the historical capacity of Crystal Springs Reservoir and to revise its current operations to increase the maximum normal operating level by four feet from the current level, increasing it from 283.8 to 287.8 ft (NGVD 29).

Elevating Crystal Springs Reservoir operating levels would inundate a portion of the existing wetland habitats to the extent that they would be converted to deepwater habitat; i.e., open water, as well as inundate some existing upland habitats. Some wetland habitats would persist, although their species composition could change due to the altered pattern of inundation. New wetland habitats would form within the new, higher operating elevations currently supporting upland habitats. It is also anticipated that some wetlands would be induced at elevations above the reservoir operating elevations, as groundwater, seeps, and streams approach a new equilibrium with the higher reservoir elevations. Estimation of the net change in habitat types and distribution around Crystal Springs Reservoir from these factors is required for the CEQA impact assessment.

The purpose of this technical memorandum is to provide the supporting details of the CEQA analysis of impacts on biological resources due to operational effects of the LCSDI project. The reader is referred to Section 5.10 of the LCSDI EIR for the complete discussion of impacts and the appropriate context of the information in this memorandum.

225 Bush Street, Suite 1700 San Francisco, California 94104 (415) 896-5900 *fax* (415) 896-0332 email: esa.sf@esassoc.com

Information Sources

The following information was used to analyze and estimate the vegetation impacts that would result from increasing the maximum normal operating level of Crystal Springs Reservoir under the LCSDI project:

1. Elevations of reservoir topography based on LiIDAR contour mapping of the Crystal Springs Reservoir and perimeter:

   LiDAR Mapping
   Airborne 1 Corporation
   300 N. Sepulveda Boulevard, #1060, El Segundo, California, 90245
   Phone: 310-414-7400 Fax: 310-414-7409
   Contact: Sean Bower, LiDAR Team Data Analyst Team Leader
   Delivery Date: January 18, 2007
   Data Description: 1 DVD containing 1 Meter Grids in ESRI ASC format in California State Plane, Zone 3, US Survey Feet, NAD83/NAVD88
   Data Accuracy: 100% of points falling within +/- 0.50 ft, 95% Confidence Level

2. Geographic information system (GIS) files of mapped vegetation at elevations below 291.8 ft surrounding Crystal Springs Reservoir prepared as part of the technical report on biological resources for the LCSDI Project (Entrix, 2006)

3. Hetch Hetchy/Local Simulation Model (HH/LSM) output of predicted Crystal Springs Reservoir storage volumes under the proposed project (Steiner, 2009)

4. Information regarding operating range of Crystal Springs Reservoir (Briggs and Cameron, 2009)

5. Data on existing and predicted inundation frequencies and average operating elevations of Crystal Springs Reservoir, presented in Section 5.12, Hydrology and Water Quality, of the LCSDI EIR.

Background

Background of the Data Set

ESA + Orion was provided with several GIS shapefiles from Entrix that contain data on biological resources at the Crystal Springs Reservoir (vegetation communities, special status plant locations, herpetology survey findings) as well as a high-resolution aerial image for the project area and LiDAR contour data (one foot intervals).

The vegetation communities layer, which includes the wetland polygons from the verified wetland delineation, has metadata that describes the steps of the mapping process. In addition, the Draft Biological Technical Reports from Entrix also includes a discussion of the methods for the vegetation mapping. A summary is provided below.

Vegetation mapping began in 2006 using a combination of hand delineation of vegetation polygons on printed aerial images and recorded GPS data[1]. This information was then digitized by hand using ArcGIS (ArcMap 9.x) and an aerial image with one pixel of resolution. High resolution LiDAR data that provide one foot elevation contour intervals were obtained at the time that digitization was taking place and with this combination of data the upper limit of the project area mapping was defined as 291.8 feet. The working vegetation map was then field verified (a process often referred to as "ground-truthing") to ensure accuracy of the mapped polygons and to identify any gaps. In general, vegetation polygons were mapped at a size of one acre and larger. The digital polygons were then modified as needed according to the results of the field verification.

The mapped vegetation communities are based on Holland's description of natural communities (Holland, 1986) and on the Cowardin wetland classification (Cowardin et al., 1979). A description of how these resources are applied to the project can be found in the project EIR and Wetland Determination Report.

The methods undertaken by Entrix to map the vegetation communities are extremely detailed and widely used. Mapping vegetation by hand digitization is generally considered to be the most accurate and cost effective method for projects of limited geographic scope. Although it may seem that delineating the boundary between two vegetation types with a relatively similar image signature (e.g. coast live oak forest and mixed evergreen forest) would be somewhat arbitrary, determining the boundary on the ground is often not clear either. Ecotones (boundaries between two or more natural communities) are often a continuum or gradual transition rather than a clearly defined line, which makes the act of determining the boundary extremely difficult. However, informed professional judgment combined with effective ground-truthing was used to resolve uncertainties of this nature.

The GIS data (shapefiles) for the special status plant and animal populations and observations were collected in the field using a GPS unit. GPS units were used to map occurrence or observation points and population polygons. There is always some degree of error or geographic inaccuracy in the data collected using a GPS unit; but this is unavoidable. The amount of error can be influenced by a variety of variables including: defined accuracy of the individual GPS unit, satellite reception, and potential for differential correction.

