Appendix 2.B
Vernal Pool Complex Mapping and Modifications to Natural Community Mapping

Contents

Acronyms and Abbreviations

CNDDB	California Natural Diversity Database
DHCCP	Delta Habitat Conservation and Conveyance Program
DWR	California Department of Water Resources
GIS	geographic information system
GPS	geographic positioning system
NAIP	National Agriculture Imagery Program
pH	potential of hydrogen
SSURGO	Soil Survey Geographic Database
USFWS	U.S. Fish and Wildlife Service

Appendix 2.B
Vernal Pool Complex Mapping and Modifications to Natural Community Mapping

2.B.1 Introduction

Map data layers for the BDCP were originally compiled from existing spatial datasets that were produced primarily by state and federal agencies. The data sources used to create the 13 natural community data layers in the Plan Area are discussed in Chapter 2, *Existing Ecological Conditions* (Table 2-3; Figure 2-14). This appendix provides additional details about the rationale and methods used in natural community mapping for the BDCP. Section 2.B.2, *Vernal Pool Complex Mapping*, describes the approach used to map the vernal pool complex for the BDCP and explains the refinements made as a result of the analysis performed by the Vernal Pool Review Team. Section 2.B.3, *Modifications to Mapping of Other Natural Communities,* describes the geographic information system (GIS) methods, GIS data sources, assumptions, and rationale for modifications that have been made to other natural community mapping layers as a result of comments received on the preliminary GIS dataset.

2.B.2 Vernal Pool Complex Mapping

Vernal pools are shallow depressions underlain by an impervious soil layer (e.g., a claypan or hardpan) that fill with water during winter rains and dry by evaporation in spring. Vernal pools have high levels of native biodiversity, and provide habitat for several covered plant, crustacean, and amphibian species (Platenkamp 1998). They tend to be small features, typically 0.125 acre or smaller, and cannot easily be identified on aerial imagery unless they are filled with water at the time. With few exceptions, vernal pools are well below the minimum size of features mapped by Hickson and Keeler-Wolf (2007) and Boul and Keeler-Wolf (2008), the main sources for habitat mapping used in the BDCP. Because vernal pools often occur in clusters or complexes within grassland, and because these complexes can be characterized by white alkali/saline scalds or occur on sites with a typical *mima mound* topography (undulating terrain with small, more or less equally sized mounds), vernal pool complexes frequently can be identified by using aerial photographs in combination with soil type maps and detailed topographic imagery (e.g., LiDAR data).

Topography, soils, vegetation data, field observations, and aerial imagery were used to identify vernal pool complexes. These were mapped into a vernal pool complex GIS layer that was then incorporated into the natural communities GIS dataset.

The Plan Area supports two different types of vernal pools. Vernal pools in the western part of the Plan Area tend to be alkali/saline pools of the *Lastenia fremontii-Distichlis spicata* alliance and *Frankenia salina* alliance (Sawyer et al. 2009). They occur on alkaline or saline claypan soils in Conservation Zones 1, 2, 11, and 8. Vernal pools on the west side of the Plan Area in and adjacent to Stone Lakes National Wildlife Refuge and the Cosumnes River Preserve tend to be hardpan vernal pools that tend to be shallow and mostly are in the *Lasthenia fremontii-Downingia* (*bicornuta*) alliance (Sawyer et al. 2009), underlain by hardpan soils. The alkali/saline vernal pool complexes in

the western part of the Plan Area often occur in a mosaic with alkali seasonal wetlands. Vernal pools in both the eastern and western part of the Plan Area may occur in areas where the land surface has been leveled for agricultural uses in the past. Leveling reduces the duration of ponding and the suitability of that habitat for vernal pool species.

2.B.2.1 Methods

Vernal pool complex identification in the Plan Area began with an initial GIS analysis by SAIC in 2009, which was reviewed and modified by a vernal pool review team including staff from California Department of Water Resources (DWR) and ICF in 2013.

