TECHNICAL APPENDIX ◦ FEBRUARY 2021

Assessment of Groundwater Dependent Ecosystems for the Owens Valley Basin Groundwater Sustainability Plan

PREPARED FOR

Owens Valley Groundwater Authority

PREPARED BY

Stillwater Sciences
2855 Telegraph Ave., Suite 400
Berkeley, CA 94705

Stillwater Sciences

Suggested citation:
Stillwater Sciences. 2021. Assessment of Groundwater Dependent Ecosystems for the Owens Valley Basin Groundwater Stability Plan. Technical Appendix. Prepared by Stillwater Sciences, Berkeley, California for Owens Valley Groundwater Authority.

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1 BACKGROUND AND SETTING

This Technical Appendix to the Owens Valley Groundwater Sustainability Plan (GSP) addresses the extent and condition of groundwater dependent ecosystems (GDEs) in the Owens Valley Groundwater Basin. The Owens Valley Groundwater Basin is managed by the Owens Valley Groundwater Authority (OVGA). As part of the California's Sustainable Groundwater Management Act (SGMA), Groundwater Sustainability Agencies (GSAs) are required to consider GDEs and other beneficial uses of groundwater when developing their GSPs. SGMA defines GDEs as "ecological communities of species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" (23 CCR § 351(m)). As described in The Nature Conservancy's guidance for GDE analysis (Rohde et al. 2018), a GDE's dependence on groundwater refers to reliance of GDE species and/or ecological communities on groundwater for all or a portion of their water needs. Mapping GDEs requires mapping vegetation that can tap groundwater through their root systems, assessing where the depth of groundwater is within the rooting depth of that vegetation, and mapping the extent of surface water that is interconnected with groundwater (Rohde et al. 2018). Once the GDEs are mapped, the occurrence of special status species can be used to assess the value of GDEs in the basin, while remote sensing measurements can be used to track the health of groundwater dependent vegetation through time. This information will be used to inform sustainable management criteria for each management unit. This appendix relies on hydrologic and geologic data presented in the GSP and its technical appendices.

The central portion of the Owens Valley Groundwater Basin contain lands owned by the City of Los Angeles where groundwater and GDEs are managed following a legal settlement and are not subject to SGMA. This area is hereafter referred to as the Adjudicated Area (Figure 1.1-1). Groundwater pumping in the Adjudicated Area is managed jointly by Inyo County and the City of Los Angeles to maintain vegetation cover at 1984–1987 levels (Groenveld 1992). This technical appendix to the Owens Valley GSP addresses GDEs in the Owens Valley Groundwater Authority (OVGA) Assessment Area (Figure 1.1-1) which includes all lands outside of the Adjudicated Area. While this technical appendix focuses on the OVGA Assessment Area, groundwater and vegetation data gathered in the Adjudicated Area were used to inform and provide context to our analysis. The Owens Valley Groundwater Basin was classified as a low-priority basin by the California Department of Water Resources (DWR 2020a). The GSP and the approach outlined below was presented during public meetings of the OVGA.

The Owens Valley basin has characteristics that make GDE assessment difficult. The basin is over 125 miles long and ranges in width from 2–15 miles. The basin has a total area of 1,062 square miles, 65% of which is outside of the adjudicated area (DWR 2020a). The adjudicated area extends across the center of the Owens Valley from Bishop downgradient to the Owens Lake area. The elongate shape, coupled with a strong gradient in runoff from west to east creates diverse habitats.

1.1 Physiography, Geology, and Soils

This section includes a brief discussion of the physiography, geology, and soils. These data are presented in more detail in Section 2.1 of the GSP. The Owens Valley Groundwater Basin underlies alluvial sediments in Benton, Hammil, and Chalfant valleys (hereafter the Tri-Valley Area) in Mono County and Round Valley, Owens Valley and Owens Lake in Inyo County (CA Department of Water Resources 2016, Figure 1.1-2). The basin is bounded to the north by the Benton Range and the Bishop Tuff, to the west by the Sierra Nevada, to the southeast by the Coso Range, and to the east by the Inyo and White mountains (Figure 1.1-1). The southern extent of the alluvial basin is marked by the groundwater and topographic divide at Hawiee Reservoir. It is approximately 130 miles long and varies in width from approximately 1 mile between Big Pine and Poverty Hills to approximately 15 miles at Owens Lake. The basin surface is a high desert rangeland valley that ranges in altitude from about 3,500 feet above sea level at Owens Lake to about 4,500 feet north of Bishop (Danskin 1998).

Water in the basin originates in the Sierra Nevada and White/Inyo Mountains. The basin is drained by the Owens River which originates south of Mono Lake and terminates in Owens Lake, a closed basin at the downstream end of the groundwater basin. The primary water-bearing unit in the basin is the Quaternary sediment that fills the valley (Figure 1.2-1). Numerous tributaries drain the Sierra Nevada, forming extensive coalesced alluvial fans that extend nearly to the valley axis on the west side. The Sierra Nevada creates a rain-shadow effect for the Owens Valley and the White and Inyo ranges. Runoff and associated alluvial fans at the base of the drier White and Inyo mountain are therefore less extensive. Although valley fill material is heterogeneous, in general, sediment at the basin boundaries is unconsolidated, coarse, permeable alluvial fan material, grading into fluvial and lacustrine sand and silt deposits toward the valley axis.

The majority of soils in the Owens Valley Basin are alluvial or eolian in origin. The geologic complexity of the region results in a wide variety of parent materials; over 200 soils are mapped in the basin. Soils on the valley floor are typically alkaline (Tallyn 2002), but the well-drained soils on the alluvial fans host vegetation that is generally intolerant of high alkalinity (Sorenson et al. 1991).

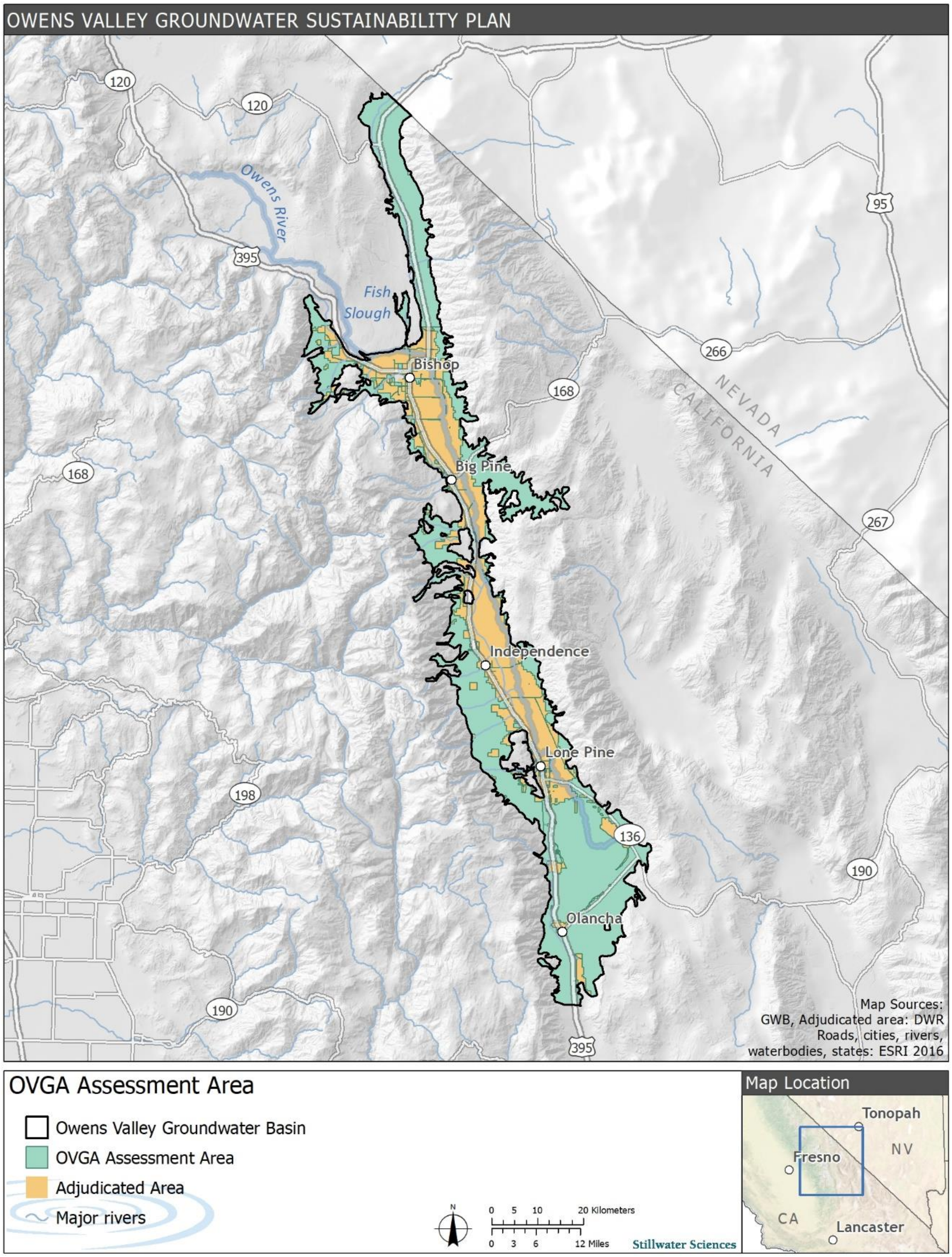

Figure 1.1-1. OVGA Assessment Area showing the exclusion of the Adjudicated Area.

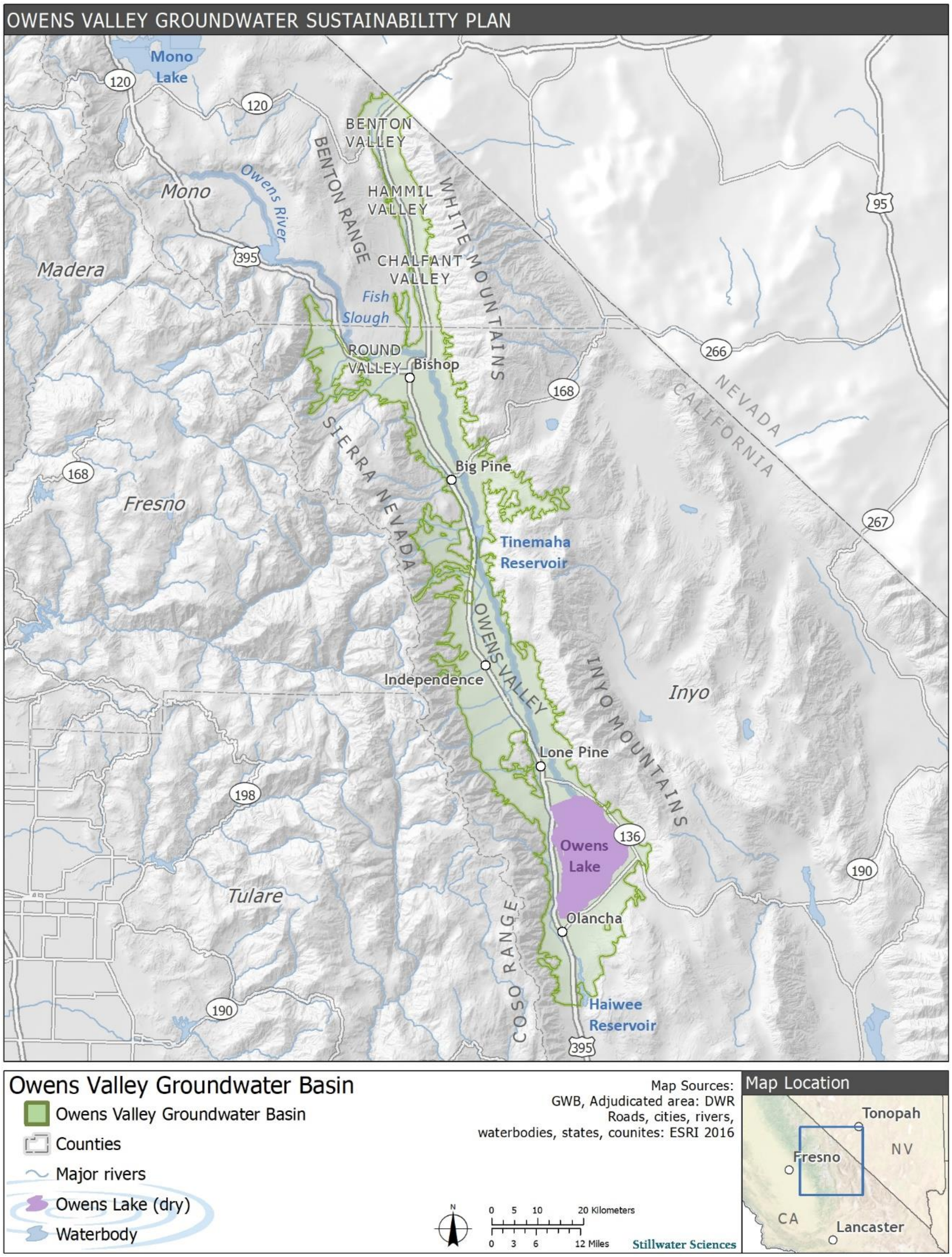

Figure 1.1-2. Owens Valley groundwater basin.

1.2 Management Areas

Based on the geology, hydrology, and pre-existing management policies, the non-adjudicated portion of the Basin (referred to herein as the OVGA Assessment Area) has been divided into three management areas: Tri-Valley and Fish Slough, Owens Valley, and Owens Lake as described in the GSP (Section 2.2.4). For the GDE analysis, the Tri-Valley area and Fish Slough will be assessed separately to account for the interconnected surface flows and rare plant and animal species unique to Fish Slough. The four management areas are shown in Figure 1.2-1 and their extent is shown in Table 1.2-1. Owens Valley is the largest management area in the OVGA Assessment Area totaling 43% of the Assessment Area, with the Owens Lake management area covering 40%. The Tri Valley management area is about 17% of the Assessment Area, with Fish Slough slightly less than 1% of the Assessment Area (Table 1.2-1).

Table 1.2-1. Area of Management Areas (area does not include the Adjudicated Area).

GDE management area	Area (acres)	% of total
Owens Valley	184,788	43.0
Owens Lake	170,491	39.6
Tri-Valley	71,839	16.7
Fish Slough	2,943	0.7
Total	**430,061**	**100**

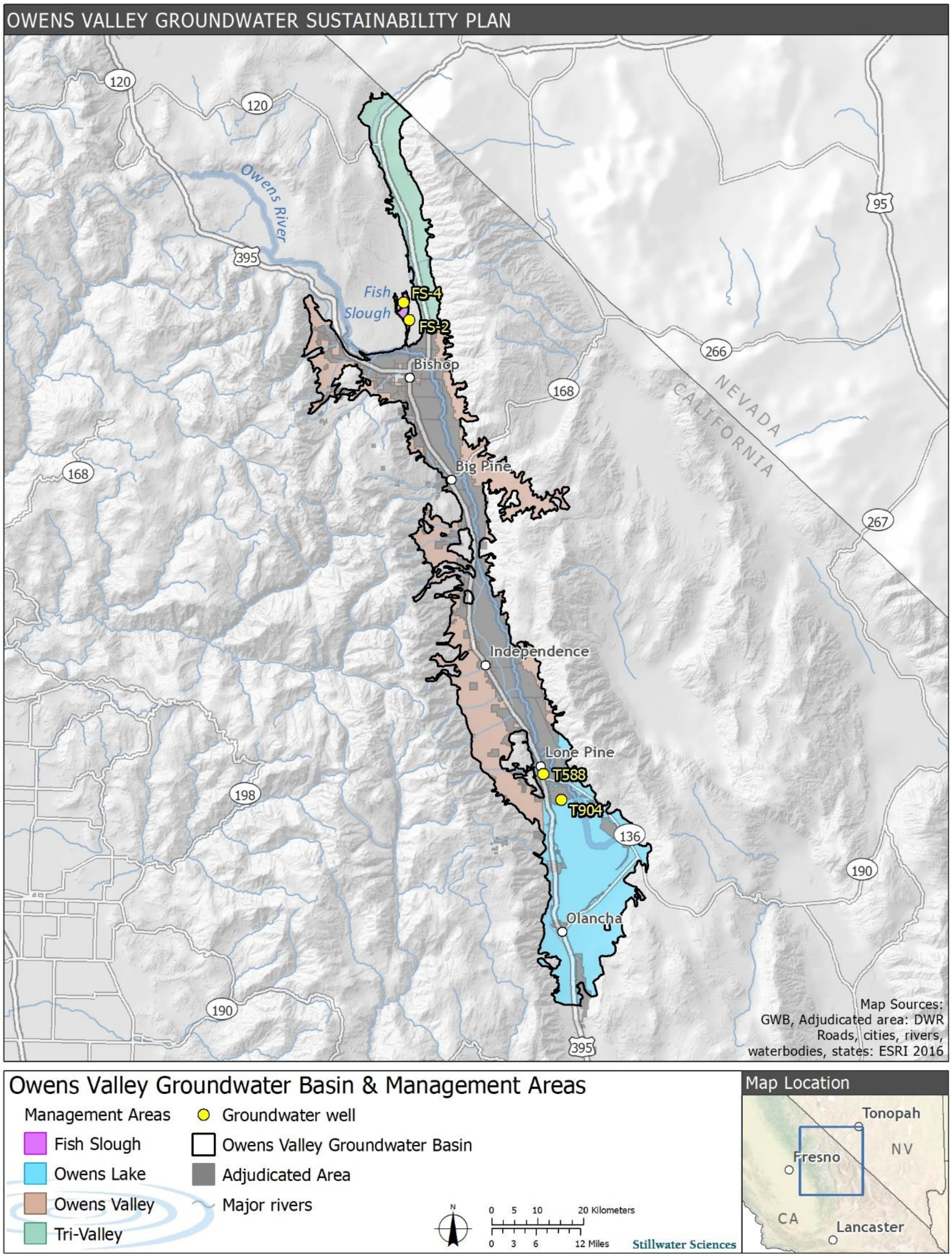

Figure 1.2-1. Owens Valley Groundwater Basin and Management Areas. The figure also shows groundwater wells discussed in the Section 1.3.

1.3 Hydrology

The physiography and geology of the Owens Valley is described in Section 2.2 of the GSP. Here we describe the surface and groundwater hydrology relevant to the GDE analysis. Much of the surface water and some of the groundwater in the Owens Valley is diverted to the Los Angeles Aqueduct. The valley has no natural surface-water outlet and water naturally drained into the Owens River, flows southward into Owens Lake, and evaporates. Flow in the Owens River upstream of the Los Angeles Aqueduct intake, located south of Poverty Hills, is controlled by releases from Lake Crowley and the Tinemaha Reservoir. Flow in the Lower Owens River, a 62-mile stretch between the aqueduct intake and Owens Lake, is controlled by releases from the river-aqueduct system and groundwater-surface water exchange (Danskin 1998). Water exports caused the lake to dry up by 1926, and it remained a playa until the early 2000s, when water application to the lake was implemented as part of the Los Angeles Owens Lake Dust Control Project (Herbst and Prather 2014). The Lower Owens River was also essentially dry until the early 2000s. In 2006, re-watering of the river and floodplain commenced with the Lower Owens River Project. Since December 2006, the river has maintained a minimum flow of 40 cfs (LADWP 2019a).