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[1] The unit used for the GPS work was a hand-held Trimble CE Series, which has sub-meter accuracy, and is currently the most accurate hand-held GPS equipment available for civilian use. The level of accuracy depends greatly on the number of satellites available, the geometry of the satellites, and the amount of interference (clouds, trees, mountains, etc), which was substantial in steep canyons and wooded areas around Crystal Springs Reservoir. The GPS, although essential to the mapping efforts, provided just a basis for wetland boundaries and additional refinement was added to it. Wetland boundaries and soil pits were hand drawn on large-scale aerial images during field work, and all the mapped data was edited by hand using the field-verified map notes. This was especially applicable to wetland areas beneath tree canopy.

Definition of the Data Set

Given the information sources described above, ESA+Orion worked with the data in order to identify and define the appropriate data set relevant to the analysis. This included the following steps:

1. LiIDAR one-foot increment elevations of the reservoir periphery were superimposed over the mapped GIS vegetation cover layer. The vegetation cover polygons were then divided into one-foot increments to determine the type and extent of vegetation by elevation. A total of 1,479.5 acres, plus an additional 177 acres not attributed to a cover type, were categorized from elevations 0 to 295 ft. **Table J-1** presents this preliminary, raw data.

2. GIS convention is to report acreage to four decimal places, but for this analysis the actual precision was more appropriately reported as a single decimal place.

3. Delete all data at elevations greater than 292 ft. Vegetation was not consistently mapped above 292 ft because the limits of the project area were defined as the 292-ft contour interval. Little if any impact from the proposed project would be expected to occur above this elevation because the maximum operating elevation, that is, the highest elevation the reservoir would be expected to sustain for periods long enough to support the development of shoreline wetlands, is proposed to be 288 ft. Although this analysis predicts that higher prevailing groundwater elevations with the project could "induce" (rather than directly cause) the formation of wetlands higher than the proposed average operating elevation of 288 feet, it is anticipated that most of this effect would occur within the 4-foot elevation between 288 and 292 ft.

4. Combine "fluctuation zone/lacustrine" with "open water"; rename "lacustrine/unvegetated".

5. Delete all data at elevations below 263 ft. The full extent of wetlands were mapped as far as they could be seen, including submerged wetlands that were mapped by boat. Less than 1.5 percent of the total mapped wetland vegetation was found at elevations below 263 feet, and this elevation was concluded to be the practical lower limit of wetlands at the time of the survey. In fact, it would be difficult to define a lower elevation limit in the reservoir below which inundated wetlands could not occur or be mapped, since seasonal wetlands can form at any elevation as the reservoir subsides. This is part of the phenomenon of establishing a baseline as a single point in time in a highly variable system. In the baseline, no significant amount of wetland vegetation was present below 263 ft, and the lacustrine/unvegetated cover type at these elevations is expected to remain unchanged under the proposed project. This acreage, totaling 913 acres, was eliminated from further analysis. Therefore, the relevant range of elevations subject to this analysis was defined as 263 – 292 ft.

6. The proportion of acreage with high and low slope was also calculated, by one-foot increments. Throughout the relevant range, 263 – 292 ft, slopes of 0-6% averaged 40% of the total area and this proportion was fairly consistent among the one-foot increments.[2] To find the proportion of acreage in the 0-8% slope range found to consistently support wetland vegetation, we estimated that the extent

[2] Due to an error, the area within the slope interval 0-6 percent was calculated, rather than the slope interval 0-8 percent. The calculation involves identifying and summing the acreage within each slope polygon and elevation interval. Because the process is so laborious, the investigators chose to extrapolate the acreage in the additional slope interval, 6-8 percent slope. This extrapolation was justified on the basis that the average slope in the elevation range of interest is very consistent, as evidenced by the consistent number of total acres in each additional foot of reservoir elevation. The interval 0-8 percent is numerically one-third larger than the interval 0-6 percent, so we conservatively estimated that the area in the additional slope interval 6-8 percent was one-fourth larger than the area in the 0-6 percent slope interval, thus predicting a conservative (that is, low) estimate of the extent of potentially suitable habitat for the development of wetlands.

of 0-8% slope would encompass one-third more area than the 0-6% interval (since the 0-8% slope interval range is one-third larger than the 0-6% interval). One-third more area would encompass 54% of the total area, so we conservatively assumed that 50% of the acreage is within the low slope interval 0-8%, and 50% is steeper than 8%.

7. Delete “developed” areas, totaling 0.6 acres, within the 263 – 292 ft range. Habitat characteristics of these small areas could not be determined. If this acreage is developed, it is likely to remain so under future conditions. As a result, it was eliminated from further analysis.

8. Extend all vegetation polygons within the 291 – 292 ft range up to the 292 ft LiDAR contour interval to calculate the total acreage by vegetation type within this range by extending the cover type polygon having the longest shared border. Initial vegetation mapping was completed in the range between 0 – 291.8 ft based on a contour shapefile that was not derived from the LiDAR data and therefore did not completely cover the 291 – 292 ft range. An additional 13.7 acres of vegetation is now accounted for in the 291 – 292 ft range to bring the total acres of habitat to 23.6 between 291 and 292 ft.

9. Rearrange the columns of habitats to group upland habitats together and wetland habitats together (no change in acreage).