2.B.2.1.1 GIS Analysis

The vernal pool complex mapping relied primarily on existing data sources, including aerial photography, vegetation mapping data and LiDAR topography data, with results validated by comparing them to field data collected during surveys of portions of the Plan Area performed by Delta Habitat Conservation and Conveyance Program (DHCCP) staff in 2009 and 2010. The resulting vernal pool complex polygons included both vernal pools and surrounding uplands. Additional modifications were made in 2013 by vernal pool experts Jean Witzman (DWR) and Gerrit Platenkamp (ICF) in consultation with U. S. Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW), using data collected by Holland (2005), Google Earth aerial imagery (Google Inc. 2012), and field experience in the Plan Area. No minimum mapping unit or scale was used during the process as the goal was to be as inclusive as possible.

The vernal pool complex natural community GIS layer was created using the following data: Soil Survey Geographic Database (SSURGO) (Natural Resources Conservation Service 2009 to 2013); BDCP composite vegetation GIS layer (Hickson and Keeler-Wolf 2007; Boul and Keeler-Wolf 2008; TAIC 2008); Google Earth aerial imagery (Google Inc. 2009 to 2013); DWR (2007) LiDAR elevation data; California Natural Diversity Database (CNDDB) records, and existing management plans and habitat conservation plans.

On the east side of the Delta, the potential region of the vernal pool complex near Stone Lakes was identified using existing vernal pool GIS data, CNDDB records, management plans, *South Sacramento Habitat Conservation Plan* vernal pool maps, expert knowledge, and Google Earth aerial imagery (California Department of Water Resources 2007; Kleinschmidt Associates 2008; California Department of Fish and Game 2007; Google Inc. 2009). The areas in this region were then inspected using LiDAR imagery to determine the extent of ground disturbance and the presence of appropriate pool and swale microtopography.

Vernal pool complexes in the remainder of the Delta, Yolo Bypass, and areas along the northern edge of Suisun Marsh was mapped by identifying areas with alkaline soils and the appropriate geomorphic characteristics and drainage condition, based on aerial photography and LiDAR data. Ancillary data were used to determine the presence vernal pools using CNDDB data, maps produced for the *East Contra Costa Habitat Conservation Plan/Natural Community Conservation Plan*, and various management plans. The BDCP composite vegetation layer. Google Earth and LiDAR imagery were then used to identify areas with the appropriate microtopography (Leigh Fisher Associates 2005; California Department of Water Resources 2007; California Department of Fish and Game 2007; Google Inc. 2009).

A few areas showing vernal pool signatures on aerial photographs, were not identified by the soil-vegetation analysis, but were digitized as vernal pool complex. (GPS)- linked photographs taken during BDCP floristic field surveys in the spring and summer of 2009 were used to assess the accuracy of the mapping at several sites in these areas (California Department of Water Resources 2009).

Some areas were mapped as a degraded vernal pool complex vegetation type, but included in the vernal pool natural community. These were areas of low quality ephemeral habitat that ranged from areas with vernal pool and swale visual signatures that display clear evidence of significant disturbance due to plowing, disking, or leveling to areas with clearly artificial basins such as shallow agricultural ditches, depressions in fallow fields, and areas of compacted soils in pasture.

Definitions of the two types of vernal pool complexes included in the BDCP vernal pool complex natural community are as follows.

- **Vernal pool complex.** High-quality, permanent habitat consisting of vernal pools and uplands that display characteristic vernal pool and swale aerial imagery signatures that have not been significantly impacted by agricultural or development practices.
- **Degraded vernal pool complex.** Low-quality, ephemeral habitat ranging from areas with vernal pool and swale visual signatures that display clear evidence of significant disturbance due to plowing, disking, or leveling, to areas with clearly artificial basins such as shallow agricultural ditches, depressions in fallow fields, and areas of compacted soils in pastures.

Both types are considered suitable habitat for covered vernal pools species, although the abundance of those species would be higher in vernal pool complex than in degraded vernal pool complex.

The following sections provide the vegetation units of the BDCP composite vegetation GIS layer (Hickson and Keeler-Wolf 2007; Boul and Keeler-Wolf 2008; TAIC 2008) and soils from the SSURGO (Natural Resources Conservation Service 2009 to 2013) that were considered to have potential to support vernal pool complexes.