The productive aquifer unit of the valley fill is divided into three hydrogeologic units from the surface downward. Unit 1 represents the unconfined part of the aquifer system and is the unit from which most GDEs obtain their water (Danskin 1998). Unconfined conditions exist in most of the aquifer system. Unit 1 has a saturated thickness of about 100 ft. Locally, less transmissive layers of volcanic flows or fine-grained sediment (related to paleo lacustrine or fluvial conditions) can create localized confinement described as hydrologic Unit 2 by Danskin. Most of the groundwater extraction in the valley is from Unit 3, consisting of older, more consolidated alluvial sediments (Danskin 1998). This unit occurs well below the rooting depth of trees. Faults in the Owens Valley can produce springs and seeps with discharge from both Unit 1 and Unit 3. From Water Year 2000 through the first half of Water Year 2019, average annual groundwater pumping in the Owens Valley was about 73,000 acre-feet per year (LADWP 2019b).

Aquifer recharge is primarily runoff from the Sierra Nevada that infiltrates through the heads of alluvial fans and tributary stream channels. Additional recharge results from seepage from canals and ditches, precipitation on sparsely vegetated volcanic rocks, irrigation, and leakage from the Owens River-Los Angeles Aqueduct system. In general, groundwater flows horizontally through Units 1 and 3 from recharge locations at the valley margins, mainly the west margin, toward the center of the valley, and then south toward Owens Lake.

Throughout the basin, faults impede horizontal groundwater flow across the strike of the fault. For example, the Owens Valley Fault, which trends north-south along the valley axis in the Owens Valley and Owens Lake, impedes west-east flow in the southern and central parts of the basin. Faults also create relatively isolated hydrologic compartments in the basin, with recharge and discharge occurring from localized sources only, such as streams and springs or wells, respectively (Figure 1.3-1). Areas bounded by parallel faults like the Owens Valley and Owens River faults south of Lone Pine at the Owens Lake are an example of such compartments. Faulting in areas with surface and subsurface volcanic flows have created highly transmissive, preferential flow paths typically along the axis of the fault and are the sites of springs and seeps through out the basin.

Rohde et al. (2018) recommend defining vegetation as GDEs if the groundwater is within 30 feet of the ground surface. This is deeper than most roots, but accounts for differences between the location of monitoring wells and GDEs, uncertainty in groundwater modeling (if used), and uncertainty in the rooting depth. We therefore focus on shallow groundwater, where present, in our assessment of groundwater in the basin. Trends in groundwater are explored in Appendix XX Monitoring Plan and Data Gap Analysis and are only briefly described here. We also explore the extent of interconnected surface water in each management area. Because this analysis of the GSP does not include a groundwater model, we explore past trends in hydrology using the identified monitoring wells in the four analysis areas. Where possible, we use shallow water wells identified as monitoring wells in Appendix XX Monitoring Plan and Data Gap Analysis.

There are numerous seeps and springs mapped in the OVGA Management Area (Figure 1.3-1). Seeps and springs are located along faults and at geologic contacts. LADWP gages springs with significant flows in the Owens Valley (primarily in the Adjudicated Area (Aaron Steinwand, personal communication. Below we focus on flows in Fish Slough, which is almost entirely spring fed. Additional details on spring flows are available in Appendix XX Monitoring Plan and Data Gap Analysis.

For the remainder of this report, shallow groundwater refers to groundwater accessible by roots (< 15 below the ground surface [bgs]). Changes in groundwater through time are investigated in Appendix XX Monitoring Plan and Data Gap Analysis

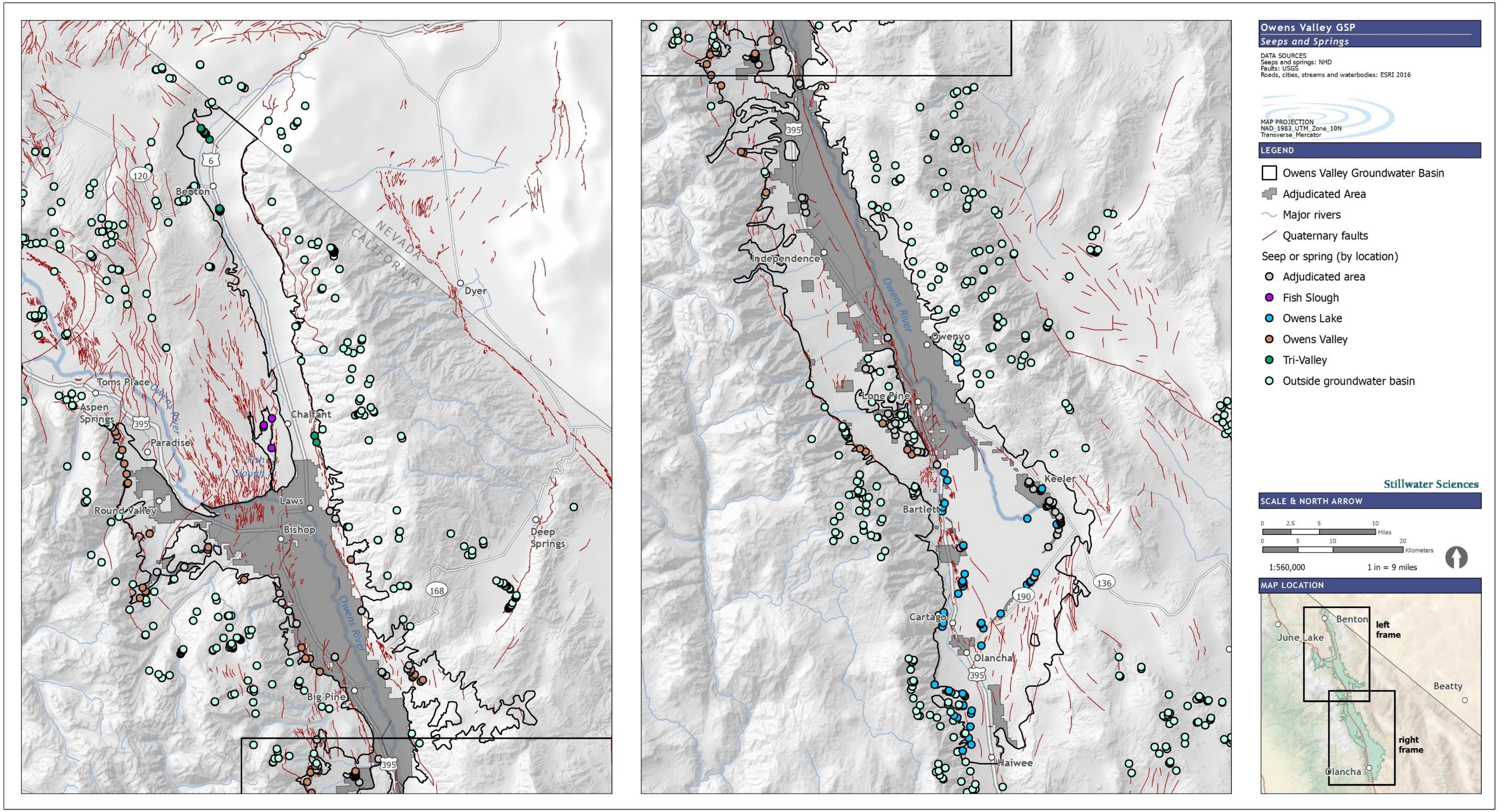

Figure 1.3-1. Seeps and Springs in the Owens Valley Groundwater Basin and vicinity.

1.3.1 Owens Valley

The Owens Valley management area contains numerous tributaries and seeps and springs that on the valley floor are typically associated with faults (Danskin 1998). Because there are few wells within the potential GDE areas, monitoring wells in the Adjudicated Area are used in places to evaluate long term trends in groundwater levels. As discussed in the Monitoring Plan and Data Gap Analysis Technical Appendix, shallow wells located in the Adjudicated Area in the Owens Valley Management Unit have depths to water that are generally < 20 ft below ground surface (bgs). Within a given year, groundwater depths are typically shallower in the winter and spring and deeper in summer and fall. Over longer timescales, groundwater depths decline during droughts but recover during wetter years. In general groundwater is closer to the ground surface in the center of the basin than at the edge, near the alluvial fans where depth exceeded 30 feet bgs during the 2012–2016 drought but recovered after 2017.

The Owens River is connected to groundwater in places within the Adjudicated Area (Danskin, 1998). Outside of the Adjudicated Area, however, the extent of interconnected surface waters is unknown in the Owens Valley management area. It is, however, likely that flowing interconnected surface water is relatively rare outside of the Adjudicated Area because groundwater depths generally increase toward the mountains due to the steep, upsloping topography and the tributaries are known losing reaches and not groundwater discharge zones (Aaron Steinwand, personal communication). Because shallow groundwater measurements are sparse, we rely on local expertise to assess the extent of interconnected surface water at tributaries. Given that vegetation tends to occur in narrow bands along the tributaries, sufficiently shallow groundwater to maintain a connection with surface water is unlikely. Local interconnected water does occur where groundwater emerges at springs (Danskin 1989).

1.3.2 Owens Lake

As discussed in the Monitoring Plan and Data Gap Analysis Technical Appendix, the Owens Lake management area includes five confined aquifer layers with aquifer numbers increasing with deeper stratigraphic positions. In general, the units grade from coarser, permeable materials in the delta area north of Owens Lake to clays near the center of the lake (LADWP and MWH 2011). Monitoring well data for the Owens Lake Management Area presented in the Monitoring Plan and Data Gap Analysis Technical Appendix show generally stable shallow groundwater elevations, with short term fluctuations corresponding to water year type (Figure 1.3-2). Groundwater levels in Aquifer Unit 1 are within the maximum rooting depth of many GDEs (~10ft). The location of wells in Figure 1.3-2 are shown on Figure 1.2-1.

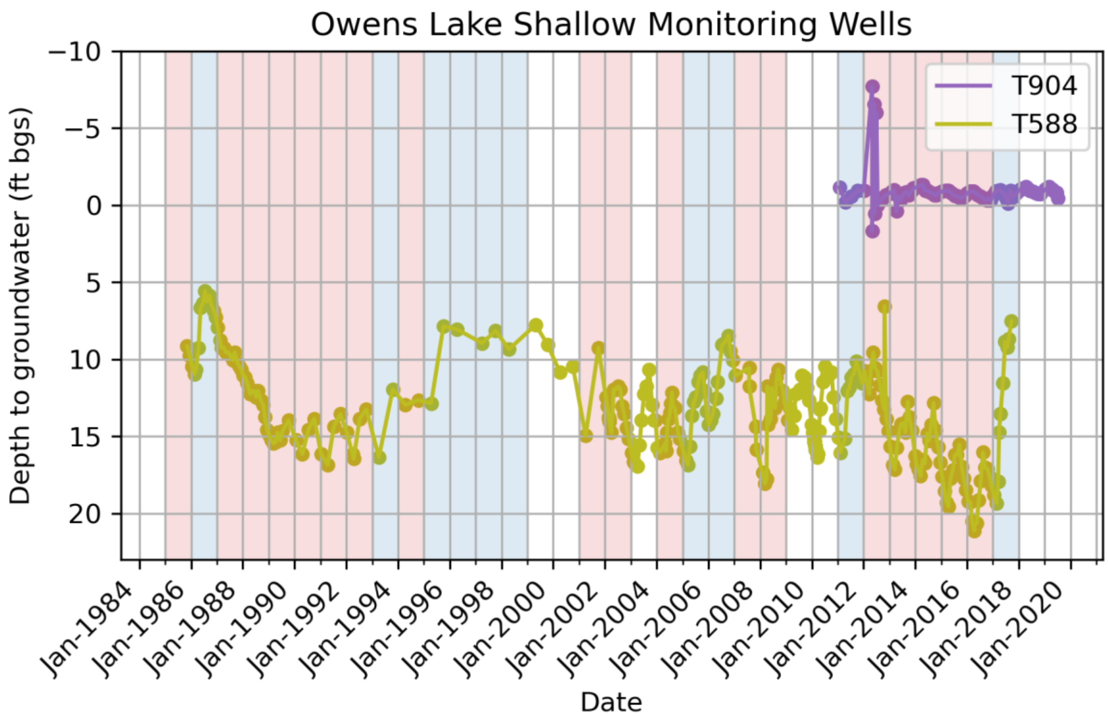

Figure 1.3-2. Changes in depth to shallow groundwater in Owens Lake monitoring wells. Red shading indicates dry years and blue indicates wet years.

Owens Lake is currently managed to limit air pollution from dust. This management includes ongoing and planned restoration to improve plant and bird habitat including groundwater-dependent plants. Dust management primarily involves diverting surface water from the Los Angeles Aqueduct to the lake surface (LADWP 2010, National Academy of Sciences 2020). As part of the ongoing Owens Lake Groundwater Development Program, LADWP is investigating the impacts of deep groundwater extraction from beneath Owens Lake to supplement dust control water demand. To date, groundwater levels have remained relatively stable and shallow groundwater salinity has not increased (LADWP 2010, LADWP 2021, LADWP and MWH 2011, National Academy of Sciences 2020).

The Lower Owens River is located within the Adjudicated Area prior to entering the lake and is generally a gaining reach. Seeps and spring have been mapped along the margin of the lake bed and south of Olancha along the western margin of the Owens Lake management area (Figure 1.3-1). GDEs likely derive their water from the confined aquifers where faulting or stratigraphy allow upward groundwater flow and discharge at seeps or springs.

1.3.3 Tri-Valley

The Tri-Valley management area differs from the Owens Valley and Owens Lake management areas in that none of its water is derived from the Sierra Nevada. Water in the Tri-Valley area originates from the relatively low-lying Volcanic Tablelands consisting of the Bishop Tuff pyroclastic flow to the west and the Mesozoic granites and sedimentary rocks of the White Mountains to the east. Large alluvial fans extend from the White Mountains into the Tri-Valley area, overlying and to the west of these fans is the Bishop Tuff. Both the Volcanic Tablelands and the White Mountains are in the rain-shadow of the Sierra and consequently received significantly less precipitation. Small tributaries drain out of the White Mountains but the water infiltrates into the groundwater system, is used for irrigation, or evaporates and there is little surface water connection with other parts of the basin except for an ephemeral wash that flows only after extreme precipitation events. The White Mountain fault extends along the base of the White Mountains on the east side of the Tri-Valleys.

Depth to water in monitoring wells in the Tri-Valley area are typically greater than 85 feet below the ground surface, and the presence of shallow groundwater available for GDEs is not known or monitored (Figure 1.3-3). As shown in the Monitoring Plan and Data Gap Analysis Technical Appendix, monitoring wells in the Tri-Valley Management Area have been consistently declining. Because the groundwater is deep relative to the rooting depth of plants, the connection between the groundwater decline and GDEs is unknown. The presence of potential GDEs in the management unit suggest that shallow groundwater may occur in places. The linkage between GDE health and groundwater decline in the Tri-Valley Management Unit is explored in Section 4.2.

Seeps and spring have been mapped in the northwest and southeast portions of the Tri-Valley management area (Figure 1.3-1).

1.3.4 Fish Slough

The Fish Slough spring complex lies in Fish Slough Valley, north of Bishop and southeast of the Bishop Tuff Volcanic Tablelands, and consists of multiple spring systems, from small seeps to fourth-order springs (discharge of 380 L to 1700 L per minute). Because there is no upstream surface flow except infrequent ephemeral runoff, nearly all the flow in Fish Slough is derived from groundwater. Several major springs are located along the Fish Slough fault zone, a series of north-south trending normal faults. Using surface topography, faulting, and inferred subsurface geology, Hollett et al. (1991) identified the Tri-Valley area as one of the potential water sources for Fish Slough, which was supported by geochemical analysis by Zdon et al. (2019).

Fish Slough is spring fed and has interconnected surface water throughout its length. Surface flow originates from springs that drain into a perennial stream that flows south through Fish Slough to the Owens River. The combined discharge of the Fish Slough spring complex is measured at surface flow gage SW3216, on Fish Slough about two miles north of its confluence with the Owens River. Mean annual flow at SW3216 has declined over the entire period of record, from over 500 acre-feet per month in the late 1960s to less than 250 acre-feet per month in 2011 (Figure 1.3-3). From 1940 to 1965, mean annual discharge at SW3303, less than one mile upstream along Fish Slough, declined from approximately 550 acre-feet per month to 450 acre-feet per month. Mean annual discharge at SW3209, another mile upstream, declined from 55 acre-feet per month in 1990 to 30 acre-feet per month in 2001. Discharge at SW3209 stabilized between 2001 and 2010 and increased to over 80 acre-feet per month by 2016. Mean annual discharge at SW3217 in the northwestern (upstream) end of Fish Slough declined from 270 to less than 240 acre-feet per month between 1990 and 2000. Discharge at SW3217 subsequently increased and stabilized at approximately 270 acre-feet per month between 2014 and 2017. Mean annual discharge at SW3208 in the northeastern (upstream) end of Fish Slough has declined from 90 acre-feet per month in 1990 to less than 10 acre-feet per month in 2017, a decrease of almost 90 percent. The origins of this decreased surface flow in Fish Slough are explored in more detail elsewhere in this GSP.

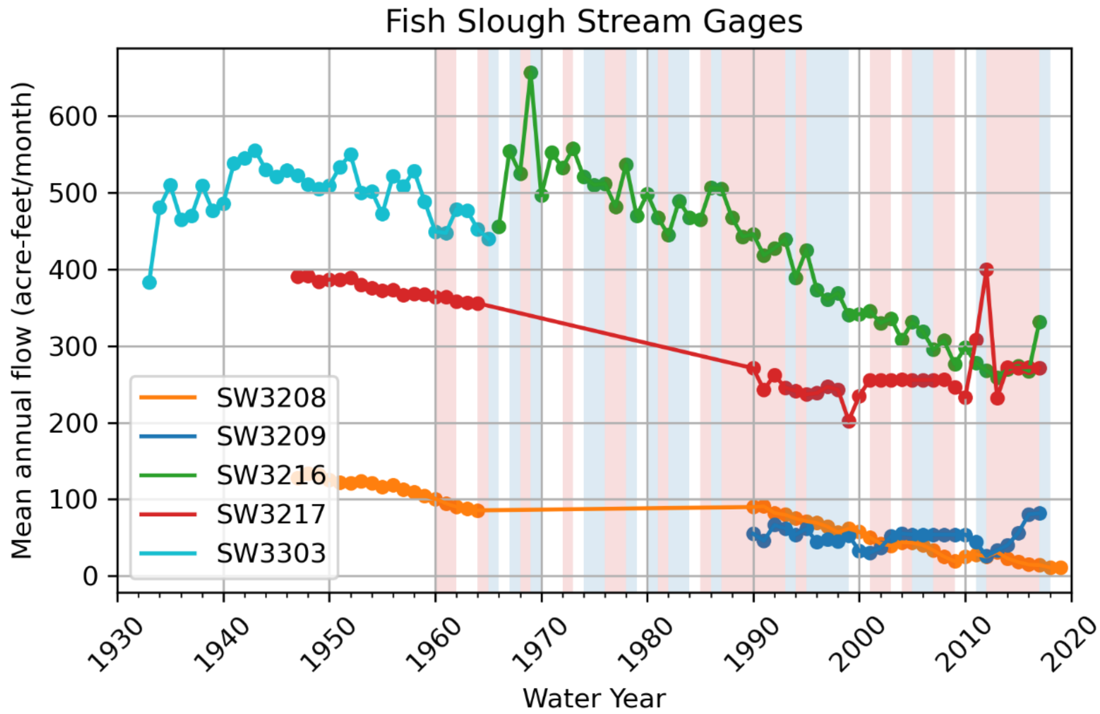

Figure 1.3-3. Mean annual surface water flows (acre-feet per month) for gages in Fish Slough. Red shading indicates dry years and blue indicates wet years.

Groundwater levels in the Fish Slough monitoring wells have also declined (see the Monitoring Plan and Data Gap Analysis Technical Appendix). Well FS2 has steadily declined with time and has dropped about 1 ft from 2000–2017 (with annual variability of 0.5–1 ft).