10. Assign to lacustrine/unvegetated 0.7 ac of woody upland vegetation in elevations less than 283 ft. This anomalous data was due to conditions such as overhanging tree canopy. Wherever wetland vegetation grew below overhanging tree canopy, wetlands were given priority for mapping, so logically, tree canopy mapped over low elevations were overhanging lacustrine/unvegetated habitat. One example of this situation is at the southern end of Upper Crystal Springs Reservoir, where willows and other riparian vegetation growing on the floodplain form a continuous canopy over the deeply incised Laguna Creek channel. Standard practice in wetland delineations is to map a riparian type as continuous where the canopy cover is continuous, yet when LiDAR topographic mapping is superimposed on the mapped, continuous canopy, riparian vegetation appears to grow at much greater depth than it actually does.

11. Small amounts of grassland totaling 1.2 acre were mapped between elevations 264 and 279 ft. These areas were reassigned to lacustrine/unvegetated to correct for anomalous data.

12. To correct for anomalous data, acreages assigned to riparian vegetation in elevations 263 – 274 ft, normally areas inundated for too long to support woody riparian vegetation, were reassigned to lacustrine/unvegetated. For example, “riparian” was mapped as complete canopy at the mouth of Laguna Creek. LiDAR shows an incised drainage passing through the riparian stand, so riparian canopy cover was assigned to the lower elevation of the incised channel, even though the trees themselves were growing only on the banks at higher elevations (B. Leitner, Orion, pers., obs.). By superimposing the mapped, continuous canopy over the LiDAR mapping, riparian vegetation appears to grow at much greater depth than it actually does. These anomalies were corrected by re-assigning the area within the incised channel to lacustrine/unvegetated. Such areas totaled 1.9 acre.

13. *Scirpus/Typha* mapped at elevations 263 – 269 ft, was reassigned to lacustrine/unvegetated. These areas had inundation frequencies of 85% or more, ecologically would have limited potential to support this vegetation type, and could be attributable to a small amount of sampling error (less than 0.4 percent of the total of *Scirpus/Typha* and Herbaceous Wetland acreage, which is combined for the purpose of predicting impacts. This simplification was employed where the acreage for any given cover type in a one-foot elevation increment was less than one-half acre, which was 269 ft in the case of *Scirpus/Typha*. A total of 0.9 acre was thus reassigned.

14. Delete all acreage assigned to lacustrine/unvegetated below 276 ft on the basis that conditions would remain unchanged under the proposed project. This eliminated 90.7 acres.

Following this interpretation, the acreage in the relevant data set totals 488.6 acres, shown in **Table J-2**.

Approach to Analysis

The analysis of impacts on natural communities is based on broad ecological principles in combination with empirical data collected during wetland delineation and habitat surveys conducted in 2006 around the periphery of Crystal Springs Reservoir. The basic assumption used in the analysis is that the current extent and elevational limit of a natural community (approximated by cover types in the GIS mapping) is closely associated with the prevailing pattern of inundation, expressed as inundation frequency. **Table J-3** shows the relevant data set and compares it to the current and future, with-project inundation frequencies.

Table J-3 also provides color coding to depict how habitat types at different elevation ranges are predicted to change under the future, with project conditions. Where GIS data showed the acreage of a cover type declined sharply from a one-foot elevation increment to the next, the inundation frequency at that elevation was concluded to be the limiting factor. **Table J-4** summarizes the results of the predicted changes acreages in vegetation and habitat types that would occur with the proposed long-term operation of Crystal Springs Reservoir following implementation of the LCSDI project. Table J-4 includes notes that explain the rationale used in making each determination and cross-references the detailed discussion below.

The rationale (identified as “R1”, “R2” and so on) used to predict how each cover type responds individually to prevailing conditions is described in the paragraphs that follow.

R1. <u>Changes in inundation frequencies are predicted to change the type and extent of cover types</u>. Inundation frequencies at Crystal Springs Reservoir (see columns ** in Table J-3) would remain essentially unchanged at elevations above 292 ft (above the spillway elevation) and below 263 ft, which was reported as the lower limit of herbaceous wetland vegetation. Therefore, the elevation from 263 – 292 ft is the range in which vegetation change is predicted. A total of 488.6 acres of is encompassed in this elevation range, as described below under “Definition of Data Set” (See Note 1, Table J-4).

R2. <u>The lower limit of riparian cover can be predicted based on inundation frequency</u>. GIS data showed that riparian cover dropped off sharply below elevation 274 – 275 ft, which corresponds to a current inundation frequency of about 61%. This elevation is assumed to be the lower limit of suitable conditions for riparian vegetation. Where future inundation frequency is predicted to remain less than 61%, existing riparian cover is predicted to persist (see Note 2, Table J-4). Where inundation frequency is predicted to be greater than 61% with implementation of the proposed project, existing riparian cover is predicted to be converted to other wetland types (see Note 8, Table J-4). It is assumed that slope and soil conditions currently supporting wetland (and riparian) vegetation within the future fluctuation zone will continue to do so under future with-project conditions, which is why all riparian habitat is predicted to be converted to other wetlands rather than lacustrine habitat. Slope was used as a predictive factor only for areas that are currently mapped as lacustrine/unvegetated.

R3. The lower limit of *Scirpus/Typha* cover can be predicted based on inundation frequency. The lower limit of *Scirpus/Typha* is currently 269 – 270 ft[3], which is correlated with an inundation frequency of about 81%. This is supported by the scientific literature indicating a requirement for about 9 months of inundation for optimum growth of this vegetation. Where inundation frequency is predicted to remain at no more than 81% (277 ft and higher), the extent of existing *Scirpus/Typha* cover is predicted to remain unchanged (see Note 3, Table J-4). Where future inundation frequency is predicted to increase to more than 81% (below 277 ft), existing *Scirpus/Typha* cover is predicted to be lost, converting to herbaceous wetland at depths of 12 ft or less below the average operating elevation[4] (see Note 9, Table J-4) or lacustrine/unvegetated at greater depths (see Note 10, Table J-4).