2.B.2.1.2 Vegetation Units

The following vegetation subunits were selected from the BDCP composite vegetation layers for alkali seasonal wetland complex, other natural seasonal wetlands, and grassland natural communities.

- Alkali heath (*Frankenia salina*)
- Alkaline vegetation mapping unit
- *Allenrolfea occidentalis* mapping unit
- Annual grasses generic
- Annual grasses/weeds
- *Baccharis*/annual grasses
- California annual grasslands–herbaceous
- Creeping wild ryegrass (*Leymus triticoides*)
- *Distichlis* (generic)

- *Distichlis spicata*
- *Distichlis spicata*–annual grasses
- *Distichlis spicata–Juncus balticus*
- *Distichlis spicata–Salicornia virginica*[1]
- *Distichlis*/annual grasses
- *Distichlis*/lotus
- *Distichlis*/*S. americanus*
- *Distichlis*/*S. maritimus*
- *Distichlis*/*Salicornia*[2]
- *Frankenia salina–Distichlis spicata*
- Italian ryegrass (*Lolium multiflorum*)
- *Juncus bufonius* (salt grasses)
- *Lepidium* (generic)
- *Leymus* (generic)
- *Lolium* (generic)
- Pickleweed (*Salicornia virginica*)
- *Polygonum-Xanthium-Echinochloa*
- Ruderal herbaceous grasses & forbs
- *Salicornia virginica*
- *Salicornia virginica–Distichlis spicata*
- *Salicornia*/annual grasses
- Saltgrass (*Distichlis spicata*)
- Rabbitsfoot grass (*Polypogon maritimus*)
- *Salicornia virginica–Cotula coronopifolia*
- Salt scalds and associated sparse vegetation
- Seasonally flooded grasslands
- *Sesuvium*/*Distichlis*
- *Suaeda moquinii*–(*Lasthenia californica*) mapping unit
- Vernal pools

[1] Currently known as *Sarcocornia pacifica*.
[2] Currently known as *Sarcocornia*.

2.B.2.1.3 Soils

Soils in Sacramento, San Joaquin, Alameda, Contra Costa, Solano, and Yolo Counties were considered suitable for the vernal pool complex when their reported alkalinity met an alkalinity threshold. Soils with potential of hydrogen (pH) cha.racteristics defined as average (pH of 7.3) or including a comment describing the soils as being *strongly alkaline, alkaline, moderately alkaline,* or *slightly alkaline* were included in the habitat model. This liberal interpretation of alkalinity was meant to be inclusive, as other soil characteristics were used to further specify potential habitat for vernal pool species.

Two other reported soil characteristics were used to further constrain the soils included in the vernal pool complex: geomorphic description and drainage condition.

Geomorphic description includes the following areas.

- Alluvial fans
- Alluvial fans, valley floors
- Alluvial fans, valleys
- Basin floors
- Basin floors, benches
- Basin floors, rims on basins
- Basin floors, valleys
- Benches
- Fan skirts, valleys
- Hills
- Rims on basin floors
- Rims on basin floors, valleys
- Rims on basins
- Rims on basins, valleys
- Stream terraces, valleys
- Terraces
- Valley floors

The following terms describe drainage condition.

- Moderately well-drained
- Poorly drained
- Somewhat poorly drained
- Very poorly drained

2.B.2.1.4 Spatial Analysis Procedure

A spatial intersection of the vegetation types and soils was used to identify potential vernal pool complexes. The results of the intersection were then overlaid on Google Earth aerial imagery to assess physical characteristics and use conditions (Google Inc. 2009). Additionally, portions of the vernal pool complex that had not been mapped either as vernal pools or other types of wetlands were digitized and added to the results. These digitized vernal pool complexes were located near the Clifton Court Forebay and along the border of Suisun Marsh.

Potential vernal pool complexes without concave surfaces (except for seeps along the border of Suisun Marsh) were removed from the vernal pool complex. LiDAR elevation data were then visually inspected to further assess specific locations that had been identified by the selection process. These areas were selected based both on *a priori* knowledge of the region, and because they were identified by the intersection of the selected vegetation types and soils. The analysis of the LiDAR data further refined the extent of the vernal pool complex and provided a more accurate demarcation of the community. The GIS-derived vernal pool complex community was then compared against field data and GPS-linked photographs taken during BDCP field surveys in the spring and summer of 2009 and 2010, and those data were used to assess the accuracy of the mapping at several sites (California Department of Water Resources 2009). Land uses incompatible with the vernal pool complex, for example polygons falling on leveled or developed lands, were removed from the model.

