Appendix J

Vegetation Change Analysis Methodology

APPENDIX J- LAKE MERCED VEGETATION CHANGE ANALYSIS METHODOLOGY

Building upon prior studies, ESA updated a Geographic Information System (GIS) vegetation layer created by Nomad Ecology in 2010[1]. Using ArcGIS, ESA overlaid the 2010 vegetation data on high resolution 2010 aerials and then ground-truthed the resulting imagery in the field in May 2012. In general, the 2010 data correlated well with aerial signatures of the various vegetation types on the 2010 aerial photo and conditions on the ground. All discrepancies were mapped in the field and the 2010 vegetation layer was updated using the annotated field maps and aerial interpretation comparing the 2008 and 2010 aerials. To reduce the complexity of modeling vegetation change in response to water level management, many of the distinct vegetation types mapped by Nomad Ecology (Nomad 2011) were combined with similar types. Table J-1 presents the results of the vegetation mapping update, along with results from 2002 and 2010, for comparative purposes. See Figure 5.14-1 (Lake Merced 2012 Vegetation Types) in Section 5.14, Biological Resources for the updated Lake Merced vegetation map.

A GIS database was constructed using Light Detection and Ranging (LIDAR) (Foxgrover and Barnard 2012) surface topographic data, and bathymetric data supplied by the San Francisco Public Utilities Commission (SFPUC) (Sea Survey/Entrix 1987). The two data sets differ substantially in precision and vertical control, such that the bathymetric data were adjusted by hand to conform more closely with the greater vertical precision of the LIDAR data[2] as well as current aerial photos (USGS 2011). For example, in many cases, overlays of vegetation mapping and the bathymetric data resulted in the appearance of certain species or vegetation types occurring in much deeper water than field observations would support.

A set action of “action rules” was developed to predict the response of different vegetation types to changing inundation levels. Action rules were drawn from previous modeling efforts specific to Lake Merced (Stillwater Sciences 2009; EDAW 2004) and the Lower Crystal Springs Reservoir (ESA 2009), available literature on vegetation tolerance to inundation, and field observations. The action rules (see Table J-1 [Vegetation Model Action Rules]) are based on the following general principles:

1 The 2010 GIS vegetation layer was created by Nomad (Nomad 2011) using heads up digitizing on a 2008 aerial photo base and then verifying the results in the field.

2 The original bathymetric data created by Sea Survey and Entrix in 1987 was digitized from a scanned image and adjusted to “fit” a 2001 orthophoto background by Talavera & Richardson in 2001. Upon comparing the bathymetric data with April, 2011 aerial imagery it was clear that the data did not fit within the confines of lake as shown in the current aerial imagery. ESA adjusted the bathymetry again to fit the current imagery. The accuracy of the bathymetric data affects the amount of vegetation impacted with decreasing water surface elevation, which may be overestimated or underestimated.

TABLE J-1
Vegetation Model Action Rules

Class/Vegetation Type	Remove:	Add:	Replacer Status	Conflict Rule for Adding:
Class 1[(a)]				
Bulrush wetland	< -5	0 to -5	Primary Replacer	In areas of replacement overlap, the adjacent replacer wins. In areas where both replacers are adjacent, bulrush wins. In areas of no replacer adjacency, bulrush wins.
Cattail	< -3	0 to -3	Secondary Replacer	
Knotweed wetland	< -2	0 to -2	Secondary Replacer	
Class 2[(a)]				
Arroyo willow	< 0	1 to 0	Primary Replacer	In areas of replacement overlap, the adjacent replacer wins. In areas where both replacers are adjacent, willow wins. In areas where no adjacency, willow wins.
Rush meadow	< -1	1 to 0	Secondary Replacer	
Giant vetch	< -1	n/a	n/a	
Class 3[(a)(b)]				
Coastal scrub	< 1	n/a	n/a	
Dune scrub	< 1	n/a	n/a	
Oak woodland	< 1	n/a	n/a	
Non-native forest	< 1	n/a	n/a	
Non-native herbaceous	< 1	n/a	n/a	
Annual grassland	< 1	n/a	n/a	
Perennial grassland	< 1	n/a	n/a	

Source: ESA 2012

Notes:

Seasonal variation is 1 foot higher than average in wet season and 1 foot less than average in dry season.
Elevations are relative to modeled water surface elevation.

(a) **Class 1 - Tolerant:** Can survive permanent inundation at depths equal to or less than 5 feet below average annual WSE.
Class 2 - Moderately Intolerant: Survives inundation up to three months during dormant season.
Class 3 - Intolerant: This class is generally unable to survive inundation for more than two consecutive weeks.

(b) Upland vegetation types would not replace others as WSE rises.

The lower limit of both woody and herbaceous upland vegetation is determined by the maximum water surface elevation (WSE). The lower limit of upland vegetation is determined by inundation frequency and duration, a principal that also is applied in the federal method for determining the boundary between wetlands and non-wetlands for jurisdictional purposes. Observations of current conditions at Lake Merced, coupled with previous mapping and descriptions (SFRPD 2006; May and Associates 2009; Nomad 2011) indicate that the lower limit of upland woody vegetation is above the maximum WSE, which restricts upland plant species lacking adaptation to prolonged inundation or soil saturation. Upland woody vegetation will occur, but not persist, at the mean water level, and will be replaced by opportunistic wetland vegetation dominated by bulrush and knotweed. The lower limits of upland herbaceous communities also extend down to the maximum WSE, and would be replaced by wetlands if the water level rises.

The upper and lower limits of wetland vegetation depend on depth of inundation and inundation tolerance. For example, most herbaceous wetlands fringing Lake Merced occur no higher than 1 foot above the projected existing conditions mean WSE of 5.7 feet and at assumed depths no greater than 2 feet below WSE. The wetland species that make up these communities do not require year-round inundation. In contrast, bulrush wetlands require at least nine months inundation or soil saturation, readily tolerate permanent inundation, and are found at elevations no more than 1 foot above the seasonal high water elevation, and no greater than 5 feet lower than mean WSE.