R4. Existing wetlands within the future fluctuation zone are assumed to be retained, although their composition and structure may change. It is assumed that slope and soil conditions currently supporting wetland vegetation within the future fluctuation zone will continue to do so under future with-project conditions in the fluctuation zone; that is, where inundation frequencies are greater than 0% and less than 100%. Although not quantifiable, it is likely that some riparian habitat in this zone will be converted to *Scirpus/Typha* or herbaceous wetland, and some herbaceous wetland may be converted to *Scirpus/Typha* because of changes in the predicted inundation patterns under the proposed project (see Note 9, Table J-4).

R5. The lower limit of wetland vegetation is determined by depth below average operating elevation. Through the comparison of LiDAR data and mapped wetland vegetation, ENTRIX concluded that most wetland vegetation grew no more than 12 feet below the average operating elevation, reported as 275.5 ft[5] (ENTRIX, 2008). In a changeable system, seasonal wetlands can form at any elevation where inundated habitat is exposed for several weeks during the growing season, so the actual extent of wetlands could vary from year to year. Thus, the lower limit of existing wetland cover (of all types, of which herbaceous wetland vegetation grew the lowest) was taken to be 263 – 264 ft. The future average operating elevation is predicted to be about 282 ft. Under proposed future conditions, the lower limit of wetland cover is predicted to be 12 ft lower, or 270 ft. Herbaceous wetland cover above 270 ft is predicted to persist (see Note 4, Table J-4), while herbaceous and *Scirpus/Typha* cover below 270 ft would be converted to lacustrine/unvegetated cover (see Notes 10 and 11, Table J-4).[6]

R6. Lacustrine/unvegetated is predicted to remain unchanged except where inundation frequency rises from below 5% to at least 5% and slopes are 0-8%. Most areas currently mapped as lacustrine/unvegetated are steep and rocky, conditions unsuitable for the development of wetland vegetation, even where the inundation frequency is high enough to support it (below 283 ft).

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[3] The lower elevational limit was generally taken as the one-foot increment containing at least 0.5 acre of the cover type.

[4] The average operating elevation for the purposes of this analysis is based on the elevation (in ft) that is predicted to be inundated 50 % of the time (based on HH/LSM model predictions). This corresponds to about 282 ft.

[5] More recent inundation frequency calculations have place the average operating elevating elevation at 276-277 ft, but we have retained the ENTRIX value for consistency here.

[6] The 12-foot generalization was not discussed in the wetland delineation, because it was not relevant to the determination of jurisdictional waters. Although LiDAR sampling was carried out after the fieldwork for the wetland delineation was completed, the LiDAR data were used to define the water elevation lines in the delineation report. The purposes of the wetland delineation and of the EIR analysis are different—by its nature, the wetland delineation is charged with identifying the current extent of wetlands, while the EIR analysis is required to predict impacts. The latter requires a broader, more synoptic view of a changeable system, and a lower level of precision is inherent in this analysis. As stated earlier, the wetlands below 263 feet comprise 0.4 percent of the total wetlands delineated. This far exceeds the level of precision in any EIR analysis we are aware of, and in most comparisons is also expected to exceed the year-to-year variation in seasonal wetlands at Crystal Springs Reservoir.

However, some mapped lacustrine/unvegetated areas are situated above herbaceous wetland vegetation, suggesting that the inundation regime, rather than substrate, is limiting. For the elevation range (283 – 287 ft), which contains 4.4 acres of lacustrine/unvegetated habitat, inundation frequencies are predicted to increase from below 5% to above 5%. Using the assumed 50% of area having a slope of 0 to 8%, 2.2 acres are predicted to develop wetland vegetation and 2.2 acres are predicted to persist as lacustrine/unvegetated habitat. (see Notes 5 and 14, Table J-4).

R7. The lower elevational limit of woody upland vegetation is determined by maximum reservoir elevations. The mapped lower limit of existing woody upland vegetation is about 283 ft, which corresponds to an inundation frequency of about 5%. In general, woody upland vegetation at elevations with projected future inundation frequencies of less than 5% are predicted to be retained (287 – 292 ft; see Note 6, Table J-4), while woody upland vegetation at elevations with projected future inundation frequencies greater than 5% under the proposed project would be lost (below 287 ft; see Note 13, Table J-4).

R8. Grasslands are predicted to persist where inundation frequencies are 25% or less. Grassland cover was mapped at elevations as low as 279 – 280 ft, which corresponded to an inundation frequency of 25% under current operating conditions. Existing grasslands with projected future inundation frequencies of less than 25% (286 – 292 ft) are predicted to persist (see Note 7, Table J-4).

R9. Grasslands at elevations below the projected 25% inundation frequency are predicted to be converted entirely to wetland vegetation. Existing grasslands with predicted future inundation frequencies greater than 25% (up to 286 ft) under the proposed project are predicted to be lost. Areas currently supporting grasslands have sufficient soil development and water retention capacity to be capable of supporting wetland vegetation. Moreover, grassland cover is generally located on low-slope sites. Thus, all grassland habitats in the zone with a projected inundation frequency greater than 25% (below 286 ft) is predicted to be converted to wetland vegetation (see Note 12, Table J-4).