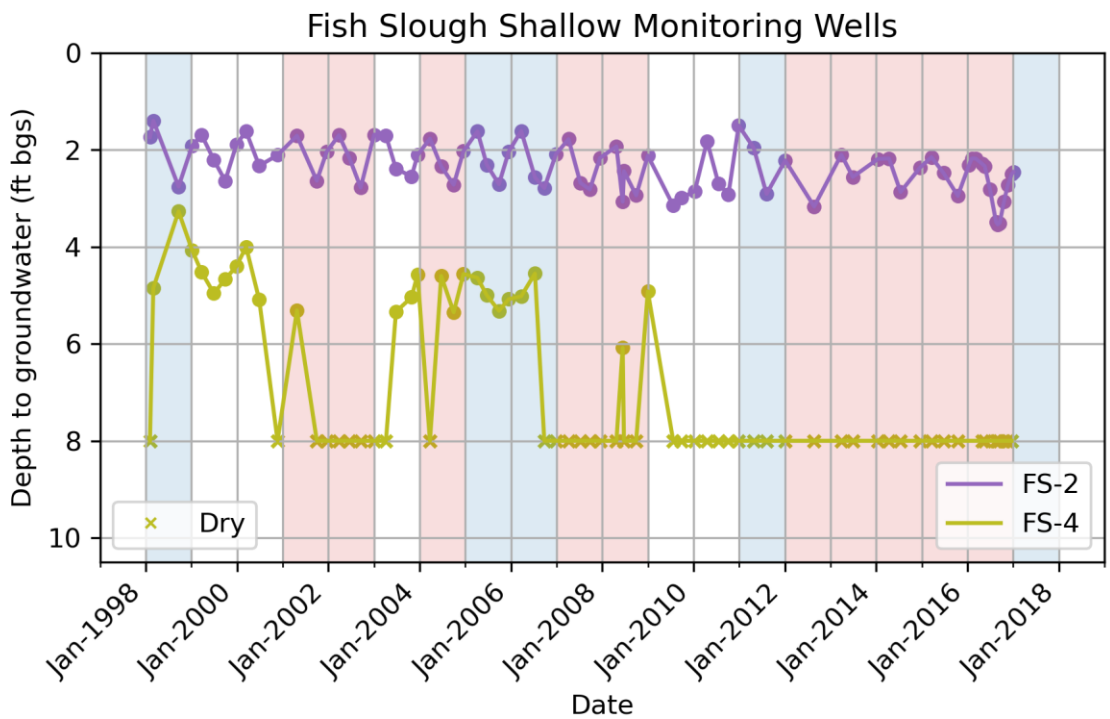

Figure 1.3-4. Changes in depth to groundwater in shallow Fish Slough monitoring wells. Red shading indicates dry years and blue indicates wet years.

1.3.5 Hydrology summary

The OVGA Assessment Area is extensive and shallow wells outside of the Adjudicated Area are uncommon. Nevertheless, we can make some generalizations about groundwater and interconnected surface water. Interconnected surface waters are likely absent in the Owens Valley management area. Groundwater flow models (e.g., Danskin 1998) and limited groundwater data outside the Adjudicated Area suggest that the tributaries are not interconnected with groundwater (except maybe at their extreme downstream ends, suggesting that they are unlikely to be connected upstream where the groundwater is typically deeper. The connection between groundwater and flowing surface water in the Owens Lake management area has not been assessed. Surface water releases to the lake are highly managed, but some groundwater wells suggest the lake, at least, is connected to shallow groundwater. There is no evidence of interconnected surface water in the Tri-Valley management area. Interconnected surface water is present in the Fish Slough management area and surface water flows have been declining for some time.

Groundwater levels in the Owens Valley management area generally rise and fall depending on recharge, with declining groundwater often occurring during droughts and rising groundwater occurring during wetter years. There is no evidence that groundwater is systematically falling, but shallow wells are relatively sparse and further investigation might be warranted if GDE health is declining. Similarly, groundwater levels have been steady in the Owens Lake management area, with short-term changes due to wet and dry years, but no discernable trend in groundwater elevation changes. Groundwater levels have been steadily declining in the Tri-Valley management area. Finally, groundwater elevation has been steadily dropping in the Fish Slough management area. Because surface flow in Fish Slough is almost entirely derived from groundwater, the declining groundwater elevations are linked to the observed decline in surface flows. The trends in interconnected surface water and groundwater in the four management areas are summarized in Table 1.3-1.

Table 1.3-1. Summary of groundwater and interconnected surface water in the OVGA Assessment Area.

Management area	Shallow groundwater change	Interconnected surface water change
Owens Valley	Stable, within baseline range	Not present
Owens Lake	Stable, within baseline range	Managed flows, Lake connects with shallow aquifer
Tri-Valley	Unknown, groundwater declining	No interconnected surface water present
Fish Slough	Declining	Declining

2 GDE IDENTIFICATION

In this section, we detail the information sources used, new information gathered, and methods applied to make determinations and to describe the conditions of GDEs identified in the OVGA Assessment Area. Methods established by Rohde et al. (2018) as well as the text of SGMA itself were used as primary guides.

2.1 Vegetation Communities

Potential GDE units in the Owens groundwater basin were identified using the California Department of Water Resources' (DWR) indicators of groundwater dependent ecosystems (iGDE) database. The database, which is published online and referred to as the Natural Communities Commonly Associated with Groundwater dataset (DWR 2020b), includes vegetation and wetland natural communities. These data were reviewed and augmented with additional vegetation mapping datasets to produce a revised map of GDEs; additional information on vegetation community composition, aerial imagery, depth to groundwater from local wells (where available), plant and species distributions in the area, plant species rooting depths, and local observations from Inyo County Water Department (ICWD 2020) were also reviewed to support this determination.

2.1.1 Data sources

This section includes brief descriptions of the vegetation community data and other information sources used to identify and aggregate potential GDEs into final GDE units.

The iGDE database (DWR 2020b) was reviewed in a geographic information system (GIS) and used to generate a preliminary map to serve as the primary basis for initial identification of potential GDEs. This dataset is a combination of the best available data obtained from publicly available sources and uses the following sources to identify potential GDEs in the Owens groundwater basin:

- Vegetation Classification and Mapping Program (VegCAMP), California Department of Fish and Wildlife

  - Central Mojave Vegetation Database (United States Geologic Survey [USGS] 2002)
  - Fish Slough (California Department of Fish and Wildlife [CDFW] 2014)
  - Manzanar National Historic Site (United States National Park Service 2012)
- Classification and Assessment with Landsat of Visible Ecological Groupings (CalVeg) – United States Department of Agriculture - Forest Service (USDA 2014)
- Fire and Resource Assessment Program (FRAP) – California Department of Forestry and Fire Protection (CalFire 2015)
- National Wetlands Inventory - Version 2.0 (NWI v2.0), U.S. Fish and Wildlife Service (USFWS 2018)
- National Hydrography Dataset (NHD) – Springs and seeps, USGS (USGS 2016)

In addition to the sources identified by the iGDE database listed above, the final GDE map includes vegetation data from the following sources:

- Vegetation Classification and Mapping Program (VegCAMP), California Department of Fish and Wildlife
  - Vegetation Mapping and Classification of the Jawbone Canyon Region and Owens Valley (Menke et al. 2020)
- Delineation of Waters of the United States for the Owens Lake Playa (Jones and Stokes and Great Basin Unified Air Pollution Control District [GBUAPCD] 1996).

The extent of the integrated data sources is shown in Table 2.1-1 and Figure 2.1-1.

Table 2.1-1. Vegetation sources for Owens Valley GDE management areas.

Data source	**Mapped area (acres)**				
	Fish Slough	**Owens Lake**	**Owens Valley**	**Tri-Valley**	**Total**
Vegetation					
CalVeg	446	8,722	109,527	71,637	190,332
FRAP	-	11,446	377		11,822
VegCAMP – Fish Slough	2,497	-	153	177	2,827
VegCAMP – Mojave	-	21,277	1	-	21,279
VegCAMP – Jawbone Canyon Region and Owens Valley	-	128,850	74,113	-	202,963
Wetland					
GBUAPCD – Waters of the U.S.	-	160	1	-	161
NHD	-	3	7	4	14
NWI	-	32	608	20	661
Total[1]	**2,943**	**170,491**	**184,788**	**71,839**	**430,061**

[1] Totals may not appear to sum exactly due to rounding error.

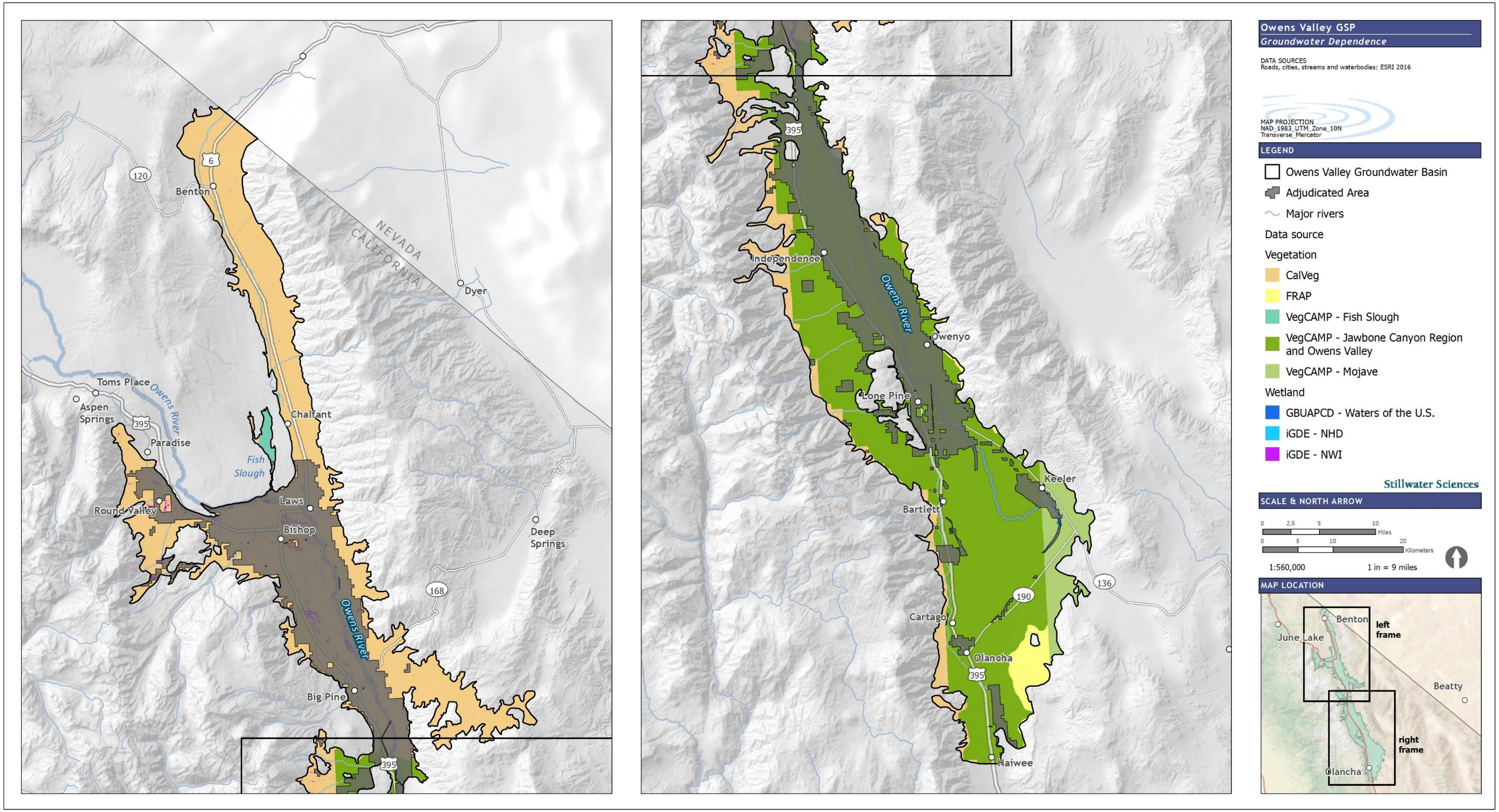

Figure 2.1-1. Wetland and vegetation data sources used for the final GDE map.

2.1.2 Procedure

Rohde et al. (2018) outline steps for defining and mapping GDEs and these were used as a guideline for this process. A decision tree was applied to determine when species or biological communities were considered groundwater dependent based on definitions found in SGMA and Rohde et al. (2018). This decision tree, created to systematically and consistently address the range of conditions encountered, is summarized below, where the term 'unit' refers to an area with consistent vegetation and hydrology:

The unit is a GDE if groundwater is likely:

1. An important hydrologic input to the unit during some time of the year, AND
2. Important to survival and/or natural history of inhabiting species, AND
3. Associated with:
    a. A regional aquifer used as a regionally important source of groundwater OR
    b. A perched/mounded unconfined aquifer.

The unit is not a GDE if its hydrologic regime is primarily controlled by:

1. Surface discharge or drainage from an upslope human-made structure(s), such as irrigation canal, irrigated fields, reservoir, cattle pond, water treatment pond/facility.
2. Precipitation inputs directly to the unit surface. This excludes vernal pools from being GDEs where units are hydrologically supplied by direct precipitation and very local shallow subsurface flows from the immediately surrounding area.

Rohde et al. (2018) recommend that maps of likely GDEs be compared with local groundwater elevations to determine where groundwater is within the rooting depth of potential GDEs. Given uncertainties in extrapolating well measurements to GDEs and differences in surface elevation of wells and GDEs, Rohde et al. (2018) recommend assigning GDE status to vegetation communities within 30 feet of the ground surface, or where interconnected surface waters are observed. This is not possible in the OVGA basin where groundwater data were relatively sparse outside of the adjudicated area. Instead, we follow Rohde et al. (2018) and rely on a combination of local expertise of ICWD and literature on groundwater dependence of plant communities in the Owens Valley as described above. The extensive history of studies of GDEs in the valley to manage LADWP's groundwater pumping had previously established the typical DTW ranges for plant communities that are unavailable elsewhere.

The additional vegetation community mapping data sources identified in Section 2.1.1 were combined in GIS to create a groundwater basin-wide vegetation map. Consistent with Klausmeyer et al. (2018), the most recent and highest resolution mapping was prioritized over earlier and coarser scale datasets. The datasets were prioritized in the following order, with the highest priority data sources listed first: VegCAMP (CDFW 2014, Menke et al. 2020, USGS 2002), CalVeg, Delineation of Waters of the United States for the Owens Lake Playa (Jones and Stokes and GBUAPCD 1996), and FRAP.

Finally, additional wetland mapping was incorporated where vegetation data were coarse and did not accurately capture wetland features. These additional wetland data sources were incorporated unilaterally across the selected vegetation data source and were chosen to represent the best available data for the extent of each vegetation data source. CalVeg and FRAP were supplemented with the iGDE wetland mapping (DWR 2020b) which is derived from the National Wetlands Inventory (USFWS 2018) and National Hydrography Dataset (USGS 2016). The

VegCAMP Mojave dataset was supplemented using the Delineation of Waters of the United States for the Owens Lake Playa. The Jawbone Canyon Region and Owens Valley and Fish Slough VegCAMP datasets were mapped to a scale that did not require supplemental wetland data.

2.1.3 Refine potential GDE map

To inform the assessment of GDE condition and potential effects (Sections 3 and 4), the basin-wide vegetation and wetland map was reviewed and each community was assigned a groundwater dependence category (i.e., unlikely, likely, certain). This determination was based on species composition and the groundwater dependency of dominant species, whether they were considered groundwater dependent either by the iGDE database (DWR 2020b) or by Mathie et al. in their review of phreatophytic vegetation in the Great Basin Ecoregion (Mathie et al. 2011), and wetland indicator status (Lichvar et al. 2016). Although Klausmeyer et al. (2018) includes species with upland facultative wetland indicator status (Lichvar et al. 2016) in their list of groundwater dependent mapping units, based on feedback from ICWD and the position of these upland facultative species on the landscape (i.e., at the top of alluvial fans on the fringe of the basin), these vegetation types were classified as unlikely to be groundwater dependent. Plant communities classified as certain GDEs would generally be expected to have greater water requirements than communities classified as likely GDEs. Section 3.1 discusses the vegetation communities that were identified as certain or likely to depend on groundwater.

In addition to the species-based groundwater dependency determination discussed above, a preliminary map with these determinations was reviewed by ICWD to help determine which vegetation communities included by the iGDE database (DWR 2020b) are likely to be GDEs in the Owens Valley based on the type of vegetation. ICWD has been assessing the groundwater dependence of plant species, primarily those found within the adjudicated area of the Owens Valley, since the 1980s (Inyo County/City of Los Angeles Technical Group 1990). The ICWD analysis focused on species composition (e.g., whether units contained phreatophytes) rather than the likelihood of groundwater connection. ICWD has extensive data linking groundwater depth and species occurrence (e.g., Manning 1997) as well as measurements of evapotranspiration (ET) using measurements of stomatal conductance (Steinwand et al. 2001) and eddy covariance (Steinwand et al. 2006). These ET measurements can be compared with measurements of local rainfall to determine the portion of the plants water needs are supplied by groundwater (Steinwand et al. 2006). As a result, ICWD has a strong local understanding of what plant species and vegetation communities are likely to be GDEs and those that are likely not connected to groundwater. ICWD's assessment and revisions were completed using the iGDE database, which identifies possible groundwater dependence areas based on Calveg, FRAP, and the Mojave and Fish Slough VegCAMP vegetation map sources. The Jawbone Canyon Region and Owens Valley map (Menke et al. 2020) was obtained after the ICWD review and predominantly replaced FRAP. ICWD's review of the FRAP data was used to inform the GDE determination of the Jawbone Canyon and Owens Valley map based on species composition and landscape position, but the size and location of the mapped polygons differed between the two map sources. Although models suggest that tributaries to the Owens Valley are disconnected from groundwater, potential GDEs along the tributaries were not removed due to uncertainty about their groundwater connection at their downstream ends and sparse groundwater data upstream.

Figure 2.1-2 shows the iGDEs database and the assessment by ICWD. ICWD removed 63.9% of the vegetation iGDEs originally identified by DWR (2020) (Table 2.1-2); ICWD's analysis did not address wetland data from the iGDE database. In the northern half of the OVGA Assessment Area, approximately 89% of the iGDEs identified using CalVeg as a map source were removed by ICWD. Nearly all (96% [~31,000 acres]) of the CalVeg iGDEs removed were Alkaline Mixed Scrub (Figure 2.1-2) which are primarily located on alluvial fans bordering the White/Inyo mountains (Figure 2.1-1). ICWD removed 30% of iGDEs mapped using FRAP as a data source; these were predominantly Alkali Desert Scrub (4,800 acres), which has a similar composition to the CalVeg Alkaline Mixed Scrub type. Together, these two iGDEs represent 90% of the vegetation removed by ICWD. The remaining vegetation removed from the GDE map were approximately 34% of the Iodine Bush-Bush Seepweed map units, 100% of the Alluvial Fan Scrub, and 100% of the Mid-Elevation Wash System vegetation unit (Figure 2.1-3). The ICWD analysis was used wherever the final assessment was based on CalVeg, FRAP, or VegCAMP (Mojave VegCAMP or Fish Slough).