Vegetation was categorized into three classes associated with water inundation tolerance. Inundation tolerance is largely a function of seasonal fluctuations in lake levels. Monthly water levels increase up to 1 foot above the annual average during winter (February through May), declining to 1 foot below average annual water level towards the end of the growing season (August through November) (Stillwater 2009). Class 1 includes vegetation types that are extremely tolerant and can survive permanent inundation. Class 2 vegetation is somewhat tolerant and can survive partial inundation due to seasonal variations. Class 3 vegetation is intolerant and cannot survive seasonal inundation. ESA developed action rules based on this classification that determined how vegetation would die or establish as WSE rises.

Replacement criteria not only took elevation relative to WSE into account but also adjacency of vegetation types. Overlapping depth tolerance among different wetland types requires complex rules for resolving conflicts when two wetland types have the potential to occupy the same elevation zone. For the purposes of the analysis, therefore, these conflicts were resolved by creating action rules that restrict the amount of overlap. The action rules also govern interactions between vegetation types for projected WSE that would cause the loss of one type and its replacement by one or more other type. For example, bulrush and knotweed have a somewhat overlapping tolerance to inundation. Priority rules for replacement instruct the GIS-based analysis to replace a “drowned” vegetation type with bulrush or knotweed (the most aggressive “replacer” types) based on the elevation of the replaced vegetation and its proximity to the nearest replacer type.

The GIS-based analysis was conducted to estimate vegetation response to changes in lake levels over time using the newly updated vegetation data, topography, bathymetry, slope, output from the water level models, and the action rules for vegetation change. For the purposes of the vegetation change analysis, the initial baseline estimates for existing vegetation acreage are those which would occur at a mean annual WSE of 6 feet City Datum. This is slightly higher than the baseline WSE of 5.7 feet used for the Kennedy Jenks hydrologic modeling but was necessary in order to correspond to the topographic data, which was created at 1 foot elevation intervals. The 2012 vegetation mapping update was based on a April 2011 aerial photo, at which time, according to historic WSE data (SFPUC 2011) Lake Merced WSE was at about 7 feet City Datum. The acreages given for the 6-foot WSE were obtained by running the receding WSE model on the 2012 vegetation data. In addition, the analysis only included vegetation at or below 13 feet City Datum, since this is the maximum possible lake water level due to the existing spillway height and therefore, elevation, at which vegetation change would be expected due to changes in WSE. Therefore, for the upland vegetation types and for arroyo willow riparian scrub, acreage located above the 13 foot elevation, as mapped in Figure 15.4-1 (Lake Merced 2012 Vegetation Types), would remain unchanged.

To determine impacts to vegetation associated with water surface elevation change it is necessary to have an accurate topographical representation of the area. For elevation above the surface of Lake Merced, ESA obtained a high resolution LIDAR derived digital elevation model (DEM) to provide accurate elevation data. Past Lake Merced inundation studies used 1 foot photogrametically created elevation contour data derived from flights of the area in 1996. The LIDAR derived elevation data were used in place of the photogrammetry data because they are considerably more current (2010) and determined to be a better representation of current conditions[3]. From the DEM, ESA created 1 foot elevation contour polygons so that areas could be calculated for each elevation range. For bathymetric topography ESA used contour data provided by the SFPUC. These contours were originally created from depth soundings of the lakes in 1987; the data was subsequently adjusted in 2001 to fit current aerial photos of that time. Visual analysis of the contour data compared to current aerial photos (2011) revealed inconsistencies along the shoreline. It was therefore necessary to modify the bathymetric data to match the aerial photos and surface DEM to create an accurate topographical representation. The adjusted bathymetric data was converted to a Triangular Irregular Network (TIN) which in turn was used to produce 1 foot contour polygons by interpolating elevation gaps in the original contour data. The 1 foot bathymetric elevation contours and the 1 foot DEM derived surface elevation contours were then combined to create a complete elevation dataset of the area. This finished elevation dataset was intersected with the vegetation data to determine distribution of vegetation by elevation ranges.

Two different approaches were used to determine impacts to vegetation associated with increasing and decreasing WSE under the proposed project. For impacts associated with water surface increase, a GIS approach similar to past inundation studies was used. As described above, action rules were established for each vegetation type dictating how vegetation would respond to increasing water surface elevation. Once the action rules were established for a relative water surface elevation, they were applied to every 1 foot contour up to the 13 foot spillway elevation. The resulting vegetation statistics were used to determine impacts to vegetation types due to increase in water surface elevation.

For decreasing water levels, a statistical approach was used to determine vegetation response. Unlike water rising scenarios in which parameters can be applied to current vegetation, the majority of land associated with decreasing water levels is currently inundated and free of vegetation (except for certain wetland species). For this approach ESA analyzed the proportions of vegetation at each elevation contour relative to the current water surface level and applied the statistics to lower water surface elevation. This approach keeps the vegetation distribution the same for each elevation range relative to the WSE, but due to differences in area for each elevation range the vegetation area totals are different for each modeled WSE. For example, if the contour range of 0 to 1 foot is currently inhabited with 60 percent bulrush wetland and 40 percent knotweed wetlands, that proportion (60 percent and 40 percent) would be assigned to the -1 to 0 foot contour range modeling a water surface decrease of 1 foot.

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3 LIDAR tends to be superior when there is dense vegetative cover. ESA compared aerial photos where the historic WSE was known with the LIDAR and the photogrammetry derived elevation data and the LIDAR was a better match relative to the shoreline, which represents the WSE.

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