R10. Slope and inundation frequency determine whether upland habitats are converted to wetland habitats or to lacustrine/unvegetated. Observations during the wetland delineation surveys found that wetland habitats were generally present in areas with inundation frequencies of at least 5% and on slopes of 0 – 8%; steeper slopes often have rocky substrate and insufficient soil development to support wetland vegetation. Therefore, wetland habitats are predicted to form in newly-inundated areas with similar slopes under future with-project conditions. As described in the section on definition of the relevant data set, GIS data indicates that about 50% of the acreage in the affected area is defined as low slope. As a result, half of the acreage currently supporting woody upland vegetation in the elevation range 283 – 287 ft is predicted to develop wetland vegetation, while half is predicted to convert to lacustrine/unvegetated (see Note 13, Table J-4).

R11. The upper limit of wetland vegetation depends on wetland type. The upper limit of herbaceous wetland and riparian vegetation may be determined by hydrology associated with seeps, springs, creeks, and groundwater at elevations above the operating levels, as well as the elevation of reservoir waters themselves. Herbaceous wetland vegetation was found in significant amounts up to 290 ft elevation. Riparian vegetation was present in significant amounts up to 292 ft elevation, and was more abundant above the current average operating elevation than below it. By contrast, the upper limit of the inundation-dependent *Scirpus/Typha* community was distinct at about 283 ft, which corresponded to an inundation frequency of about 5% (see Note 14, Table J-4).

R12. Wetlands may be induced at elevations above the predicted maximum operating elevations, and their proportion is predicted to be similar to that above the current operating elevations. GIS data indicate that within the 5-foot elevation interval above the current maximum operating elevation (283 – 288 ft), wetland cover types occupy 51 acres in the 108 acres found in the elevation range, or about 47% of the total acreage. The wetland habitat here is supported by groundwater, seeps, and stream discharge into the reservoir, as well as proximity to the reservoir itself. Since groundwater, seeps and stream discharge features will rise under the proposed project because of increased operating elevations, it is predicted that some wetland habitat will form at commensurately higher elevations under future with-project conditions. In the 5-ft elevation range 287 – 292 ft above the proposed future maximum operating elevation, wetland vegetation currently occupies only 30 acres out of a total of 111 acres, or 28% of acreage. If wetlands are predicted to form proportional to the extent of wetlands in the interval above the current operating maximum, an additional approximately 22 acres of wetlands are predicted to form in what is currently 83 acres of uplands. Conservatively, 25% of uplands (both woody and grasslands) in the elevation range 287 – 290 ft are predicted to be converted to form 20.8 acres of induced wetlands under the proposed project (see Notes 15 and 16, Table J-4).

References

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Table 1: Summary of Raw GIS vegetation mapping data, by one-foot elevation increments