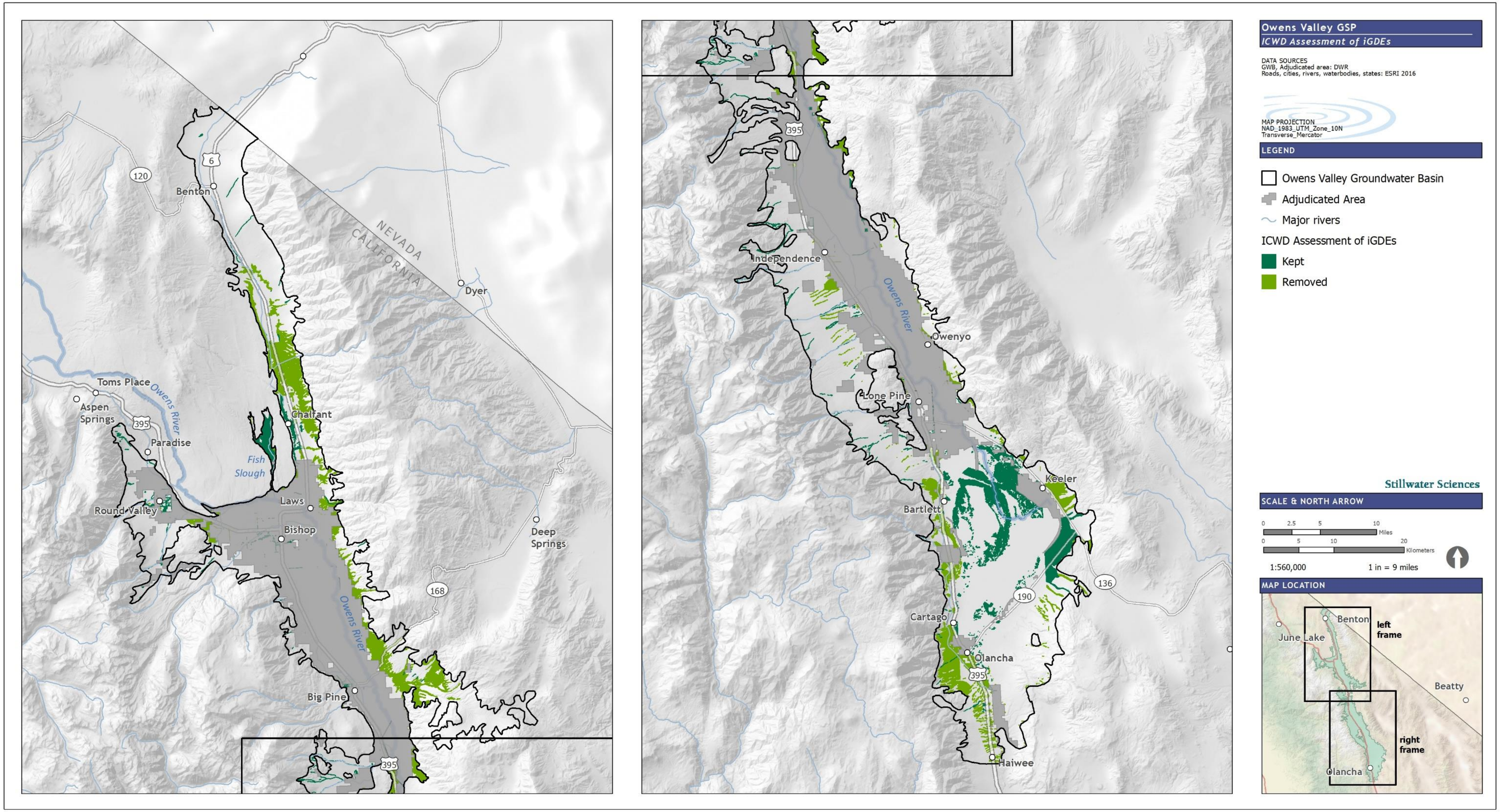

Figure 2.1-2. Revised iGDE map including vegetation polygons kept and removed by ICWD.

Table 2.1-2. Changes to the iGDE map based on ICWD recommendations.

Source	Initial area (acres)	After ICWD (acres)	Area removed (acres)	% removed
VegCamp (Fish Slough and Mojave)	9,917	6,959	2,958	29.8
CalVeg	35,718	4,033	31,685	88.7
FRAP	16,165	11,317	4,848	30.0
Total	**61,800**	**22,308**	**39,491**	**63.9**

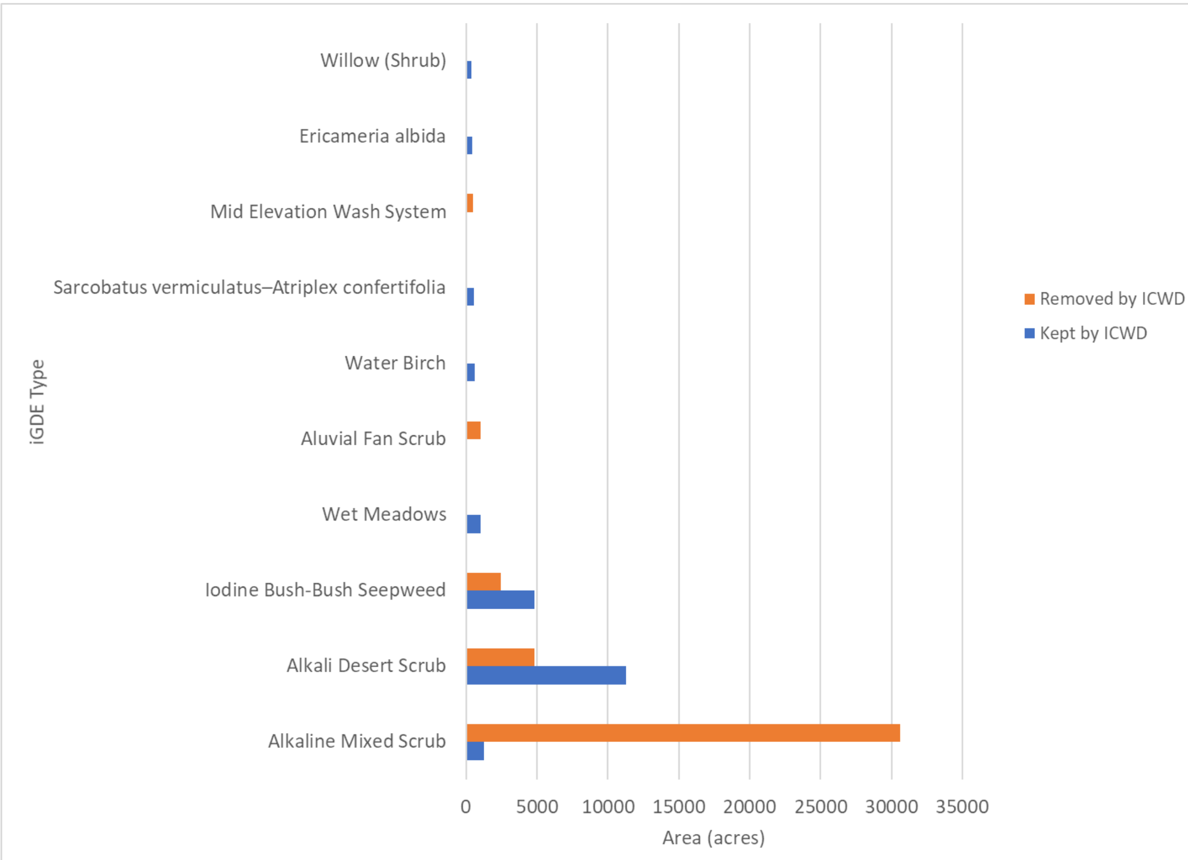

Figure 2.1-3. ICWD changes by vegetation type for the ten most extensive vegetation types in the iGDE database (DWR 2020). This database does not include Great Basin Wetlands mapping or the Jawbone Canyon Region and Owens Valley vegetation maps, which were obtained after ICWD's assessment.

2.2 Special-status Species

As part of the ecological inventory, special-status species, sensitive species, and ecological community types that are potentially associated with GDEs in the OVGA Assessment Area were identified. For the purposes of this memorandum, special-status species are defined as those:

- listed, proposed, or under review as endangered or threatened under the federal Endangered Species Act (ESA) or the California Endangered Species Act (CESA);

- designated by CDFW as a Species of Special Concern;
- designated by CDFW as Fully Protected under the California Fish and Game Code (Sections 3511, 4700, 5050, and 5515);
- designated as Forest Service Sensitive according to the Regional Forester's Sensitive Species Management Guidelines listed per USFS Memorandum 2670 (USFS 2011);
- designated as Bureau of Land Management (BLM) sensitive;
- designated as rare under the California Native Plant Protection Act (CNPPA); and/or
- included on CDFW's most recent Special Vascular Plants, Bryophytes, and Lichens List (CDFW 2020a) with a California Rare Plant Rank (CRPR) of 1, 2, 3, or 4.

In addition, sensitive natural communities are defined as vegetation communities identified as critically imperiled (S1), imperiled (S2), or vulnerable (S3) on the most recent California Sensitive Natural Communities List (CDFW 2020b).

2.2.1 Data Sources

Stillwater ecologists queried existing databases on regional and local occurrences and spatial distributions of special-status species within the OVGA Assessment Area. Spatial database queries included potential GDEs plus a 0.5-mile buffer. Databases accessed include:

- California Natural Diversity Database (CNDDB) (CDFW 2019),
- California Native Plant Society (CNPS) Manual of California Vegetation (2019),
- eBird (2020), and
- the Nature Conservancy (TNC) freshwater species lists that were generated from the California Freshwater Species Database (CAFSD) (TNC 2019a).

2.2.2 Procedure

Stillwater reviewed the database query results and identified species and community types with the potential to occur within or be associated with the vegetation and aquatic communities in or immediately adjacent to the potential GDEs. Stillwater ecologists then consolidated a list of these special-status species and sensitive community types, along with summaries of habitat preferences, potential groundwater dependence, and reports of any known occurrences. Wildlife species were evaluated for potential groundwater dependence using determinations from the Critical Species Lookbook (Rohde et al. 2019) or by evaluating known habitat preferences, life histories, and diets. Species GDE associations were assigned one of three categories:

- Direct—species directly dependent on groundwater for some or all water needs (e.g., cottonwood with roots in groundwater, Owens pupfish in a spring-fed pool).
- Indirect—species dependent upon other species that rely on groundwater for some or all water needs (e.g., riparian birds).
- No known reliance on groundwater.

2.2.3 Refine potential use of GDE habitat

Database query results for local and regional occurrences were combined with known habitat requirements of identified special-status species to develop a list of groundwater dependent special-status species that satisfy the following criteria: (1) documented occurrence within the management area, or (2) known to occur in the region and suitable habitat is present in the GDE unit.

The special-status species evaluation for the OVGA Assessment Area included a large spatial area with diverse habitat types and numerous species. Data limitations during the scoping effort included: spatial data that were old or included non-specific locations for species sightings, limited information on habitat quality in the mapped GDEs, and lack of data on the species reliance of groundwater solely within the mapped GDE units or other waterbodies included in the adjacent adjudicated areas. To address these data limitations, special-status species monitoring is recommended, described in Section 6 GDE Monitoring.

3 GDE CONDITION

This section characterizes the Owens Lake, Owens Valley, Tri-Valley, and Fish Slough management areas based on its hydrologic and ecological conditions and assign a relative ecological value to the unit by evaluating its ecological assets and their vulnerability to changes in groundwater (Rohde et al. 2018).

3.1 Ecological Conditions

GDEs included terrestrial and aquatic habitat and other open water aquatic habitats (Table 3.1-1). The linkage between groundwater and surface water is not known for much of the OVGA Assessment Area (e.g., for many of the tributaries flowing over alluvial fans into the Owens Valley). We concentrated our interconnected surface water investigation on Fish Slough and parts of Owens Lake. Other tributaries were not included due to their position on the landscape and the depth of groundwater wells where the tributaries enter the Adjudicated Area. It is possible that interconnected surface waters may occur in the Tri-Valley area and the fringes of Adjudicated Area, but data to support this analysis was not available and it should be investigated during the 5-year update. Waterbodies like springs and sloughs that are directly fed by groundwater are considered a component of GDEs that are defined more broadly by vegetation community classification.

Table 3.1-1. Extent of GDEs by management area.

Management area	Owens Valley	Owens Lake	Tri-Valley	Fish Slough	Total
Total Area (acres)	184,788	170,491	71,839	2,943	**430,061**
GDE extent (acres)	6,115	46,129	1,033	2,191	**55,468**
Percent of area composed of GDEs (%)	3.3	27.1	1.4	74.4	**12.9**

The GDE determination (certain, likely, unlikely) is shown in Figure 3.1-1 and the final GDE map by management area is shown in Figure 3.1-2.

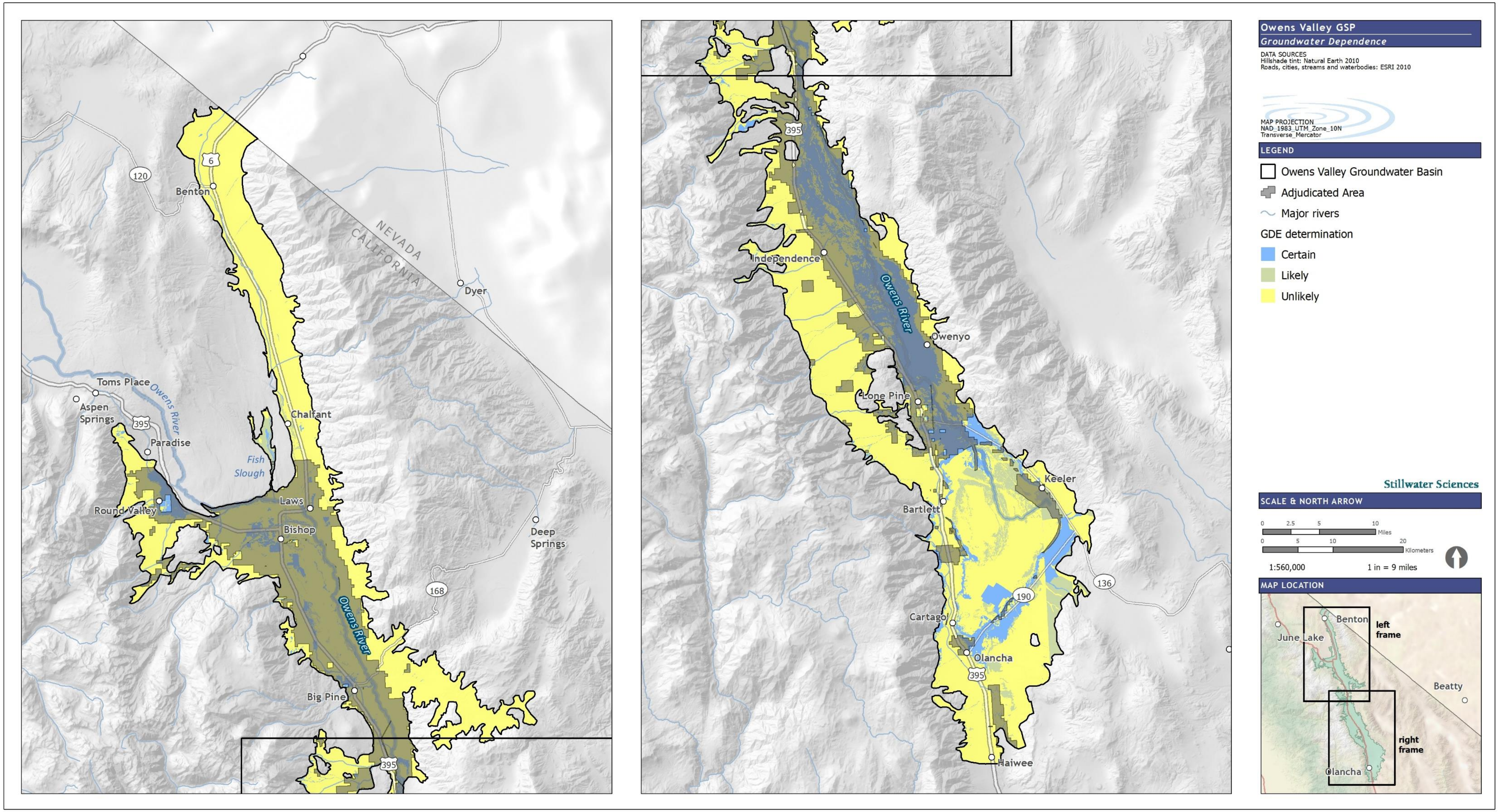

Figure 3.1-1. Final GDE determination based on the methods outlined in Section 2.2.

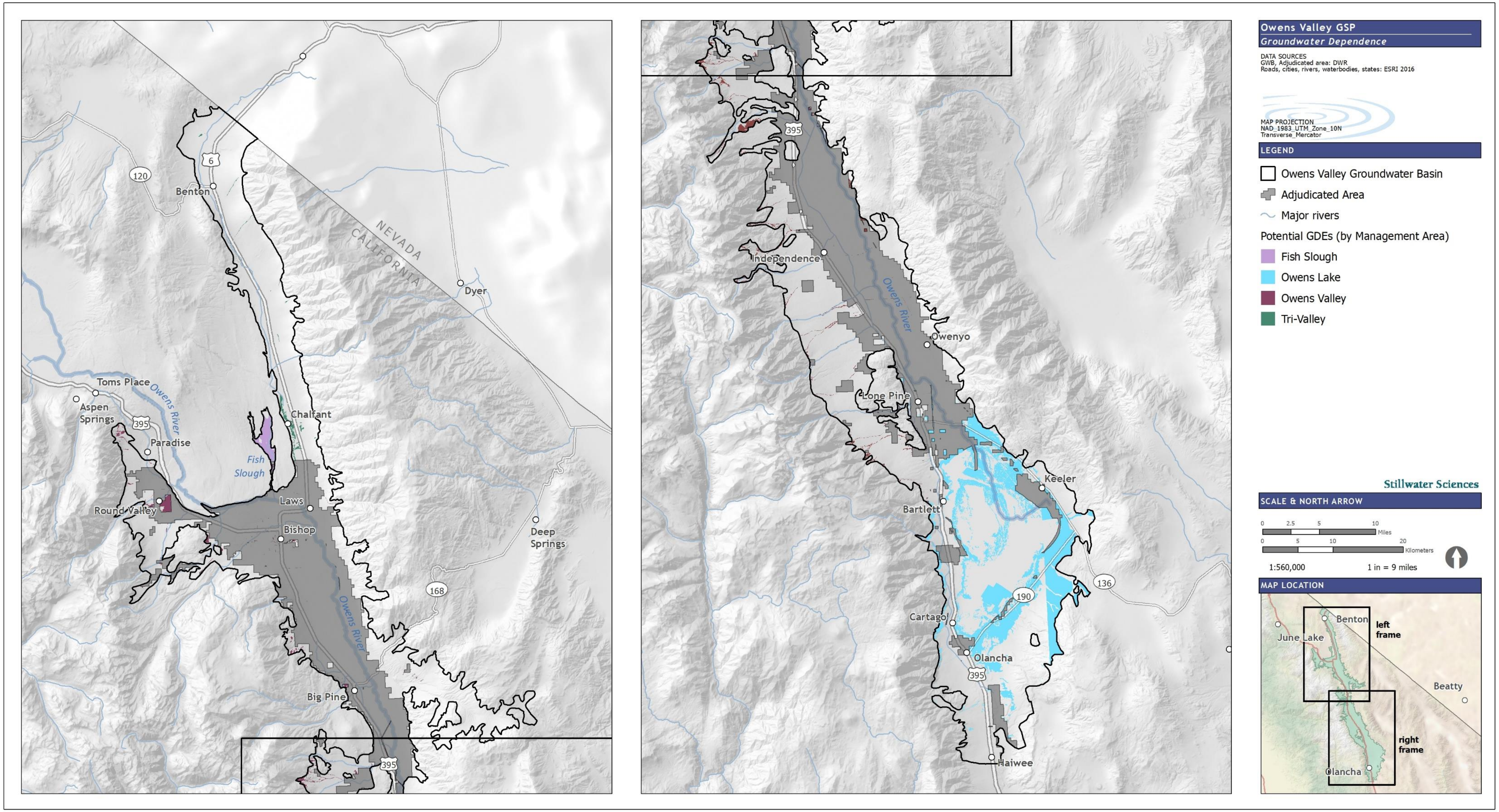

Figure 3.1-2. Potential GDEs identified by management area.