The resulting vernal pool complex natural community data were distributed to DWR, CDFW, USFWS, various BDCP technical subgroups, and the National Environmental Policy Act/California Environmental Quality Act team, and in response to comments received from these groups, some polygons classified as other communities or vegetation types were manually reclassified as either vernal pool complex natural community or degraded vernal pool complex vegetation type.

2.B.2.2 Vernal Pool Review Team Analysis

The vernal pool complex natural community mapping conducted previously was reviewed and adjustments were made at three sites in the Plan Area. One of the sites was at the Stone Lakes National Wildlife Refuge, north of Hood Franklin Road (here referred to as Stone Lakes Area). The other two sites were south of Clifton Court Forebay. One of those sites is just south of the southwestern edge of Clifton Court Forebay (here referred to as Clifton Court Forebay Area) and the other one is in the vicinity of the intersection of Bruns Road and West Kelso Road in the area in between the Jones and Banks Pumping Plants (Kelso Road Area). Changes made to the BDCP Natural Communities GIS layer are described below for each area.

2.B.2.2.1 Stone Lakes Area

The grassland area north of Hood Franklin Road (west of Interstate 5, south of North Stone Lake and east of the railroad) contains vernal pools, swales and other vernal features (tire ruts and ditches) that were surveyed for listed branchiopods in the winter of 2008/2009 (EDAW 2009) and for special-status plants in the spring of 2009. Vernal pool fairy shrimp (*Branchinecta lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardi*) were found in several features within this area (EDAW 2009: Exhibit 4c). All vernal features within this area (EDAW 2009: Exhibit 4c) are considered habitat occupied by these species according to USFWS (Jana Milliken, pers. comm.).

The site historically had the *mima mound* topography that is typical for vernal pool terrain. Field observations and aerial photograph interpretation showed that historically this site has probably been an irrigated pasture, and that the site was leveled for that purpose.

Based on observations made during the field surveys at this site several adjustments were made to the natural communities GIS layer. Two polygons mapped by Hickson and Keeler-Wolf (2007) as California annual grassland – herbaceous that were not mapped as vernal pool complex previously, were mapped as degraded vernal pool complex. One polygon mapped by Hickson and Keeler-Wolf as Italian ryegrass (*Lolium multiflorum*) was reclassified degraded vernal pool complex. Two polygons in this same area that were mapped as rabbitsfoot grass (*Polypogon maritimus*) by Hickson and Keeler-Wolf (2007) were changed from managed wetland to grassland, because these sites did not show wetland characteristics in the field during 2009 surveys.

2.B.2.2.2 Clifton Court Forebay Area

Areas that ponded water south of Clifton Court Forebay were delineated with a GPS unit in the winter of 2008/2009 and were sampled for listed branchiopods on January 13 and 26, 2009 and February 9 and 24, 2009. Vernal pool fairy shrimp was collected in one of the pools on February 24, 2009 (EDAW 2009). The USFWS (Jana Milliken, pers. comm.) notified DWR's consultant that "all vernal features in the vicinity of the collected *B. lynchi*" are considered occupied by listed branchiopods. "Vicinity" was interpreted by DWR and its consultant as the area identified as Clifton Court Forebay Approximate Survey Area depicted in Exhibit 3a of EDAW (2009). The vernal feature cluster directly adjacent to the south side of Clifton Court Forebay, depicted in Exhibit 3c of EDAW (2009), was mapped by Hickson and Keeler-Wolf (2007) as ruderal herbaceous grasses and forbs and *Allenrolfea occidentalis* mapping unit, and one small area was not attributed by CDFW. This unattributed area was identified as the *Allenrolfea occidentalis* mapping unit type by Jean Witzman (DWR), who had previously visited this site. The *Allenrolfea occidentalis* polygon was defined as vernal pool complex and the unlabeled polygon was attributed the same way. The remainder of the area that included the ponded areas was delineated as vernal pool complex, to include the approximate area that was not paved that could function as watersheds for the pools. The polygon was labeled as degraded vernal pool complex.