Elevation interval (ft)	Vegetation/ Land cover (in acres)													
	Coast live oak forest	Coastal sage scrub	Fluctuation Zone/ Lacustrine	Non-native grassland	Non-native woodland	Northern mixed chaparral	Open water	Riparian	Scirpus/ Typha	Herbaceous wetland	Developed land	Mixed evergreen forest	TOTAL	Area not attributed to cover type
294-295	0.0032			0.0084							0.001	0.1277	0.1403	63.5023
293-294	0.0033			0.0114				0.0000			0.0011	0.1523	0.1681	24.3915
292-293	0.0035	0.0000		0.0099				0.0001			0.0014	0.1629	0.1778	25.5590
291-292	3.1522	1.5095		1.0718	0.3061	0.0522	0.0140	1.2193	0.0001	0.1616	0.0266	2.2524	9.7658	13.8141
290-291	7.0714	3.7038		1.9769	1.3080	0.0526	0.0201	4.4487	0.0005	0.7723	0.0603	2.6975	22.1121	0.8627
289-290	6.2218	4.0981		2.0552	1.0465	0.0390	0.0229	4.8237	0.0009	1.2675	0.0534	2.5519	22.1809	0.7301
288-289	5.1647	3.8055		1.9875	0.8213	0.0338	0.0293	5.2406	0.0023	2.3896	0.0660	2.3461	21.8867	0.4597
287-288	4.6723	3.3601		2.1002	0.5174	0.0337	0.0382	6.4749	0.0284	1.9297	0.1090	2.1154	21.3793	0.4423
286-287	3.8510	3.0411	0.0001	2.2657	0.4815	0.0360	0.0493	7.4190	0.0460	1.5775	0.0804	1.9943	20.8419	0.4549
285-286	2.9841	2.8689	0.0011	2.8933	0.2493	0.0325	0.0698	8.4997	0.0579	1.6603	0.0509	1.9342	21.302	0.4739
284-285	2.4404	2.2569	0.0023	3.3947	0.1780	0.0251	0.1037	8.0228	0.3037	2.0444	0.0425	1.9350	20.7495	0.5064
283-284	0.8734	1.2028	0.3921	4.9343	0.0783	0.0069	3.6556	8.2165	0.3588	4.0425	0.0190	0.6332	24.4134	0.5943
282-283	0.0237	0.1336	0.2792	3.0448	0.0076		2.0564	6.8193	1.4616	6.1142	0.0058	0.0167	19.9629	0.2975
281-282	0.0095	0.0494	0.2863	2.0480	0.0051		3.2778	5.1276	1.8694	9.3615	0.0112	0.1342	22.18	0.4249
280-281	0.0016	0.0310	0.2181	1.0529	0.0043		3.2684	3.8409	2.7834	10.4235	0.0089	0.0563	21.6893	0.3820
279-280		0.0091	0.1567	0.6697	0.0037		3.4742	2.8041	2.8331	12.0538	0.0052	0.0161	22.0257	0.3778
278-279		0.0068	0.1597	0.3947	0.0024		3.4903	2.2340	2.0849	13.1536	0.0044	0.0099	21.5407	0.3585
277-278		0.0018	0.1449	0.1715	0.0017		3.6981	2.1690	1.7429	11.7205	0.0040	0.0082	19.6626	0.3618
276-277			0.1686	0.1037	0.0013		3.6880	1.6868	1.5267	11.4502	0.0037	0.0072	18.6362	0.3517
275-276	0.0004		0.1692	0.0665	0.0004		3.7804	1.0998	1.2088	11.9168	0.0035	0.0062	18.252	0.3536
274-275	0.0024		0.1715	0.0498	0.0000		3.9610	0.5461	0.9573	12.4694	0.0036	0.0057	18.1668	0.3531
273-274	0.0032		0.1674	0.0478			4.2267	0.3062	0.7789	12.1360	0.0036	0.0057	17.6755	0.3498
272-273	0.0032		0.1574	0.0500			4.3007	0.2270	0.9483	12.1406	0.0036	0.0058	17.8366	0.3564
271-272	0.0011		0.1566	0.0497			4.5318	0.1937	1.2689	10.4520	0.0037	0.0061	16.6636	0.3499
270-271	0.0003		0.1700	0.0521			4.7095	0.1562	0.7711	10.3838	0.0036	0.0063	16.2529	0.3493
269-270	0.0002		0.1429	0.0537			4.9935	0.1472	0.4873	11.8824	0.0035	0.0062	17.7169	0.3488
268-269	0.0002		0.1143	0.0558			5.4585	0.1647	0.2960	11.7596	0.0033	0.0056	17.858	0.3523
267-268	0.0001		0.0524	0.0606			6.7241	0.1998	0.2276	10.8331	0.0035	0.0118	18.113	0.3472
266-267			0.0606	0.0354			8.4006	0.2192	0.1596	9.8452	0.0039	0.0162	18.7407	0.3440
265-266			0.0708	0.0223			9.6260	0.1958	0.1163	10.5269	0.0038	0.0185	20.5804	0.3426
264-265			0.0887	0.0106			11.4037	0.0794	0.0802	8.2982	0.0036	0.0164	19.9808	0.3408
263-264			0.5871				12.9413	0.0098	0.0512	4.2713	0.0044	0.0123	17.8774	0.3418
262-263			0.8205				12.3777	0.0091	0.0402	2.1786	0.0067	0.0072	15.44	0.3377
261-262			0.7275				13.3980	0.0088	0.0219	1.0823	0.0069	0.0052	15.2506	0.3337
260-261			0.145				13.6976	0.0088	0.0046	0.5428	0.0053	0.0051	14.4092	0.3353
0-260			0.2128				860.851	1.1964	0.0005	0.6685	2.7926	2.1836	867.9054	37.1144
TOTAL:	36.4872	26.0784	5.8238	30.7489	5.0129	0.3118	1012.3382	83.815	22.5193	231.5102	3.4139	21.4754	**1479.535**	176.9961

[grey shading] Indicates data not relevant to analysis of proposed future reservoir operations

Table 2: Vegetation/Land Cover Data for LCSDI Impact Analysis of Increased Operating Levels

Elevation interval (ft, NGVD)	**Vegetation/ Land cover** (in acres)										
	Upland Forest			**Upland Scrub**		**Upland Herbaceous**	**Aquatic**	**Wetland**			**TOTAL**
	Coast live oak forest	Mixed evergreen forest	Non-native woodland	Coastal sage scrub	Northern mixed chaparral	Non-native grassland	Lacustrine/ Unvegetated	Riparian	Scirpus/ Typha	Herbaceous wetland	
291-292 [a]	14.7	2.3	0.3	2.1	0.1	1.7	0.2	2.0	0.0	0.2	23.6
290-291	7.1	2.7	1.3	3.7	0.1	2.0	0.0	4.4	0.0	0.8	22.1
289-290	6.2	2.6	1.0	4.1	0.0	2.1	0.0	4.8	0.0	1.3	22.1
288-289	5.2	2.3	0.8	3.8	0.0	2.0	0.0	5.2	0.0	2.4	21.8
287-288	4.7	2.1	0.5	3.4	0.0	2.1	0.0	6.5	0.0	1.9	21.3
286-287	3.9	2.0	0.5	3.0	0.0	2.3	0.0	7.4	0.0	1.6	20.8
285-286	3.0	1.9	0.2	2.9	0.0	2.9	0.1	8.5	0.1	1.7	21.3
284-285	2.4	1.9	0.2	2.3	0.0	3.4	0.1	8.0	0.3	2.0	20.7
283-284	0.9	0.6	0.1	1.2	0.0	4.9	4.0	8.2	0.4	4.0	24.4
282-283						3.0	2.5	6.8	1.5	6.1	20.0
281-282						2.0	3.8	5.1	1.9	9.4	22.2
280-281						1.1	3.6	3.8	2.8	10.4	21.7
279-280						0.7	3.7	2.8	2.8	12.1	22.0
278-279							4.1	2.2	2.1	13.2	21.5
277-278							4.0	2.2	1.7	11.7	19.7
276-277							4.0	1.7	1.5	11.5	18.6
275-276								1.1	1.2	11.9	14.2
274-275								0.5	1.0	12.5	14.0
273-274									0.8	12.1	12.9
272-273									0.9	12.1	13.1
271-272									1.3	10.5	11.7
270-271									0.8	10.4	11.2
269-270									0.5	11.9	12.4
268-269										11.8	11.8
267-268										10.8	10.8
266-267										9.8	9.8
265-266										10.5	10.5
264-265										8.3	8.3
263-264										4.3	4.3
TOTAL:	48.0	18.5	5.0	26.4	0.3	30.1	30.2	81.5	21.5	227.1	488.6