3.1.1 Vegetation communities and GDE habitats

3.1.1.2 Owens Valley

The Owens Valley management area covers 43% of the OVGA Assessment Area and has 11% of the total GDE acreage across the entire area. It contains 6,115 acres of mapped GDEs which compose 3.3% of the total area of the unit. The most prevalent vegetation community is the shrub willow alliance which makes up 18.8% of all mapped GDEs in the unit; other dominant communities include wet meadow, willow, riparian mixed hardwood, Freemont cottonwood, and water birch alliances (Figure 3.1-3). These dominant vegetation communities are associated with riparian zones along perennial drainages located predominantly on the west side of Owens Valley draining the eastern slopes of the Sierra Nevada. Based on the data available, it is not clear if vegetation along tributaries to the Owens River (e.g., much of the water birch alliance and Fremont cottonwood alliance) are connected to groundwater, and this connection should be explored during the 5-year update.

Aquatic habitat within the Owens Valley management area mapped GDEs includes: seasonally flooded wetlands (307 acres), wet meadows (1,083 acres), riverine (73.2 acres), tule-cattail dominated waterbodies (17.6 acres), and seeps and springs (7.2 acres) (USDA 2008, 2009, 2014; USGS 2016; USFWS 2018) (Appendix A). These waterbodies include riparian habitat (e.g., cottonwood, willow, and alders) (Appendix A). Terrestrial habitat within the mapped GDEs include: sparsely vegetated playa (11 acres), alkaline mixed scrub (131 acres), irrigated pastures (27.6 acres), and grassland (12 acres) (USDA 2008,2009, 2014; Menke et al. 2020) (Appendix A).

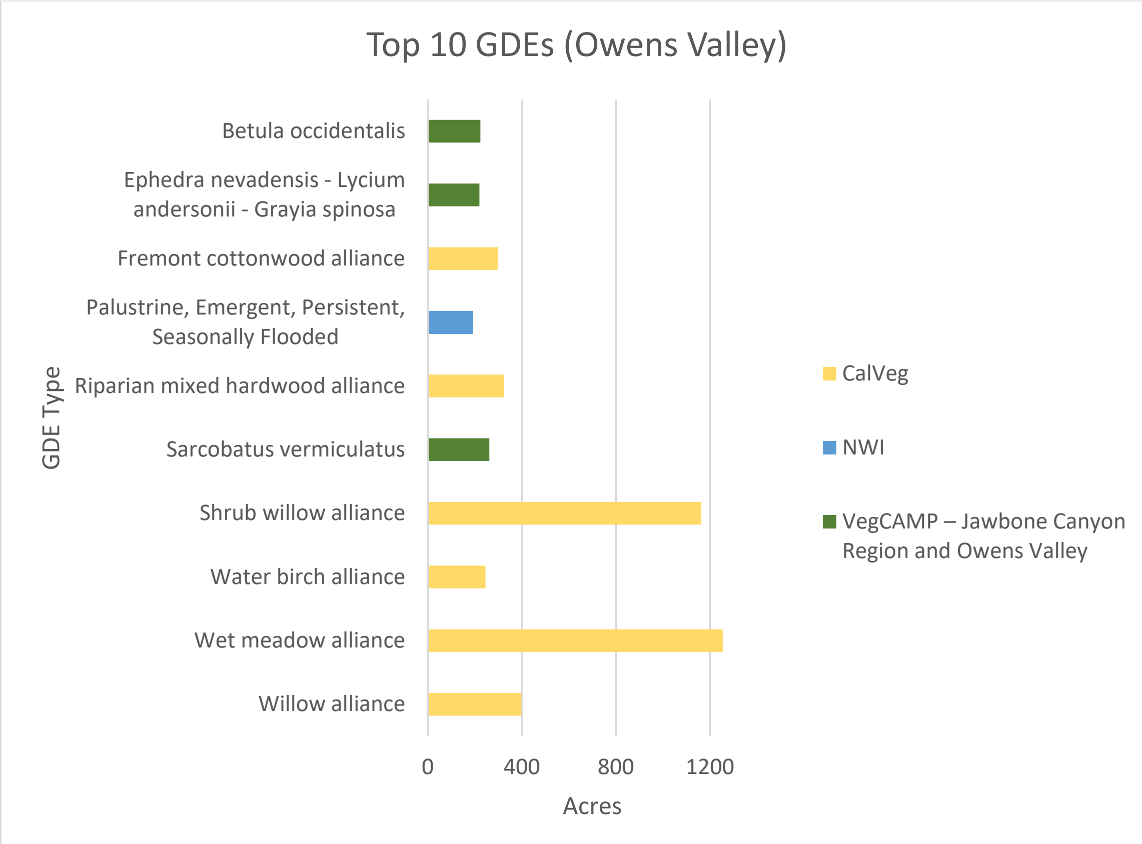

Figure 3.1-3. Ten most common GDEs within the Owens Valley Management area, by source.

3.1.1.3 Owens Lake

The Owens Lake management area covers 40% of the OVGA Assessment Area and has 83% of the total GDE acreage across the entire area. It contains 46,129 acres of mapped GDEs which compose 27.1% of the total area of the unit (Table 3.1-3). The most prevalent vegetation community is *Sarcobatus vermiculatus* (black greasewood) which makes up 22.9% of all mapped GDEs in the unit; other dominant communities include sparsely vegetated playa (ephemeral annuals), *Distichlis spicata* (salt grass), and iodine bush-bush seepweed (Figure 3.1-4). These dominant vegetation communities are tolerant of the alkaline conditions and predominantly occur in the sediments deposited by Owens Lake and surrounding areas.

Historically Owens Lake was a 70,400-acre saline lake until water exports dried up the main body of the lake by 1926 (Orme and Orme 2008). The bed of Owens Lake remains predominantly dry and the wetted area has been reduced to 75% of its historic area (LADWP 2010). Aquatic habitats within the Owens Lake management area are created by groundwater discharge onto the lakebed, surface water flows across the lakebed, and the implementation of water-based dust control measures (LADWP 2010). Aquatic habitat within the Owens Lake management area includes water impoundments (166 acres), wetlands (158 acres), tule-cattail dominated waterbodies (235 acres), wet meadow (13.6 acres), riverine (8 acres), springs and seeps (2.5 acres), and canals (0.1 acre) (USGS 2016; USDA 2008, 2009, 2014; Jones and Stokes and GBUAPCD 1996; USGS 2016; USFWS 2018) (Appendix A). Riparian habitat includes cottonwoods, willows, and emergent plants (Appendix A). Salinity in aquatic habitats range from freshwater to hypersaline.

Terrestrial habitat within the mapped GDEs includes sparsely vegetated playa (5,479 acres), alkaline mixed scrub (783 acres), montane riparian (18.7 acres), and grassland (22.2 acres) (USDA 2008, 2009, 2014; CalFire 2015; Menke et. Al. 2020) (Appendix A).

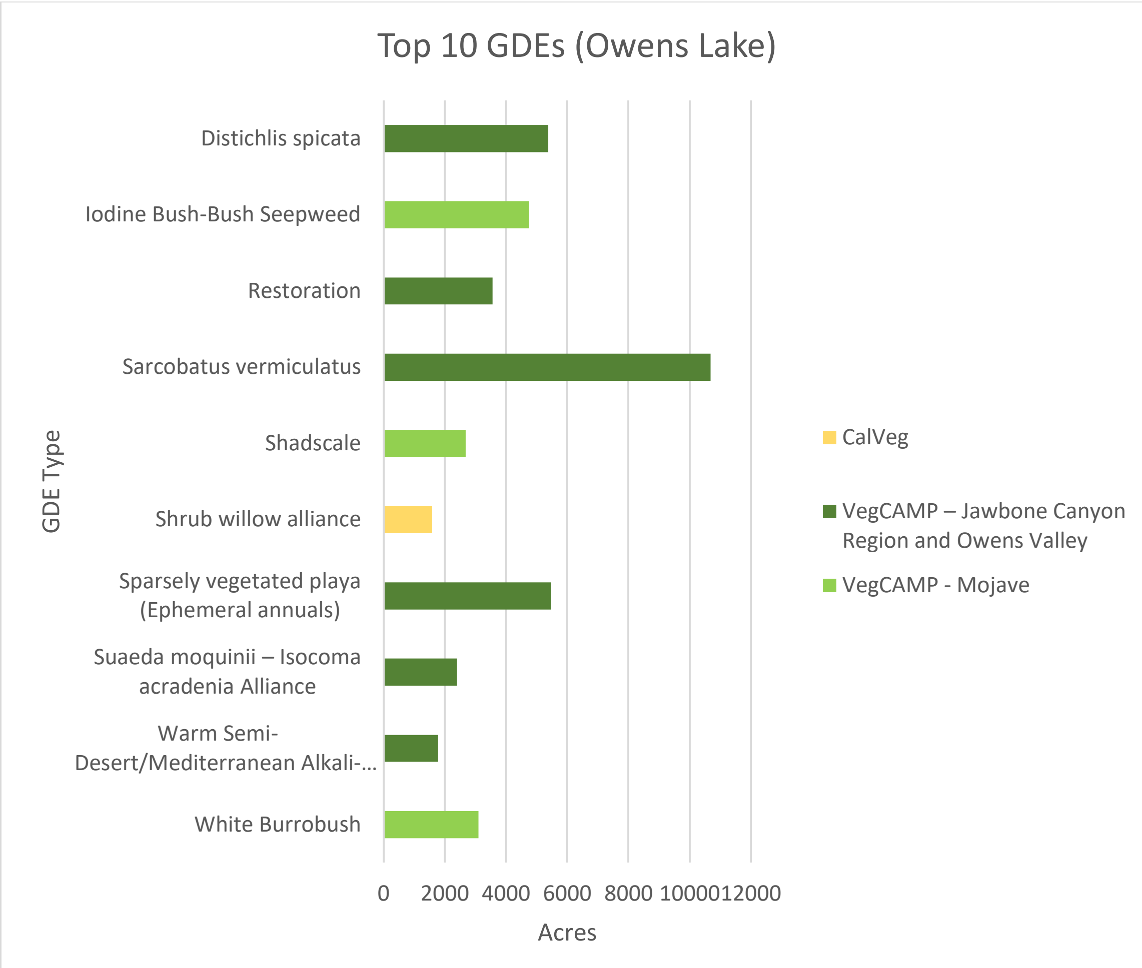

Figure 3.1-4. Ten most common GDEs within the Owens Lake management area, by source.

3.1.1.4 Tri-Valley

The Tri-Valley management area covers 17% of the OVGA Assessment Area and has 2% of the total GDE acreage across the entire area. It contains 1,033 acres of likely GDEs, which cover 1.4% of the Tri Valley Area. These GDEs include alkaline mixed scrub alliance which makes up 75.8% of all mapped GDEs in the unit (Figure 3.1-5) and occur at the alluvial fan front located along tributaries to the valleys and shrub willow alliance along tributaries to the valley and wet meadows along the distal edge of fans.

Tri-Valley management area contains the smallest acreage of aquatic habitat within OVGA Assessment. Groundwater dependent aquatic habitats within mapped GDEs include the following: wet meadow (113 acre), seep or springs (4.1 acres), riverine (1.4 acres), and seasonally flooded wetlands (14.2 acres) (USGS 2016, USFWS 2018) (Appendix A). Riparian habitat includes willows and cottonwoods. Terrestrial habitat within the mapped GDEs include: alkaline mixed scrub (783 acres) (USDA 2008, 20092014) (Appendix A).

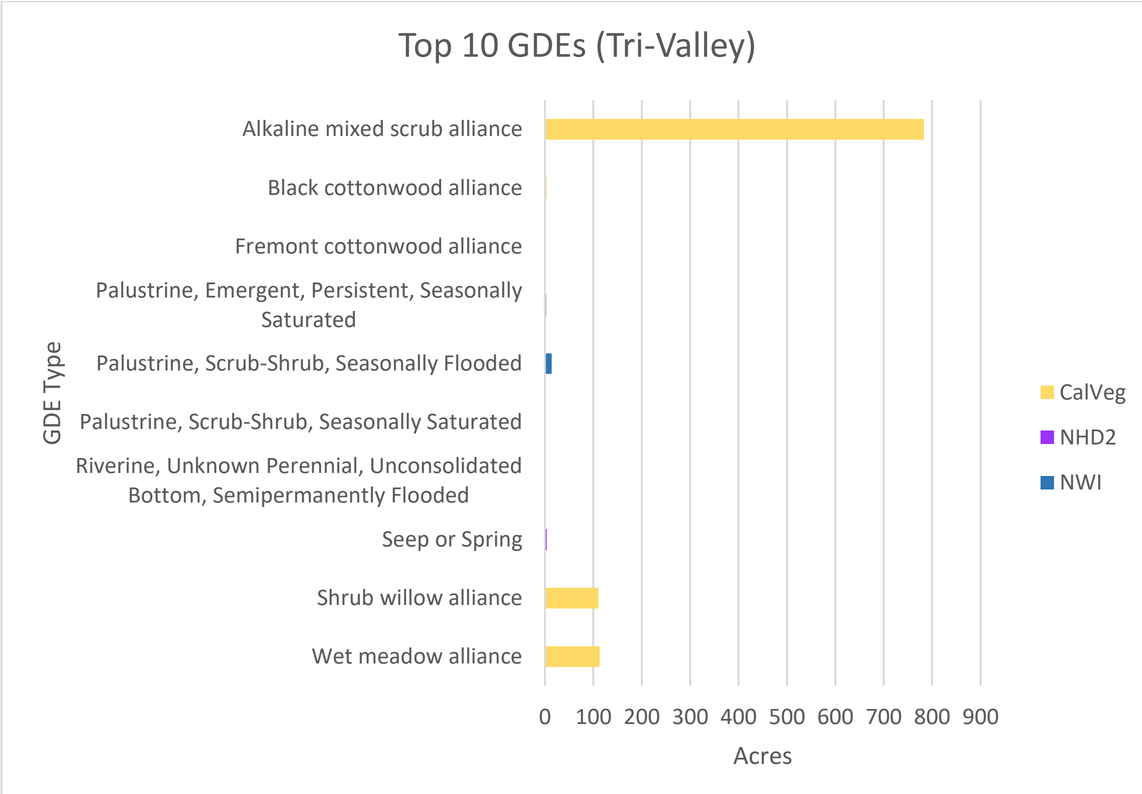

Figure 3.1-5. Ten most common GDEs within the Tri-Valley management area, by source.

3.1.1.5 Fish Slough

The Fish Slough management area covers 1% of the OVGA Assessment Area and has 4% of the total GDE acreage across the entire area. It contains 2,191 acres of mapped GDEs which compose 74.4% of the total area of the unit. Fish Slough is a spring-fed wetland complex and as such much of the vegetation present is groundwater dependent. The most prevalent vegetation communities are alkaline mixed scrub and greasewood which each make up 26.2% of all mapped GDEs in the unit; other dominant communities included alkaline mixed grasses and forbs, tule-cattail, alkaline mixed scrub and rabbitbrush (Figure 3.1-6). Many of the dominant vegetation communities are tolerant of the alkaline conditions present.

Fish Slough is a spring-complex with interconnected surface water that is primarily sourced from groundwater, either directly through spring discharge or the shallow water table. Aquatic habitats within the Fish Slough management area mapped GDEs include open-water channel habitat (9.6 acres) and tule-cattail dominated waterbodies (276 acres) (CDFW 2014) (Appendix A). Riparian habitat includes willows and cottonwood (Appendix A). Terrestrial habitats within the mapped GDEs include alkaline mixed scrub (574 acres) and alkaline mixed grasses and forbs (CDFW 2014) (Appendix A).

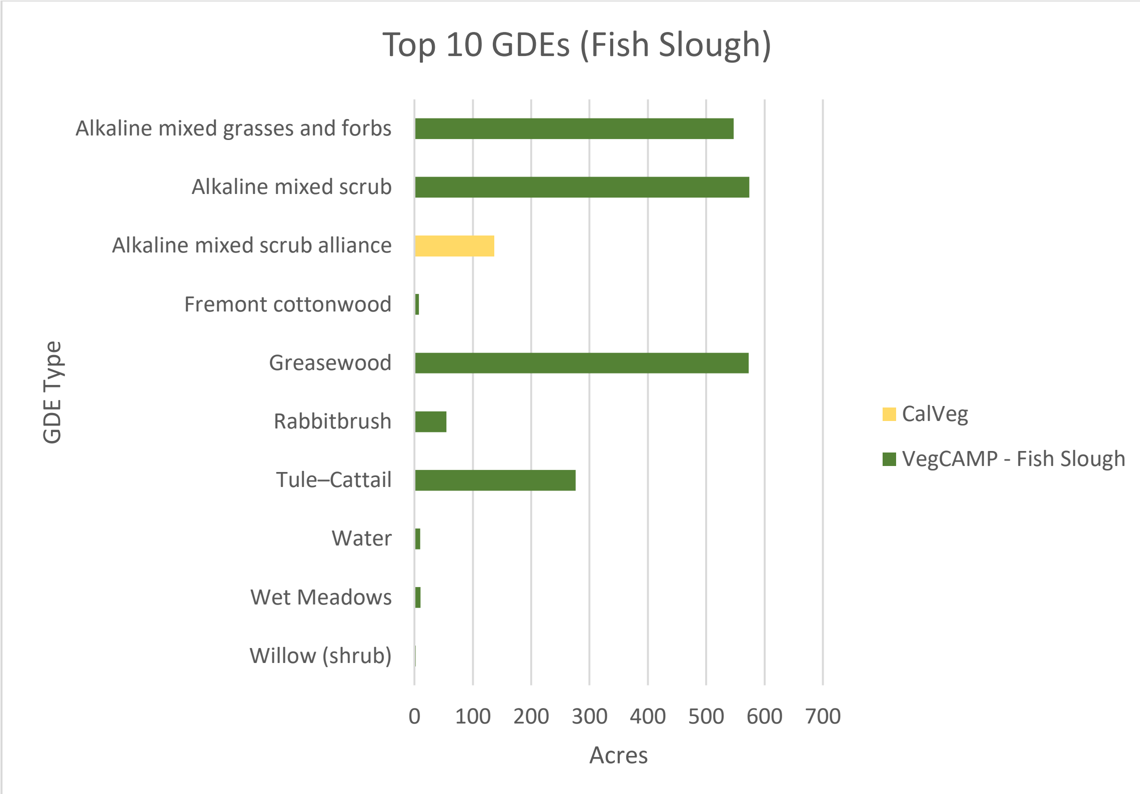

Figure 3.1-6. Ten most common GDEs within the Fish Slough management area, by source.

3.1.2 Beneficial uses

The Water Quality Control Plan (Basin Plan) for the Lahontan Region (Lahontan RWQCB 2016) identifies the surface waters in the management areas as having a variety of beneficial uses pertaining to fish, wildlife, and GDEs. Most of these beneficial uses apply to aquatic features that are fed by groundwater such as Fish Slough and Owens Lake. The beneficial uses for aquatic features in the Owens Hydrologic Unit vary and include:

- Freshwater replenishment (FRSH);
- Warm freshwater habitat (WARM);
- Cold freshwater habitat (COLD);
- Wildlife habitat (WILD);
- Preservation of biological habitats of special significance (BIOL);
- Support of habitat for rare, threatened, or endangered species (RARE);
- Aquatic organism migration habitat (MIGR); and
- Aquatic spawning habitat (SPWN).