2.B.2.2.3 Kelso Road Area

Grasslands to the east of Bruns Road and north and south of Kelso Road, showed clear *mima mount* topography and pool and swale patterns in aerial imagery of February 2, 2002, May 22, 2002 and May 14, 2009. This grassland area was delineated from NAIP 2010 aerial imagery and labeled as vernal pool complex. An area directly north of Kelso Road was mapped as degraded vernal pool complex, because the terrain showed clear evidence of leveling of the local topography.

The newly added vernal pool complex areas were incorporated in the BDCP natural communities GIS layer and were also used in the vernal pool species habitat models used in the effects analysis.

2.B.3 Modifications to Mapping of Other Natural Communities

2.B.3.1 Modifications to the Classification of Riparian Habitat in Fremont Weir Wildlife Area

2.B.3.1.1 Background

There were a significant number of acres of grassland in the Fremont Weir Wildlife Area that were initially incorrectly mapped as riparian habitat. As a result, the species models for taxa associated with riparian habitat overestimated the amount of suitable habitat, which led to an artificially high estimate of affected acres for those species. This area was remapped to better characterize the locations of riparian and grassland natural communities.

2.B.3.1.2 Methods

Using 2010 NAIP aerial imagery, this portion of the Plan Area was re-digitized and the associated polygon attributes were reclassified into mapping units within the grassland natural community (Table 2-16) or the valley/foothill riparian natural community (see Table 2-9). Polygons that remained classified as grasslands were categorized as upland annual grasslands & forbs formation. Riparian polygons were reclassified into one of the three vegetation alliances listed below, to represent mature valley oak forest, cottonwood-dominated mature forest, and early to mid-successional riparian scrub forest. The following data fields in the natural community layer were changed: SAIC_Type, Veg_name, and Datasource.

2.B.3.1.3 Results

Riparian polygons were reclassified into one of the following alliances:

- Valley oak alliance
- Fremont cottonwood- valley oak willow (ash-sycamore) riparian forest NFD alliance
- Mixed willow super alliance.

2.B.3.2 Modifications to the Classification of Tidal Habitat in Dutch Slough and White Slough

2.B.3.2.1 Background

Agency experts commented that some areas were incorrectly classified as tidal when they actually were non-tidal, leading to large areas of known, occupied black rail habitat being left out of the black rail habitat model, therefore these areas were identified and reclassified.

2.B.3.2.2 Methods

DWR species experts provided explicit direction for correctly mapping the areas in question (Danika Tsao, pers. comm.) and ICF GIS staff reclassified these polygons.

2.B.3.2.3 Results

Polygons that were previously assigned to the tidal freshwater emergent wetland natural community were reclassified as nontidal freshwater perennial emergent wetland.

2.B.3.3 Modifications to the Classification of Cultivated Lands

2.B.3.3.1 Cultivated Lands to Valley/Foothill Riparian

2.B.3.3.1.1 Background

All riparian habitats need to be captured in the valley/foothill riparian natural community. Polygons previously assigned to the cultivated lands natural community (more specifically, the crop type dataset class "native riparian" and subclass "trees, shrubs, or other stream side or watercourse vegetation"; NR-3 in the CL-SUBCL field) therefore had to be reclassified as valley/foothill riparian.

2.B.3.3.1.2 Methods

Using 2010 NAIP aerial imagery, "native riparian" polygons within the cultivated lands natural community were reclassified into mapping units within the valley/foothill riparian natural community (see Table 2-9). The following fields were changed: SAIC_Type, Veg_name, and Datasource.

2.B.3.3.1.3 Results

Riparian polygons were reclassified into one of three alliances listed below to represent mature, valley oak forest, mature cottonwood-dominated forest, and early- to mid-successional riparian scrub.