[a] The acreages of vegetation/land cover in the 291-292-foot contour interval were adjusted to incorporate 13.8 acres of area not attributed to cover type in the raw data presented in Table 1. The vegetation of this acreage was estimated using the GIS data for the mapped vegetation type in adjacent polygons, and the acreages were assigned to the vegetation type with the longest shared border.

Table 3. Vegetation Types by Elevation Compared to Current and Future-with-Project Inundation Frequencies

Elevation interval (ft, NGVD)	Vegetation/Land Cover (in acres)											Inundation frequency (%)	
	Upland Forest			Upland Scrub		Upland Herbaceous	Aquatic	Wetland			Total (acres)	Current (2001-2006)	Future with Project (2018)
	Coast live oak forest	Mixed evergreen forest	Non-native woodland	Coastal sage scrub	Northern mixed chaparral	Non-native grassland	Lacustrine/ Unvegetated	Riparian	Scirpus/ Typha	Herbaceous wetland			
291-292	14.7	2.3	0.3	2.1	0.1	1.7	0.2	2.0	0.0	0.2	23.6	0	0
290-291	7.1	2.7	1.3	3.7	0.1	2.0	0.0	4.4	0.0	0.8	22.1	0	0
289-290	6.2	2.6	1.0	4.1	0.0	2.1	0.0	4.8	0.0	1.3	22.1	0	0.5
288-289	5.2	2.3	0.8	3.8	0.0	2.0	0.0	5.2	0.0	2.4	21.8	0	0.9
287-288	4.7	2.1	0.5	3.4	0.0	2.1	0.0	6.5	0.0	1.9	21.3	0.0	1.5
286-287	3.9	2.0	0.5	3.0	0.0	2.3	0.0	7.4	0.0	1.6	20.8	0.0	15.8
285-286	3.0	1.9	0.2	2.9	0.0	2.9	0.1	8.5	0.1	1.7	21.3	0.1	29.7
284-285	2.4	1.9	0.2	2.3	0.0	3.4	0.1	8.0	0.3	2.0	20.7	1.5	37.3
283-284	0.9	0.6	0.1	1.2	0.0	4.9	4.0	8.2	0.4	4.0	24.4	4.5	41.4
282-283						3.0	2.5	6.8	1.5	6.1	20.0	11.4	45.1
281-282						2.0	3.8	5.1	1.9	9.4	22.2	16.0	56.3
280-281						1.1	3.6	3.8	2.8	10.4	21.7	20.2	60.1
279-280						0.7	3.7	2.8	2.8	12.1	22.0	25.8	61.3
278-279							4.1	2.2	2.1	13.2	21.5	33.9	68.8
277-278							4.0	2.2	1.7	11.7	19.7	42.6	79.1
276-277							4.0	1.7	1.5	11.5	18.6	50.8	86.4
275-276								1.1	1.2	11.9	14.2	56.7	91.5
274-275								0.5	1.0	12.5	14.0	60.7	91.7
273-274									0.8	12.1	12.9	65.0	99.6
272-273									0.9	12.1	13.1	68.7	100
271-272									1.3	10.5	11.7	75.0	100
270-271									0.8	10.4	11.2	78.1	100
269-270									0.5	11.9	12.4	81.4	100
268-269										11.8	11.8	85.1	100
267-268										10.8	10.8	86.7	100
266-267										9.8	9.8	91.8	100
265-266										10.5	10.5	93.8	100
264-265										8.3	8.3	94.7	100
263-264										4.3	4.3	97.0	100
TOTAL:	**48.0**	**18.5**	**5.0**	**26.4**	**0.3**	**30.1**	**30.2**	**81.5**	**21.5**	**227.1**	**488.6**		

PREDICTED CHANGES TO VEGETATION (AC)

71.1	Upland woody vegetation, predicted to remain as upland habitat, although may convert to other upland types such as grassland
27.1	Upland woody vegetation predicted to be converted to wetland (50%) and open water (50%)
12.1	Grassland, predicted to remain as grassland
18.0	Grassland, predicted to be converted to wetlands
4.3	Lacustrine/unvegetated, predicted to be converted to wetland (50%) and remain as lacustrine/unvegetated (50%)
25.9	Lacustrine/unvegetated, predicted to remain as lacustrine/unvegetated
70.9	Riparian, predicted to remain as riparian
10.5	Riparian, predicted to be converted to other wetlands
13.6	*Scirpus/Typha* , predicted to remain as *Scirpus/Typha*
7.5	*Scirpus/Typha* , predicted to be converted to other wetlands
0.5	*Scirpus/Typha* , predicted to be converted to open water
159.7	Herbaceous wetland, predicted to remain as herbaceous wetland
67.4	Herbaceous wetland, predicted to be converted to open water

Note: The inundation frequency data are from Table 5.12-3 and represent the percentage of time in a given year that a perimeter contour would be inundated. Current inundation frequencies represent historical daily data for the 60-month period from July 2001 to July 2006. Future with project inundation frequencies represent modeled data over the 984-month period from July 1920 to September 2002 based on monthly time steps, with adjustments to account for Crystal Spring Reservoir daily operating patterns.