Beneficial uses include those that directly benefit groundwater conditions (e.g., groundwater recharge [GWR]) and those supported directly by groundwater via interconnected surface waters (e.g., freshwater replenishment [FRSH]; support of rare, threatened, or endangered species [RARE]).

3.1.3 Special-status species

The Owens Valley Basin is ecologically diverse and includes numerous species that are groundwater dependent. Within the four management areas, 36 special-status terrestrial and aquatic wildlife species were identified as indirectly or directly groundwater dependent (Table 3.1-2). Species endemic to Owens Valley that are likely to be found within one or more of the management areas include: Owens pupfish (*Cyprinodon radiosus*), Owens tui chub (*Siphateles bicolor snyderi*), Owens speckled dace (*Rhinichthys osculus ssp*), Owens Valley vole (*Microtus californicus vallicola*), and Owens Valley springsnail (*Pyrgulopsis owensensis*). Appendix B provides additional information on special-status terrestrial and aquatic animal species that may occur in the OVGA Assessment Area, including regulatory status, habitat associations, and likelihood to occur in management areas. In addition, 25 special-status plant species were documented within the Owens Valley Basin, 18 of which are identified as certain or likely to be dependent on groundwater. Table 3.1-3 lists the special-status plant species and natural communities with known occurrence in GDEs.

Owens Valley, Owens Lake, and Fish Slough management areas overlap with USFWS-designated critical habitat for four federally listed species: Fish Slough milk-vetch (*Astragalus lentiginosus* var. *piscinensis*), Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*), Sierra Nevada yellow-legged frog (*Rana sierrae*), and yellow-billed cuckoo (*Coccyzus americanus occidentalis*) (USFWS 2005, USFWS 2008, USFWS 2016, USFWS 2020). The acreage of critical habitat for each species within the Owens Valley, Owens Lake, Tri-Valley, and Fish Slough management areas are summarized in **Error! Reference source not found.**.1-4 and shown in Figure 3.1-7. The Sierra Nevada bighorn sheep critical habitat occurs along the western margin of the OVGA basin. The Sierra Nevada yellow-legged frog critical habitat occurs in the fringe of the basin along Independence Creek are primarily located on the fringe of the OVGA area.

Habitat management and special-status species recovery plans have been implemented in the Owens Valley Basin and include protections for special-status species and associated habitats. These plans include *Owens Basin Wetland and Aquatic Species Recovery Plan Inyo and Mono Counties, California* (USFWS 1998), *Owens Lake Habitat Management Plan* (LADWP 2010), *Owens Valley Land Management Plan* (LADWP and Ecosystem Sciences 2010), and the *LADWP Habitat Conservation Plan* (LADWP 2015).

Table 3.1-2. Dependence on groundwater for special-status terrestrial and aquatic animal species documented to occur in the management areas.

Common name (*Scientific name*)	Documented to occur and dependence on groundwater in each management area			
	Owens Valley	**Owens Lake**	**Tri-Valley**	**Fish Slough**
Mammals				
Long-legged myotis (*Myotis Volans)*	I	I		
Mohave ground squirrel (*Xerospermophilus mohavensis)*		I		
Owens Valley vole (*Microtus californicus vallicola)*	I	I	I	I
Sierra Nevada bighorn sheep (*Ovis canadensis sierrae)*	I, CH	I, CH		
Sierra Nevada red fox (*Vulpes vulpes necátor)*	I			
Spotted bat (*Euderma maculatum)*	I	I		
Townsend's big-eared bat (*Corynorhinus townsendii)*	I	I		I
Western small-footed myotis (*Myotis ciliolabrum)*	I			
Yuma myotis (*Myotis yumanensis)*		I		
Birds				
American white Pelican (*Pelecanus erythrorhynchos)*	I	I		I
Bald eagle **(***Haliaeetus leucocephalus)*	I	I	I	
Bank swallow (*Riparia riparia)*	I	I	I	I
Black tern (*Chlidonias niger)*	I	I		I
Least bittern (*Ixobrychus exilis)*	I	I		
Long-eared owl (*Asio otus)*	I	I	I	I
Lucy's warbler (*Oreothlypis luciae)*	I	I		I
Northern harrier (*Circus hudsonius)*	I	I	I	I
Redhead (*Aythya americana)*	I	I		I
Southwestern willow flycatcher (*Empidonax traillii extimus)*	I			I
Summer tanager (*Piranga rubra)*	I	I		
Swainson's hawk (*Buteo swainsoni)*	I	I	I	I
Western snowy plover (*Charadrius alexandrinus nivosus)*	I	I		
Western yellow-billed cuckoo (*Coccyzus americanus occidentalis)*	I, CH			
Yellow-breasted chat (*Icteria virens)*	I	I		I
Yellow-headed blackbird (*Xanthocephalus xanthocephalus)*	I	I		I
Reptiles				
Desert tortoise (*Gopherus agassizii)*	I	I		
Panamint alligator lizard (*Elgaria panamintina)*	I			I
Amphibians				
Inyo Mountains slender salamander (*Batrachoseps campi)*	D	D		
Sierra Nevada yellow-legged frog (*Rana sierrae)*	D, CH			
Fish				
Owens pupfish (*Cyprinodon radiosus)*		D		D
Owens tui chub (*Siphateles bicolor snyderi*)		D		
Owens speckled dace (*Rhinichthys osculus ssp.)*				D
Mollusks				
California floater (*Anodonta californiensis)*	D			
Owens Valley springsnail (*Pyrgulopsis owensensis)*	D		D	D
Wong's springsnail (*Pyrgulopsis wongi)*	D	D	D	D
Insects				
San Emigdio blue butterfly (*Plebulina emigdionis)*		I		

See Appendix B, Table B-1 for additional details included federal/state status, query sources, habitat, and references.
D=**Direct**: Species directly dependent on groundwater for some or all water needs
I=**Indirect:** Species dependent upon other species that rely on groundwater for some or water needs
CH=USFWS-designated critical habitat occurs in management area

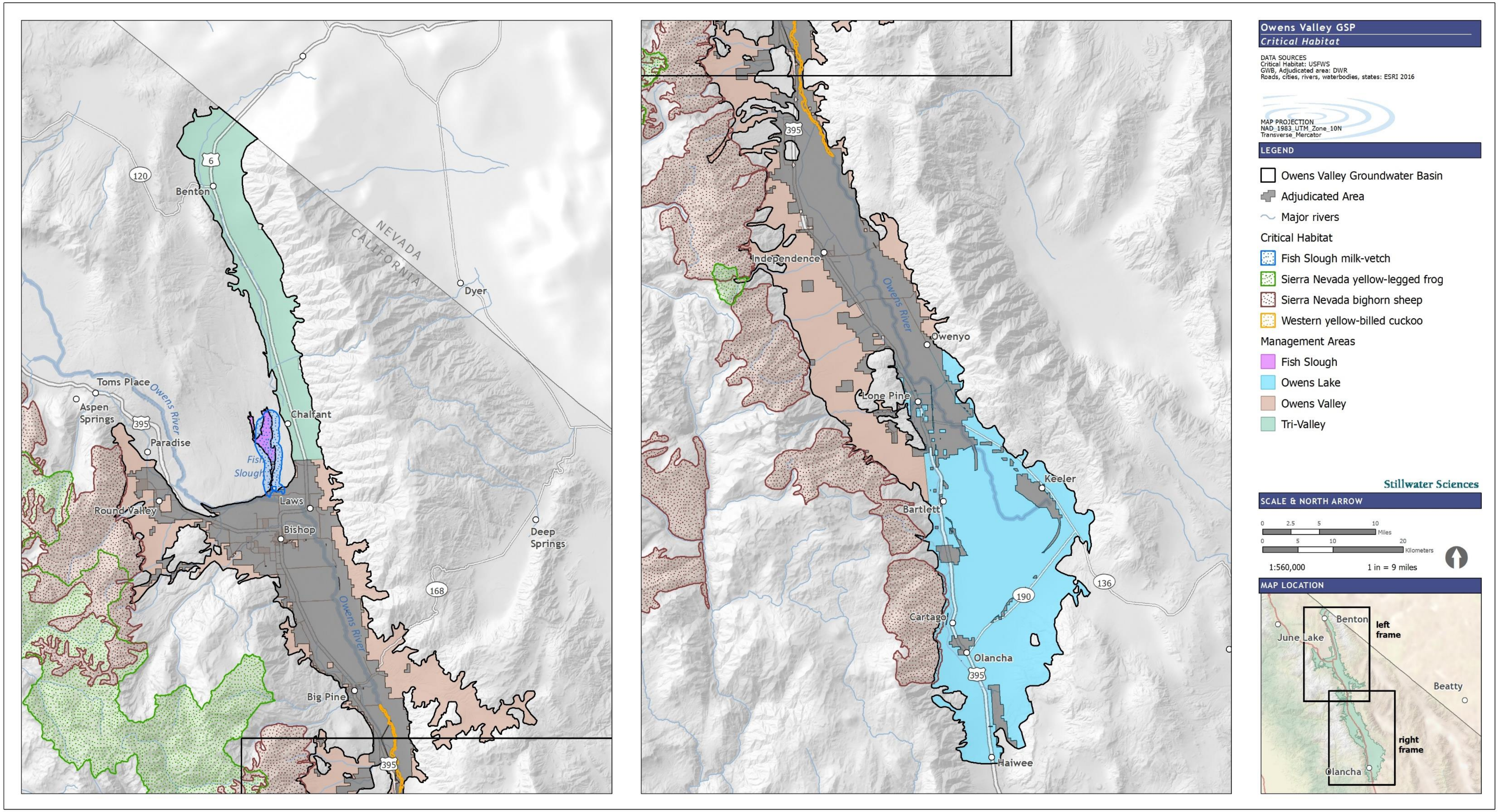

Figure 3.1-7. USFWS critical habitat and management areas within the OVGA Assessment Area.

Table 3.1-3. Special-status plant species and natural communities with known occurrence in management areas in the OVGA Assessment Area.

Common name *Scientific name*	**Status**[1]	**Association with GDE**	**Occurrence location**[2]	**Source**	**Habitat and occurrence**
Plants					
Silver-leaved milk-vetch *Astragalus argophyllus* var. *argophyllus*	2B.2, S2, G5T4, not state or federally listed	Certain	FS, TV	CNDDB	Alkaline or saline meadows, seeps, and playas; CNDDB observations in alkaline meadow southwest of Fish Slough source spring.
Horn's milk-vetch *Astragalus hornii* var. *hornii*	1B.1, S1, G4G5T1T2, not state or federally listed	Likely	Vicinity	CNDDB	Lake margins, wetland-riparian, alkaline meadows and seeps; last reported in area along Owens River in 1919.
Fish Slough milk-vetch *Astragalus lentiginosus* var. *piscinensis*	1B.1, S1, G5T1, FT	Certain	OV, FS, TV	CNDDB	Alkali sinks, playas, wetland-riparian; CNDDB sightings in shallow swales on alkali flats surrounding Fish Slough.
Shockley's milk-vetch *Astragalus serenoi* var. *shockleyi*	2B.2, S2, G4T3, not state or federally listed	Unlikely	OV	CNDDB	Sagebrush and shadscale scrub, pinyon-juniper woodland, found on alkaline soils; CNDDB occurrences along open washes and in sagebrush scrub in Owens Valley.
Hillman's silverscale *Atriplex argentea* var. *hillmanii*	2B.2, S2, G5T4, not state or federally listed	Likely	TV	CNDDB	Alkaline meadows and seeps, Great Basin scrub, saline or clay valley bottoms; two CNDDB observations in Owens Valley.
Falcate saltbush *Atriplex gardneri* var. *falcata*	2B.2, S2S3, G4T4Q, not state or federally listed	Unlikely	OV	CNDDB	Sagebrush and chenopod scrub, generally on alkaline soils; one CNDDB record in Owens Valley in 1974.
Inyo County star-tulip *Calochortus excavates*	1B.1, S2, G2, not state or federally listed	Certain	FS, OL, OV, TV	CNDDB	Alkaline meadows and seeps, mesic chenopod scrub; 58 regional CNDDB sightings in alkaline meadows.
Liddon's sedge *Carex petasata*	2B.3, S3, G5, not state or federally listed	Likely	OV	CNDDB	Broadleafed upland forest, lower montane coniferous forest, dry to wet meadows, seeps, pinyon and juniper woodland; single regional sighting in rocky stream margin.
Wheeler's dune-broom *Chaetadelpha wheeleri*	2B.2, S2, G4, not state or federally listed	Unlikely	TV	CNDDB	Sand dunes, alkali flats, creosote-bush and sagebrush scrub; last reported in area in 1938.
Fiddleleaf hawksbeard *Crepis runcinata*	2B.2, S3, G5, not state or federally listed	Likely	FS, OV, TV	CNDDB	Sagebrush scrub, pinyon and juniper woodland, wetland-riparian, alkaline seeps; all regional occurrences in alkaline meadows.

Common name *Scientific name*	Status[1]	Association with GDE	Occurrence location[2]	Source	Habitat and occurrence
Mojave tarplant *Deinandra mohavensis*	1B.3, S2, G2, SE	Unlikely	OL	CNDDB	Riparian and moist sites, openings in chaparral, desert scrub, woodland; single record from 2001 of approximately 200 individuals in swale in southwestern end of Owens Valley.
Parry's monkeyflower *Diplacus parryi*	2B.3, S3, G4G5, not state or federally listed	Unlikely	OV	CNDDB	Steep hillsides, along washes; previous sightings on slopes/washes near Highway 168.
Limestone monkeyflower *Erythranthe calcicola*	1B.3, S3, G3, not state or federally listed	Unlikely	OV	CNDDB	Disturbed areas along small streams, generally granitic soils; one previous record on limestone slope in Inyo Mountains.
Hot springs fimbristylis *Fimbristylis thermalis*	2B.2, S1S2, G4, not state or federally listed	Certain	FS, OV	CNDDB	Mineralized soils near hot springs and in seepage meadows; occurrences near Fish Slough and along eastern and western edges of Owens Valley.
Alkali ivesia *Ivesia kingii* var. *kingii*	2B.2, S2, G4T3Q, not state or federally listed	Likely	FS, OV	CNDDB	Meadows and seeps, playas, sagebrush scrub, alkali sink; previous sightings on alkaline soils near Fish Slough and along eastern edge of Owens Valley.
Small-flowered grass-of-Parnassus *Parnassia parviflora*	2B.2, S2, G5?, not state or federally listed	Certain	OV	CNDDB	Rocky seeps, mesic meadows; one previous CNDDB record on moist meadow slope at an elevation of approximately 7,600 feet.
Inyo phacelia *Phacelia inyoensis*	1B.2, S3, G3, not state or federally listed	Certain	FS, OV	CNDDB	Alkaline meadow margins, seeps in desert scrub; previous CNDDB records on alkaline meadows/scrub
Parish's popcornflower *Plagiobothyrys parishii*	1B.1, S1, G1, not state or federally listed	Certain	OL, OV, TV	CNDDB	Alkaline, mesic habitat in Great Basin scrub, desert springs, mud flats; most previous CNDDB observations in mesic areas and/or on alkaline soils in Owens Valley.
Narrow-leaved cottonwood *Populus angustifolia*	2B.2, S2, G5, not state or federally listed	Certain	OV	CNDDB	Riparian and wetland; one CNDDB record from riparian corridor along Division Creek.
Frog's-bit buttercup *Ranunculus hydrocharoides*	2B.1, S1, G4, not state or federally listed	Certain	OV	CNDDB	Freshwater marshes and swamps; two previous records within stream channels in Owens Valley.
Bailey's greasewood *Sarcobatus baileyi*	2B.3, S1, G4, not state or federally listed	Unlikely	OL	CNDDB	Alkaline soils, dry lakes, washes, scrub, roadside; single CNDDB record in upland desert scrub south of Owens Lake.

Common name ***Scientific name***	**Status**[1]	**Association with GDE**	**Occurrence location**[2]	**Source**	**Habitat and occurrence**
Owens Valley checkerbloom *Sidalcea covillei*	1B.1, S2, G2, SE	Certain	OL, OV	CNDDB	Chenopod scrub, alkaline flats, meadows and seeps; many observations in alkaline meadows in Owens Valley.
Prairie wedge grass *Sphenopholis obtusata*	2B.2, S2, G5, not state or federally listed	Certain	OV	CNDDB	Mesic cismontane woodlands, meadows and seeps, streambanks, ponds; two reported sightings in wetlands in Owens Valley.
Western seablite *Suaeda occidentalis*	2B.3, S2, G5, not state or federally listed	Likely	OV	CNDDB	Saline or alkaline wetlands, mesic alkaline Great Basin scrub; single record on saline playa in Owens Valley.
Foxtail thelypodium *Thelypodium integrifolium* ssp. *complanatum*	2B.2, S2, G5T4T5, not state or federally listed	Likely	FS, OV	CNDDB	Alkaline or subalkaline, mesic Great Basin scrub, meadows and seeps; observations on moist and alkaline soils near Fish Slough and in Owens Valley.
Sensitive Natural Communities[2]					
Alkali cordgrass *Spartina gracilis*	S1, not globally ranked	Likely	OV	VegCAMP	Moist, poorly drained, alkaline areas along streams, alluvial flats, swales, meadows, and ponds; occur primarily in Mono and Inyo counties in eastern California.
Alkali meadow	S2.1, G3	Certain	OV	CNDDB	Moist, alkaline soils in valley bottoms and on lower portions of alluvial slopes; occur east of the Cascades and Sierra Nevada.
Alkali sacaton *Sporobolus airoides*	S2, not globally ranked	Certain	FS, OL, OV	VegCAMP	Moist, poorly drained, alkaline areas along streams, alluvial flats, swales, meadows, and ponds; occur throughout much of southern and Central California, including the Central Valley, Mojave Desert, and Great Basin.
Alkali seep	S2.1, G3	Certain	OV	CNDDB	Permanently moist or wet alkaline seeps; scattered throughout desert regions of California.
American bulrush marsh *Schoenoplectus americanus* herbaceous alliance	S3.2, G5	Certain	OL, OV	VegCAMP	Stream banks, pond and lake shores, sloughs, swamps, fresh and brackish marshes, and roadside ditches on poorly aerated soils with high organic content; occur in the Mojave and Sonoran deserts, the Sacramento-San Joaquin Delta, the Owens and Central valleys, and the Modoc Plateau.
Aspen groves *Populus tremuloides*	S3, G5	Certain	OL, OV	CALVEG	Depressions, swales, slopes, meadow margins, and elevated stream terraces; occur in the Sierra Nevada, Cascades, Klamath

Common name ***Scientific name***	**Status**[1]	**Association with GDE**	**Occurrence location**[2]	**Source**	**Habitat and occurrence**
forest and woodland alliance					Mountains, and Modoc Plateau.
Black cottonwood forest and woodland *Populus trichocarpa* forest and woodland alliance	S3, G5	Certain	OL, OV	CALVEG, VegCAMP	Seasonally flooded and permanently saturated soils on stream banks and alluvial terraces; occur throughout much of California except the Central Valley, Sacramento-San Joaquin Delta, and Mojave and Sonoran deserts.
Bush seepweed scrub *Suaeda moquinii* shrubland alliance	S3, G4	Likely	OL, OV	VegCAMP	Saline or alkaline soils in flat to gently sloping valley bottoms, playas, toe slopes adjacent to alluvial fans, and bajadas; occur in the Owens and Central valleys and Modoc Plateau, Great Basin, Mojave, and Sonoran deserts.
Desert olive *Forestiera pubescens*	Provisional S1S2, G1G2	Unlikely	OL, OV	VegCAMP	Floodplains, stream banks, springs, river terraces, washes, and swales; occur at elevations between 1,250 and 7,200 ft in the Sierra Nevada, Coast, Great Basin, and southern California mountains and the Mojave Desert.
Fremont cottonwood forest and woodland *Populus fremontii – Fraxinus velutina – Salix gooddingii* forest and woodland alliance	S3, G4	Certain	OL, OV	CALVEG, VegCAMP	On floodplains, along low-gradient rivers and streams, and in alluvial fans and valleys with a dependable subsurface water supply; occur throughout much of California except the Sierra Nevada and Modoc Plateau.
Fremont's smokebush – Nevada smokebush scrub *Psorothamnus fremontii – Psorothamnus polydenius* shrubland alliance	S3, G4?	Unlikely	OL, OV	VegCAMP	Sandy soils in intermittent washes, drainage bottoms, sand dunes, and upper bajadas; occur primarily in the Great Basin and Mojave deserts in eastern California.