- Valley oak woodland
- Fremont cottonwood- valley oak willow (ash-sycamore) riparian forest NFD alliance
- Mixed willow super alliance

2.B.3.3.2 Cultivated Lands (Native Riparian Class) to Managed Wetlands

2.B.3.3.2.1 Background

Within the cultivated lands natural community, the native riparian class of the DWR crop type dataset included two managed wetland subclasses: seasonal duck marsh (dry or only partially wet during the summer) and permanent duck marsh(wet during summer). Under BDCP, these are considered managed wetlands, so polygons within the cultivated lands natural community (specifically crop type dataset class native riparian, subclasses 3 and 4; CL_SUBCLASS=NR_4 and NR_5) were reclassified to the managed wetlands natural community. The BDCP managed wetland natural community makes no distinction between seasonal and permanent duck marshes so the previous class and subclass designations are not used to differentiate managed wetland polygons within associated species' models.

2.B.3.3.2.2 Methods

Using 2010 NAIP aerial imagery, lands with specific, managed wetland signatures[3] were identified by ICF and reclassified into the managed wetland natural community.

2.B.3.3.2.3 Results

All polygons with the following three attributes were reclassified as managed wetland.

- SAIC_Type=managed wetland
- Veg_name= managed annual wetland vegetation (nonspecific grasses & forbs)
- DataSource=DWR2008

If the selected polygons did not include a managed wetland signature, they were reclassified to NV-** (that is: SAIC_Type=agricultural natural community, Class=native vegetation, Subclass=**, CL-SUBCLASS=NV-**, DataSource=ICF2013).

2.B.3.3.3 Cultivated Land (Native Vegetation Class) to Managed Wetland

2.B.3.3.3.1 Background

Within the cultivated lands natural community, the native vegetation class (**subclass, CL-SUBCLASS=NV-**) was found to also include several patches of lands with the managed wetland signature.

2.B.3.3.3.2 Methods

Using 2010 NAIP aerial imagery, lands with specific, managed wetland signatures were identified by ICF and reclassified into the managed wetland natural community.

2.B.3.3.3.3 Results

All polygons with the following three attributes were reclassified as managed wetland.

- SAIC_Type=managed wetland
- Veg_name= managed annual wetland vegetation (nonspecific grasses & forbs)
- DataSource=DWR2008

[3] A managed wetland signature is a complex of wetland units with levees and roads clearly separating the units. Wetland units often have different vegetation signatures that suggest varying water management regimes (i.e., some units appear green while others appear brown (dry)).

2.B.3.4 Modifications to the Classification of Crop Type Data in the Upper Yolo Bypass

2.B.3.4.1 Background

The Yolo County Natural Heritage Program's Land Cover Dataset (2008) was originally used to assign crop types to the cultivated land natural community in the portion of the Plan Area that is north of the statutory Delta boundary (basically north of Highway 80) in the upper Yolo Bypass. Only data corresponding to the boundaries were used for the purposes of this analysis. The classified Plan Area natural communities dataset produced from the Delta and Suisun Marsh data and the Upper Yolo Bypass vegetation cover dataset were merged to generate a single compiled natural community dataset.

2.B.3.4.2 Methods

Instead of using the Yolo County Natural Heritage GIS data to represent crop types in the upper Yolo Bypass north of I-80, the DWR land use survey data for Yolo County from 2008 were used to assign crop types to the cultivated lands natural community dataset (California Department of Water Resources 2008). The DWR land use dataset was not available when the BDCP vegetation dataset was originally created. To maintain consistency when and where possible within the crop type classifications, it was decided in the spring of 2013 to use the DWR dataset in place of the Yolo County data.

2.B.3.4.3 Results

For all cultivated land natural community polygons, DWR land use data were used to assign specific crop types. This was done using the following fields from the DWR land use dataset (2008): CLASS1, SUBCLASS1, and IRR_TYPE1PA. These fields were used to create the following fields in the BDCP land use dataset: CL_SUBCL and IRR_TYPE1PA. The CL_SUBCL field is a combination of the DWR CLASS and SUBCLASS fields. The CL_SUBCL and IRR_TYPE1P fields were then used to create the DWRType field. This field converts abbreviations and numeric designations within the dataset to discernible crop types such as corn or wheat.

2.B.4 References

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