Table 4: Summary of Predicted Impacts On Vegetation Due to Increased Normal Maximum Operating Levels

Status	Vegetation/Land cover (acres)											Notes
	Upland Forest			Upland Scrub		Upland Herbaceous	Aquatic	Wetland			Total (acres)	
	Coast live oak forest	Mixed evergreen forest	Non-native woodland	Coastal sage scrub	Northern mixed chaparral	Grassland	Lacustrine/ Unvegetated	Riparian	*Scirpus/ Typha*	Herbaceous wetland		
Existing	48.0	18.5	5.0	26.4	0.3	30.1	30.2	81.5	21.5	227.1	488.6	1. Habitat between 263 -292 ft is subject to changes in inundation frequency resulting from increased operating elevations Total = 488.6 acres. See R1 in text.
No Changes Predicted								70.9			70.9	2. Riparian cover above 279 ft will persist because inundation frequency will remain less than 61%. See R2 in text.
									13.6		13.6	3. *Scirpus/Typha* above 277 ft will persist because inundation frequency will remain less than 81%. See R3 in text.
										159.7	159.7	4. Herbaceous wetland above 270 ft will persist because it is within 12 feet of future average operating level. See R5 in text.
							28.1				28.1	5. Lacustrine/unvegetated between 276 – 292 ft will persist as lacustrine/unvegetated, except where inundation frequencies rise from below 5% to above 5% (4.3 ac in 283-287 ft). In this area, low slope areas (50% or 2.2 ac) are predicted to convert to wetland, while high slope areas (50% or 2.1 ac) will remain as lacustrine/unvegetated. See R6 in text; see Note 14 for other 50% of this acreage).
			53.3								53.3	6. Most woody upland vegetation between 287-292 ft will persist because inundation frequencies are predicted to remain <5%, but species composition may change (assume 75% of total 67.0 acres in this range). See R7; see also Note 15 for the other 25% of this acreage.
						9.1					9.1	7. Existing grasslands are found at elevations with up to 25% inundation frequency. Grasslands at elevations between 286-292 ft are predicted to persist because inundation frequency will be no more than 25%. See R8 in text.
Direct changes due to increase in maximum normal operating level								-7.7		7.7	0.0	8. Riparian cover between 274-278 ft will convert to other wetland due to increase in inundation frequency >61%. See R2 in text.
									-7.5	7.5	0.0	9. *Scirpus/Typha* between 270-277 ft will convert to other wetland where inundation frequency increases to >81% and depth is less than 12 ft below future average operating elevation. See R3 and R4 in text
							0.5		-0.5		0.0	10. *Scripus/ Typha* below 270 ft will convert to lacustrine/unvegetated because it will be more than 12 ft below the average operating level. See R3 and R5 in text.
							67.4			-67.4	0.0	11. Herbaceous wetland below 270 ft is predicted to be converted to lacustrine/unvegetated because it will be more than 12 ft below the average operating level. See R5 in text.
						-18.0				18.0	0.0	12. Grasslands between 279 - 286 ft are predicted to be converted to seasonal wetland due to predicted inundation frequency greater than 25%. See R9 in text.
	-10.1	-6.5	-1	-9.4	-0.1		13.6			13.5	0.0	13. Woody upland vegetation between 283 – 287 ft is predicted to be inundated > 5% of the time and therefore would not persist. Assume 50% will convert to wetland in low slope areas and 50% will convert to lacustrine/ unvegetated in high slope areas. See R10 in text.
							-2.2			2.2	0.0	14. Some lacustrine/unvegetated habitat between 283 – 287 ft will convert to wetland in low slope area because of increased inundation frequencies (assume 50% of total 4.3 acres). See R6 and R11 in text; see Note 5 for other 50% of this acreage.
Indirect changes due to induced wetland conditions	-9.5	-3.0	-1.0	-4.3	-0.1					17.8	0.0	15. Some woody upland vegetation between 287-292 ft will convert partially (25%) to wetland due to induced wetland conditions. See R12 in text; see Note 6 for other 75% of this acreage.
						-3.0				3.0	0.0	16. Some grassland between 286 -292 ft will convert partially (25%) to wetlands due to induced wetland conditions. See R12 in text; see Note 7 for other 75% of this acreage.
Final, post-project, acreage	28.4	9.0	3.0	12.8	0.2	9.1	109.5	73.8	13.5	229.3	488.6	Total Acres = 488.6
Net change from existing acreage	-19.6	-9.5	-2.0	-13.7	-0.2	-21.0	79.4	-7.7	-8.0	2.3	0.0	Net change Upland Forest: -31.1 acres Net change Upland Scrub: -13.8 acres Net change Grassland: -21.0 acres Net change Wetland: -13.5 acres