Common name ***Scientific name***	**Status**[1]	**Association with GDE**	**Occurrence location**[2]	**Source**	**Habitat and occurrence**
Goodding's willow – red willow riparian woodland and forest *Salix gooddingii – Salix laevigata* riparian forest alliance	S3, G4	Certain	OL, OV	VegCAMP	Terraces along large rivers, canyons, floodplains, stream and lake edges, ditches, and springs; occur throughout most of California at elevations below 9,000 ft.
Hardstem and California bulrush marshes *Schoenoplectus* (*acutus*, *californicus*) herbaceous alliance	S3S4, not globally ranked	Certain	OL, OV	VegCAMP	Brackish to freshwater marshes, stream banks and bars of river mouth estuaries, ponds and lake shores, sloughs, and roadside ditches; occur throughout most of California at elevations below 8,200 ft.
Joshua tree woodland *Yucca brevifolia* woodland alliance	S3, G4	Likely	OL	VegCAMP	Gentle to moderate slopes of alluvial fans and ridges; occur primarily in the Great Basin and Mojave deserts in eastern California.
Nevada joint fir – Anderson's boxthorn – spiny hop sage scrub *Ephedra nevadensis – Lycium andersonii – Grayia spinosa* shrubland alliance	S3S4, G5	Unlikely	OL, OV	VegCAMP	Dry, open ridges, canyons, bajadas, floodplains, valleys and washes, often with alkaline or saline soils; occur primarily in the Modoc Plateau, Great Basin, and Mojave deserts in eastern California.
Parry's saltbush *Atriplex parryi*	Provisional S2, G3	Likely	FS	VegCAMP	Dry lake beds, plains, alkali stream terraces, stable sand dunes, and barrier beaches; occur in eastern California in the Mojave Desert, Great Basin, and Modoc Plateau.
Spiny menodora scrub *Menodora spinescens* shrubland alliance	S2, G4	Unlikely	FS	VegCAMP	Well-drained ridges and slopes with soils derived from bedrock or alluvium; occur in the Great Basin and Mojave deserts in eastern California.
Transmontane alkali marsh	S2.1, G3	Certain	FS	CNDDB	Alkaline lake beds, spring margins, and river bottomlands at elevations between 3,000–7,000 ft; occur in the Modoc Plateau and east of the Sierra Nevada in Mono and Inyo counties.

Common name *Scientific name*	**Status**[1]	**Association with GDE**	**Occurrence location**[2]	**Source**	**Habitat and occurrence**
Utah juniper woodland and forest *Juniperus osteosperma* forest and woodland alliance	S3, G5	Unlikely	OV	CALVEG	Slopes, ridges, and ravines with well-drained rocky or alluvial soils; occur in the Great Basin and Mojave Desert in eastern California.
Water birch thicket *Betula occidentalis* shrubland alliance	S2.2, G4	Certain	OV	CALVEG, CNDDB, VegCAMP	Intermittently saturated stream banks, alluvial terraces, and seeps; occur primarily in the Modoc Plateau and Great Basin deserts in eastern California.

[1] Status codes:

G = Global
T = Subspecies or variety
Federal
FT = Listed as threatened under the federal Endangered Species Act
FD = Federally delisted

State
S = Sensitive
SE = Listed as Endangered under the California Endangered Species Act
ST = Listed as Threatened under the California Endangered Species Act
SSC = CDFW species of special concern
SFP = CDFW fully protected species

Global Rank
1 Critically Imperiled—At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
2 Imperiled—At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
3 Vulnerable — At moderate risk of extinction or elimination due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
4 Apparently Secure — Uncommon but not rare; some cause for long-term concern due to declines or other factors.
5 Demonstrably Secure — Common; widespread and abundant.

California Rare Plant Rank
1B Plants rare, threatened, or endangered in California and elsewhere
2B Plants rare, threatened, or endangered in California, but more common elsewhere
4 More information needed about this plant, a review list
4 Plants of limited distribution, a watch list

CRPR Threat Ranks:
0.1 Seriously threatened in California (high degree/immediacy of threat)
0.2 Fairly threatened in California (moderate degree/immediacy of threat)
0.3 Not very threatened in California (low degree/immediacy of threats or no current threats known)

[2] Location codes: FS (Fish Slough) ; OL (Owens Lake); OV (Owens Valley); TV (Tri-Valley)

Table 3.1-4. Acres of USFWS-designated critical habitat critical habitat within Owens Valley management areas.

Common name *Scientific name*	USFWS critical habitat (acres)				
	Owens Valley	**Owens Lake**	**Tri-Valley**	**Fish Slough**	**Total**
Fish Slough milk-vetch *Astragalus lentiginosus* var. *piscinensis*	221	-	-	2,512	2,732
Sierra Nevada bighorn sheep *Ovis canadensis sierrae*	2,667	1,835	-	-	4,502
Sierra Nevada yellow-legged frog *Rana sierrae*	253	-	-	-	253
Yellow-billed cuckoo *Coccyzus americanus occidentalis*	31	-	-	-	31
All species	**3,171**	**1,835**	**0**	**2,512**	**7,518**

3.1.3.1 Owens Valley

Thirty-one groundwater dependent special-status animal species were identified as likely present with the Owens Valley management area. These include seven mammal species, sixteen bird species, two reptile species, two amphibian species, and three mollusk species (Table 3.1-2, Appendix B). Habitat use within the mapped GDEs likely includes: dependence on aquatic habitat (e.g., springs and seeps) for living (e.g., Owens Valley springsnail, Wong's springsnail [*Pyrgulopsis wongi*]), indirect dependence on groundwater dependent terrestrial or aquatic habitats for foraging (e.g., Yuma myotis [*Myotis yumanensis*], bald eagle [*Haliaeetus leucocephalus*]), and indirect dependence on wetland, riparian plants, or other ground-water-dependent vegetation for nesting or dwelling (e.g., Sierra Nevada red fox [*Vulpes vulpes necátor*], bank swallow [*Riparia riparia*], southwestern willow flycatcher [*Empidonax traillii extimus]*) (Appendix B).

Fourteen potentially groundwater dependent special-status plant species were documented within the Owens Valley management area. These include nine species identified as certain to depend on groundwater and five species that are likely to depend on groundwater. Many of the species certain to depend on groundwater (e.g., Inyo County star-tulip [*Calochortus excavates*], small-flowered grass-of-Parnassus [*Parnassia parviflora*] and Parish's popcornflower [*Plagiobothrys parishii*]) are dependent on alkaline meadows and seeps and occur in the alkaline soils in Owens Valley. The species likely to depend on groundwater are generally associated with wetlands and meadows (e.g., Fiddleleaf hawksbeard [*Crepis runcinata*] and Western seablite [*Suaeda occidentalis*]).

3.1.3.2 Owens Lake

Twenty-seven groundwater dependent special-status animal species were identified as likely present with the Owens Lake management area. These include seven mammal species, fourteen bird species, one reptile species, one amphibian species, two native fish species, one mollusk species, and one insect species (Table 3.1-2, Appendix B). Habitat use within the mapped GDEs likely includes: dependence on aquatic habitat (e.g., springs and seeps) for living (e.g., Owens pupfish, Owens tui chub), indirect dependence groundwater dependent terrestrial or aquatic habitats for foraging or drinking water (e.g., spottedbat [*Euderma maculatum*], northern harrier [*Circus hudsonius*]), and indirect dependence on wetland, riparian plants, or other vegetation for nesting or dwelling (e.g., western snowy plover [*Charadrius alexandrinus nivosus]*, yellow-breasted chat [*Icteria virens*]) (Appendix B). Furthermore, Owens Lake provides valuable migratory and breeding habitat for salt-tolerant shorebirds (e.g., special- western snowy plover) (NAS 2020).

Three potentially groundwater dependent special-status plant species were documented within the Owens Lake management area, all of which were identified as certain to depend on groundwater (i.e., Inyo County star-tulip [*Calochortus excavates*], Parish's popcorn flower [*Plagiobothrys parishii*] and Owens Valley checkerbloom [*Sidalcea covillei*]). These species are each generally found in alkaline habitats including alkaline flats, seeps, meadows and springs.

3.1.3.3 Tri Valley

Eight groundwater dependent special-status animal species were identified as likely present with the Tri-Valley management area. These include one mammal species, five bird species, and two mollusk species (Table 3.1-2, Appendix A). Likely utilization of habitat within the mapped GDEs include: dependence on aquatic habitat (e.g., springs and seeps) for living (e.g., Owens Valley springsnail, Wong's springsnail), indirect dependence on groundwater dependent terrestrial or aquatic habitats for foraging (e.g., Owens Valley vole [*Microtus californicus vallicola*], and indirect dependence on wetland, riparian plants, or other vegetation for nesting or dwelling (e.g., Swainson's Hawk [*Buteo swainsoni*]) (Appendix B).

Six potentially groundwater dependent special-status plant species were documented within the Tri-Valley management area. These included four species identified as certain to depend on groundwater and two species that are likely to depend on groundwater. All species identified as potentially dependent on groundwater occur in alkaline meadows, seeps, or other mesic habitats such as mud flats or springs. Species identified as certain to depend on groundwater included Silver-leaved milk-vetch [*Astragalus argophyllus* var. *argophyllus*], Fish Slough milk-vetch [*Astragalus lentiginosus* var. *piscinensis*], Inyo County star-tulip [*Calochortus excavates*], and Parish's popcornflower [*Plagiobothrys parishii*]); likely groundwater dependent species included Atriplex argentea var. hillmanii and Fiddleleaf hawksbeard [*Crepis runcinata*].

3.1.3.4 Fish Slough

Eighteen groundwater dependent special-status animal species were identified as likely present with the Fish Slough management area. These include two mammal species, eleven bird species, one reptile species, two native fish species, and two mollusk species (Table 3.1-2, Appendix B). Utilization of habitat within the mapped GDEs likely include: dependence on aquatic habitat (e.g., springs and seeps) for living (e.g., Owens pupfish, Owens specked dace), indirect dependence on terrestrial or aquatic habitats for foraging (e.g., American white pelican [*Pelecanus erythrorhynchos*]), and indirect dependence on wetland, riparian plants, or other vegetation for nesting or dwelling (e.g., Black tern [*Chlidonias niger*]) (Appendix B).

Eight potentially groundwater dependent special-status animal species were documented within the Fish Slough management area. These included five species identified as certain to depend on groundwater and 3 species that are likely to depend on groundwater. Many of the species certain to depend on groundwater (e.g., *Astragalus argophyllus* var. *argophyllus* [Silver-leaved milk-vetch], Hot springs fimbristylis [*Fimbristylis thermalis*], and Inyo phacelia [*Phacelia inyoensis*]) are associated with seeps and springs characteristic of Fish Slough. The species likely to depend on groundwater are generally associated with alkaline meadows (e.g., Fiddleleaf hawksbeard [*Crepis runcinate*], Alkali ivesia [*Ivesia kingii* var. *kingii*] and Foxtail thelypodium [*Thelypodium integrifolium* ssp. *complanatum*]).

3.1.4 Ecological value

The ecological value of each management area was characterized by evaluating the presence and groundwater-dependence of special-status species and ecological communities, and the vulnerability of these species and their habitat to changes in groundwater levels (Rohde et al. 2018).

3.1.4.1 Owens Valley

The Owens Valley management area was determined to have **high ecological value** because: (1) it supports a relatively large number of special-status species and ecological communities (Table 3.1-2), (2) contains a relatively large amount of designated critical habitat for four federally listed species (Table 3.1-4), (3) supports species that are directly dependent on groundwater (two amphibians and three mollusks; Table 3.1-2), and (4) includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could substantially alter their distribution, species composition, and/or health (Rohde et al. 2018). The unit's high ecological value is also related to the relatively large amount of groundwater-fed aquatic habitat (i.e., 7.2 acres of seeps and springs) and the contributions of groundwater dependent vegetation to the ecological function and habitat value of many of the streams within the unit draining the eastern slope of the Sierra Nevada that support native aquatic species and beneficial uses in and adjacent to the management unit.

3.1.4.2 Owens Lake

The Owens Lake management area was determined to have **high ecological value** because: (1) it supports a relatively large number of special-status species and ecological communities (Table 3.1-2), (2) supports species that are directly dependent on groundwater (one amphibian, two fish, and one mollusk; Table 3.1-2), and (3) includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could substantially alter their distribution, species composition, and/or health (Rohde et al. 2018). The unit's high ecological value is also related to its relatively large amount of GDE area (46,129 acres), accounting for 83% of the total GDE acreage across the entire OVGA Assessment Area.

3.1.4.3 Tri-Valley

The Tri-Valley management area was determined to have **low ecological value** because: (1) it supports a relatively small number of special-status species and ecological communities (Table 3.1-2), (2) contains no designated critical habitat for federally listed species (Table3.1-3), (3) supports few species that are directly dependent on groundwater (two mollusks; Table 3.1-2), and (4) includes few species or ecological communities that are vulnerable to changes in groundwater discharge or groundwater levels that could substantially alter their distribution, species composition, and/or health (Rohde et al. 2018).

3.1.4.4 Fish Slough

The Fish Slough management area was determined to have **high ecological value** because: (1) it supports a moderate number of special-status species and ecological communities (Table 3.1-2), (2) contains designated critical habitat for the federally listed and highly endemic Fish Slough milk-vetch (Table3.1-3), (3) supports species that are directly dependent on groundwater (two fish and two mollusks; Table 3.1-2), and (4) includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could substantially alter their distribution, species composition, and/or health (Rohde et al. 2018). The unit's high ecological value is also related to the high proportion of its total area composed of GDEs (74%) and its critical role in supporting the last remaining populations of the endangered and highly endemic Owens pupfish and populations of the imperiled Owens speckled dace.

4 POTENTIAL EFFECTS ON GDEs

This section presents the methods and results of our analysis to identify how groundwater management could affect GDEs in the areas managed by the OVGA in the Owens Valley Groundwater Basin. Adverse effects (impacts) on GDEs are considered undesirable results under SGMA (State of California 2014). The analysis is based on the hydrologic conditions affecting GDEs and their susceptibility to changing groundwater conditions, trends in biological condition of the GDEs, and climate change projections and other anticipated conditions or management actions likely to affect GDEs in the future.

4.1 Approach

SGMA describes six groundwater conditions that could cause undesirable results, including adverse impacts on GDEs. These are (1) chronic lowering of groundwater levels, (2) reduction of groundwater storage, (3) seawater intrusion, (4) degraded groundwater quality, (5) land subsidence, and (6) depletion of interconnected surface waters. Rohde et al. (2018) identify chronic lowering of groundwater levels, degraded water quality, and depletions of interconnected surface water as the most likely conditions to have direct effects on GDEs, potentially leading to an undesirable result. Following this guidance and based on available information for the Owens Valley Groundwater Basin, we have eliminated reduction of groundwater storage, seawater intrusion (the subbasin is not located near or hydrologically connected to the ocean), and land subsidence from consideration. Water quality in the basin is generally high with the exception of high total dissolved solids and saline water in Owens Lake. Changes to the salinity of groundwater used by plant roots could affect the distribution of plant species and vegetation types, but water quality is not likely affected by groundwater management. Accordingly, degraded groundwater quality was not considered in the analysis of potential effects.

We evaluated the potential for chronic lowering of groundwater levels and depletion of interconnected surface waters to cause direct effects on GDEs compared to baseline conditions, with a focus on effects related to groundwater levels. First, we identified baseline hydrologic conditions for the GDE unit using available information (Section 1.3). Next, we determined each GDE unit's susceptibility to changing groundwater conditions using available hydrologic data, climate change projections, and the GDE susceptibility classifications (Rohde et al. 2018) summarized in Table 4.1-1.

Table 4.1-1. Susceptibility classifications developed for evaluation of a GDE's susceptibility to changing groundwater conditions (Rohde et al. 2018).

Susceptibility classifications	
High Susceptibility	Current groundwater conditions for the selected hydrologic data fall outside the baseline range.
Moderate Susceptibility	Current groundwater conditions for the selected hydrologic data fall within the baseline range but future changes in groundwater conditions are likely to cause it to fall outside the baseline range. The future conditions could be due to planned or anticipated activities that increase or shift groundwater production, causing a potential effect on a GDE.
Low Susceptibility	Current groundwater conditions for the selected hydrologic data fall within the baseline range and no future changes in groundwater conditions are likely to cause the hydrologic data to fall outside the baseline range.

We used these susceptibility classifications to trigger further evaluation of potential effects on GDEs. If we determined a GDE unit to have moderate or high susceptibility to changing groundwater conditions, we used biological information to assess whether evidence exists of a biological response to changing groundwater levels. This project did not include field monitoring of vegetation but instead relied on remote sensing to assess biological changes through time. The biological response analysis was based on changes in Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) data for individual vegetation polygons within the GDE unit (Klausmeyer et al. 2019). The polygons correspond to different GDE mapping units (i.e., different species compositions) and the size of the GDE polygons varied.

NDVI, which estimates vegetation greenness, and NDMI, which estimates vegetation moisture, were generated from surface reflectance corrected multispectral Landsat imagery corresponding to the period of July 9 to September 7 of each year, which represents the period when GDE species are most likely to use groundwater rather than precipitation (see Klausmeyer et al. 2019 for further description of methods). Vegetation polygons with higher NDVI values indicate increased density of chlorophyll and photosynthetic capacity in the canopy, an indicator of vegetation vigor. Similarly, high NDMI values indicate that the vegetation canopy has high water content and is therefore not drought stressed. These indices are both commonly used proxies for vegetation health in analyses of temporal trends in health of groundwater dependent vegetation (Rouse et al. 1974, Jiang et al. 2006; as cited in Klausmeyer et al. 2019) including to assess vegetation changes in the Owens Valley Adjudicated Area (Huntington et al. 2016). Both NDVI and NDMI range from -1 to 1, but have different sensitivity to exposed standing water which is likely to occur during wet years in Owens Lake and portions of Fish Slough. The NDVI of standing water approaches -1. Averaging July to September NDVI minimizes the potential for standing water to decrease NDVI (Huntington et al. 2016). The NDMI signature of standing water is less distinct, and therefore may impact NDMI in years where standing water is likely. Changes in surface water extent within a GDE polygon may impact NDVI and NDMI trends in that polygon, particularly in the Owens Lake and Fish Slough management areas. An additional source of uncertainty is the 30-m (98-ft) resolution of NDVI and NDMI. This resolution is problematic for GDEs along small tributaries to the Owens Valley which are elongate features with narrow widths that can range from 1-10 pixels (98-984 ft) in the Landsat imagery, but are typically 2-3 pixels wide.

4.2 Biological Data

To assess the health of GDEs, we explored changes in GDE vegetation via NDVI and NDMI for each management area through time using TNCs GDE Pulse Tool (Klausmeyer et al. 2019). The pulse tool calculates the average summer NDVI and NDMI for polygons in the iGDE database (DWR 2020b). The GDE map (Figure 3.2-1) includes several revisions to the iGDE map as discussed in Section 2.2.1 due to the inclusion of the Jawbone Canyon Region and Owens Valley vegetation map and the additional wetland mapping from the Great Basin Air Pollution Control District are not included in this assessment. For this analysis, we used the DWR (2020b) dataset and removed vegetation polygons that the ICWD assessed as not groundwater dependent. These revised GDE maps can be included in future monitoring efforts, however, to track biological change through time. Using the iGDE dataset (DWR 2020b) does not affect the mapping in the Fish Slough and Tri-Valley management areas. It does, however, change the southern half of the Owens Valley management area and the entirety of the Owens Lake management area (compare Figures 3.2-1 and 2.1-2). Despite the updated GDE mapping, we are including an analysis of the Owens Valley and Owens Lake management areas to provide an initial estimate of GDE health through time, but the results may differ once the new mapping is incorporated in the five-year update.

Below we examine the changes in NDVI and NDMI for ICWD corrected iGDEs in each management area over the period of record for the GDE Pulse Tool (Klausmeyer 2019). The area-weighted average NDVI and NDMI for each management area is shown in Figure 4.2-1. The mean NDVI and NDMI for each management area in the NDVI and NDMI analysis are weighted by the area of each polygon relative to the total area of GDEs in the management area.

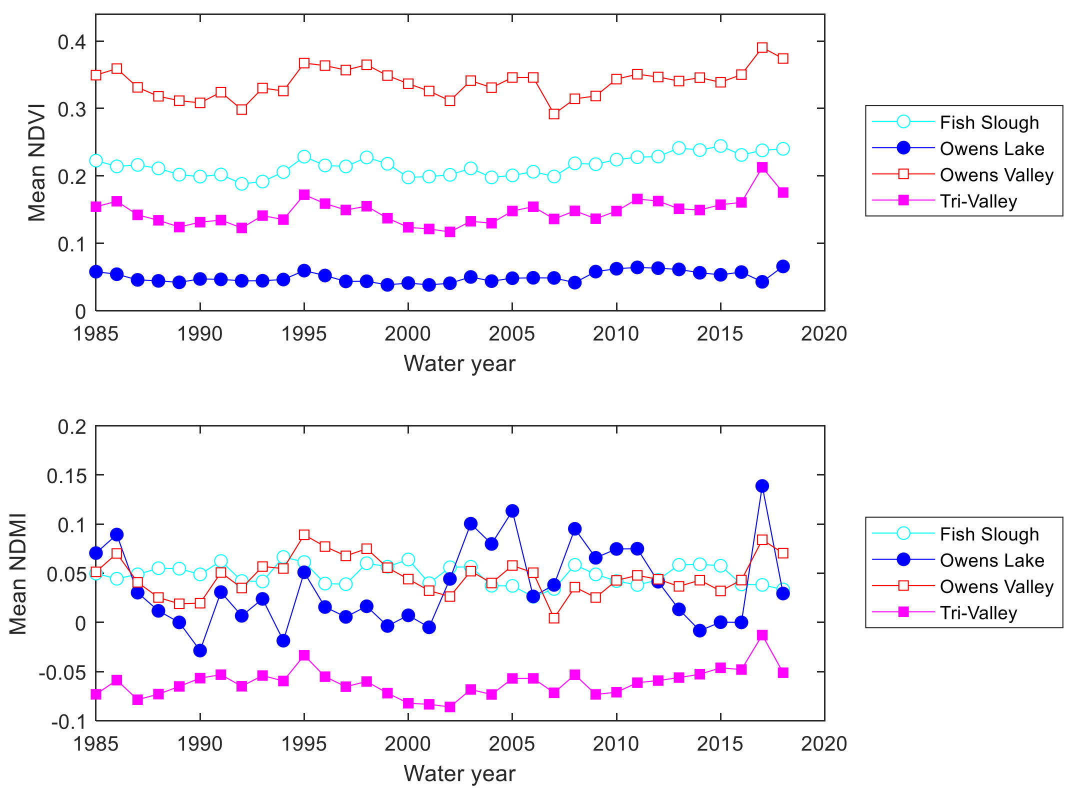

Figure 4.2-1. Area-weighted mean NDVI (top) and NDMI (bottom) for the ICWD corrected iGDEs in the four management areas through time.

4.2.1 Owens Valley

GDEs in the Owens Valley management area have the highest average NDVI of the four management units. The mean NDVI for the GDE units from 1985–2018 was 0.34 (Figure 4.2-1). The grey lines Figure 4.2-2 and 4.2-3 show the NDVI and NDMI, respectively, through time for each vegetation polygon in the iGDE map. The colored bold lines in figures 4.2-2 and 4.2-3 represent the 10th, 25th, 50th, 75th, and 90th percentile for each year of the NDVI and NDMI, respectively. Both NDVI and NDMI have similar trends through time for each percentile, suggesting that most plants are responding similarly. The NDVI of GDE plant communities were relatively steady during the period of record, with the exception of a sharp drop (particularly for NDVI) between 0.3–0.5 in 2007, followed by a gradual recovery by 2010. Thereafter the NDVI and NDMI values for GDEs were mostly stable throughout the drought, but show a rapid increase in 2017. We explored the NDVI changes for specific plant types (e.g., water birch, wet meadows, willow (scrub)), which showed a similar response to the data in Figure 4.2-2.

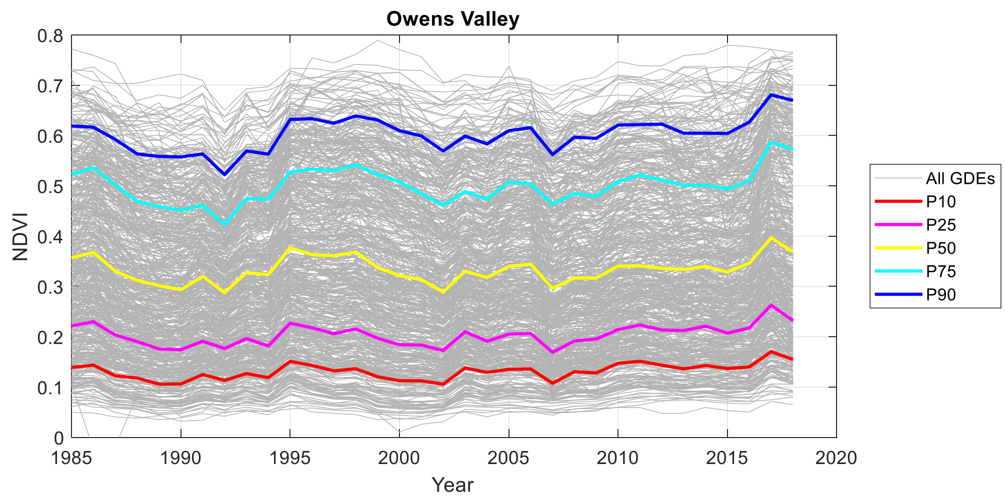

Figure 4.2-2. NDVI through time for all the GDE polygons in the Owens Valley management area (the grey lines). The color lines represent the 10th, 25th, 50th, 75th, and 90th percentile NDVI values for each year.

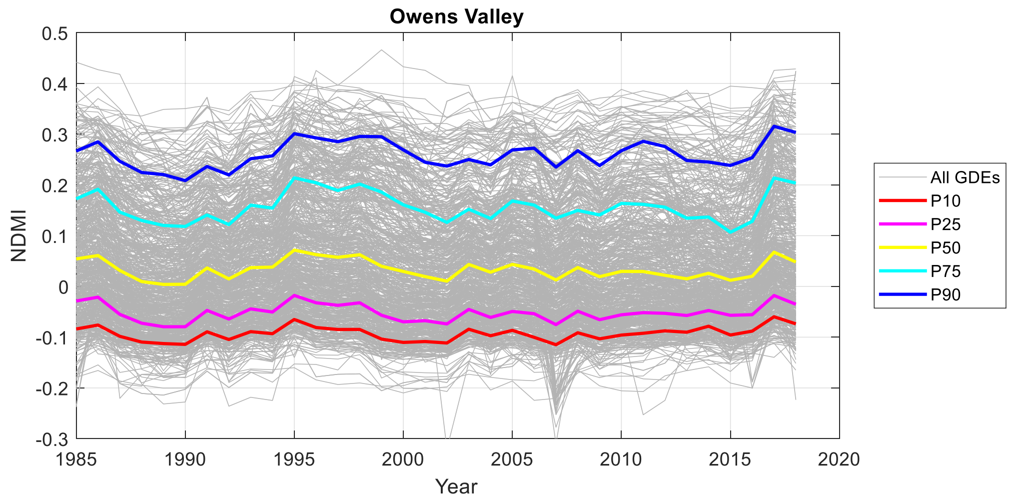

Figure 4.2-3. NDMI through time for the ICWD-corrected GDE polygons in the Owens Valley management area (the grey lines). The color lines represent the 10th, 25th, 50th, 75th, and 90th percentile NDMI values for each year.

The average NDVI and NDMI for GDEs in the Owens Valley management area rose with increases in precipitation and declined with decreases in precipitation until 2005 or 2006 (Figure 4.2-4). The drop in NDVI and NDMI observed in Figures 4.2-5 and 4.2-6 in 2007 were correlated with a drop in precipitation. Subsequently, the NDVI increased from 2007–2010, then remained quasi-steady despite very low precipitation until 2017, when it increased somewhat during the wet year. Because many of the GDEs in the Owens Valley management area are along tributaries originating in the Sierra Nevada, local precipitation is an incomplete indicator of water availability, but it roughly correlates with Sierra Nevada snowpack and other water sources. Nonetheless the stable NDVI and NDMI through the recent drought suggests that the GDEs are relatively stable. The stability of NDVI and NDMI in the Owens Valley Management Area during the 2012-2016 drought is surprising and differs from NDVI in the Adjudicated Area, which generally decreased from 2012-2016 based in ICWD data (Zach Nelson, personal communication). This difference between the Adjudicated and Non-Adjudicated areas could be a function of the poor vegetation mapping outside the Adjudicated Area or differences in the source of water (e.g., surface water along the tributaries in the Adjudicated Area). The stability of NDVI and NDMI in the Owens Valley management area should be explored using the revised vegetation map during the five-year after GSP submission.

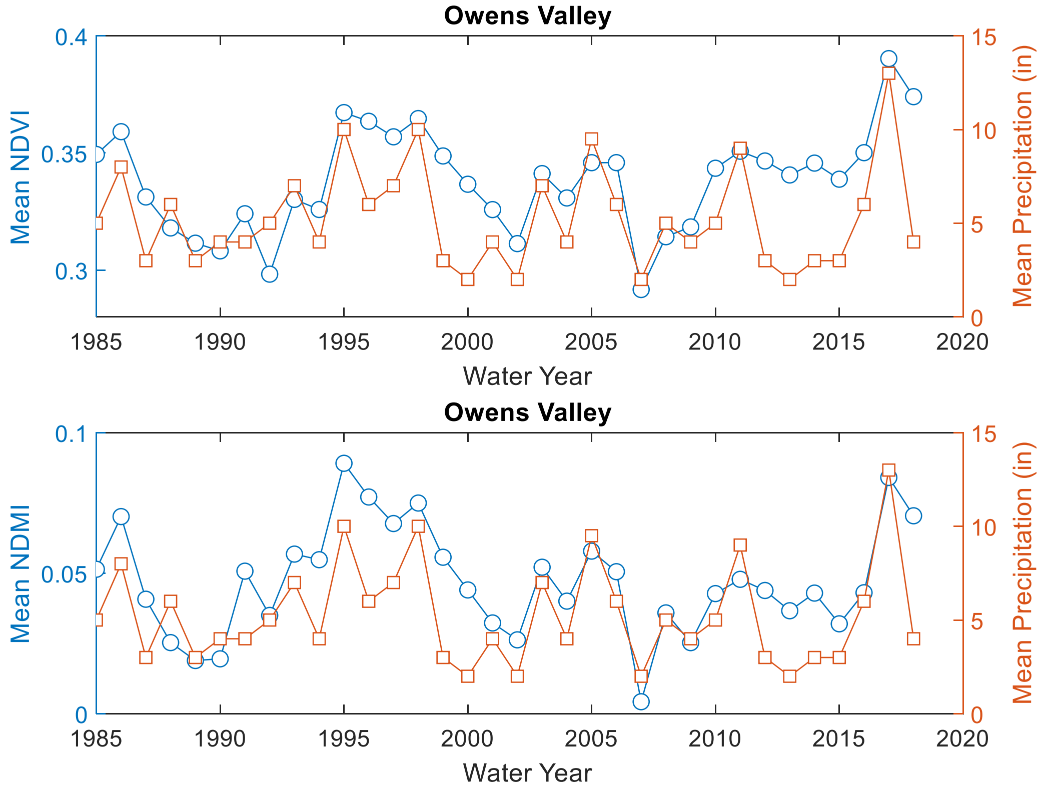

Figure 4.2-4. Weighted area mean NDVI (in blue) and mean precipitation (red) for the Owens Valley management area derived from the TNC pulse tool. The precipitation data were assembled by TNC from PRISM data.

4.2.2 Owens Lake

The Owens Lake management area has the most extensive GDEs among the 4 management areas, with over 15,000 acres in the original mapping (Table 3.1-1) and 46,129 acres in the revised map. NDVI ranges from less than 0 to 0.83 (Figure 4.2-8) and NDMI ranges from -0.17 to 1.0 (Figure 4.2-5). Despite containing the polygons with the highest NDVI and NDMI of the four areas, NDVI values for Owens Lake management area are, on average the lowest of 4 management areas, with an average NDVI of about 0.05. Part of the reason for the generally low NDVI values for Owens Lake could be the relatively poor quality of the FRAP and NWI mapping used in the pulse analysis. Spot checks of the mapping showed that FRAP polygons were often offset from available imagery. In addition, many of the polygons are very large and incorporate sparsely vegetated patches that contain a lot of bare soil on the lakebed. These maps have been updated with the new Jawbone Canyon and Owens Valley map, but this map has not yet been incorporated into the Pulse Analysis, although future monitoring of vegetation condition using NDVI can use the new map.

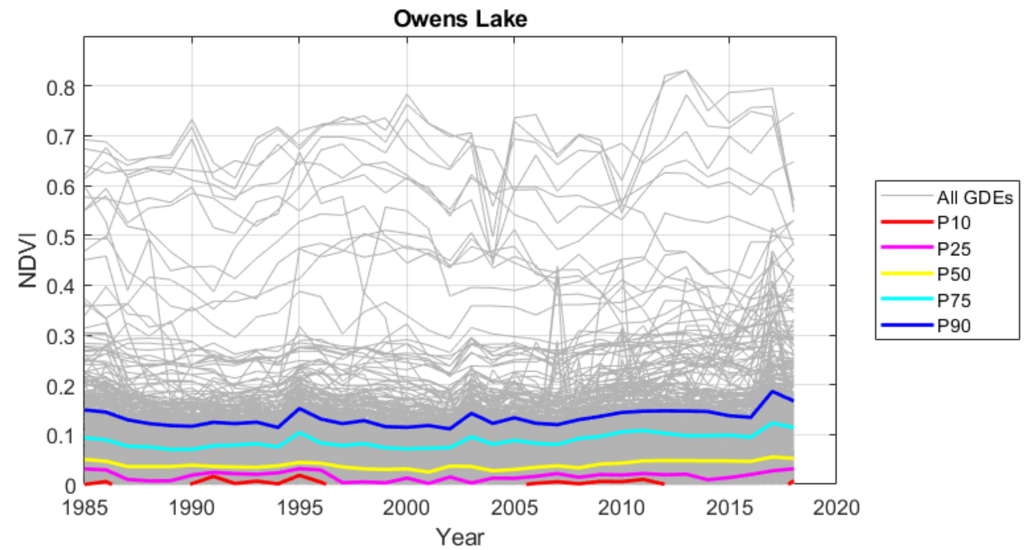

Figure 4.2-5. NDVI through time for the ICWD-corrected GDE polygons in the Owens Lake management area (the grey lines). The color lines represent the 10th, 25th, 50th, 75th, and 90th percentile NDVI values for each year.

NDVI has been relatively consistent for most of the period of record with short-term increases in NDVI in 1995, 2003 and 2018 (Figure 4.2-5). The 90th percentile NDMI has been declining since at least 2005, with increases in 1996, 2003, and 2017 (Figure 4.2-6). The largest decline in the 90th percentile NDMI occurred from 2011-2016 during the recent drought. The 75th percentile NDMI had peaks and valleys that were coincident with the 90th percentile NDMI, but without a long-term decline. The 10th, 25th, and 50th percentiles of NDVI and NDMI do not show a long-term trend, but have small increases during the same years as the 90th percentile data.

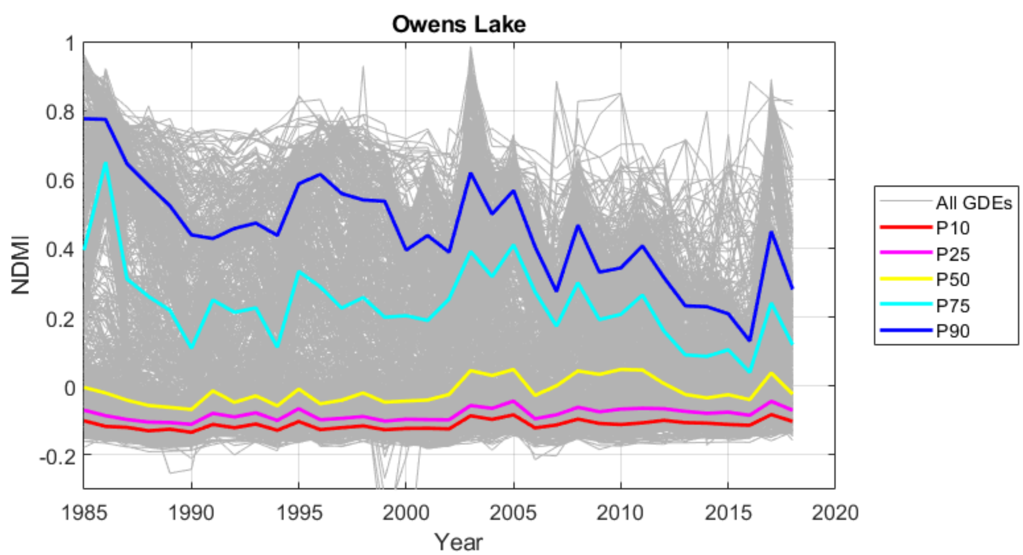

Figure 4.2-6. NDMI through time for the ICWD-corrected GDE polygons in the Owens Lake management area (the grey lines). The color lines represent the 10th, 25th, 50th, 75th, and 90th percentile NDMI values for each year.

Mean NDVI and mean NDMI are relatively independent of rainfall near Owens Lake and are likely more tied to surface water inflows to the lake. The mean NDVI was very high from 2009–2011 and gradually dropped during the 2012–2016 drought, mean NDVI then plummeted in 2017 and increased in 2018 (Figure 4.2-7). The decline in NDVI in 2017 was due to widespread ponded surface water at Owens Lake which reduced the NDVI where vegetation was sparse (as represented by the lowest NDVI polygons in Figure 4.2-5). The decline in mean NDMI values during 2012–2016 was more rapid than NDVI (Figure 4.2-7). The difference between NDVI and NDMI in 2017 is likely due to extensive surface water. It should be noted that the very low NDVI values make assessing differences through time in this arid environment using the GDE Pulse approach challenging. Instead, a revised approach looking at the spatial pattern of change for individual pixels in Owens Lake GDE rather than that averaged over the mapped polygons would be more appropriate in this setting and can be explored during the 5-year update. The cause of the decline in the 90th percentile NDMI at Owens Lake over time is unclear and may reflect changes in the distribution of vegetation not reflected in the iGDE map.

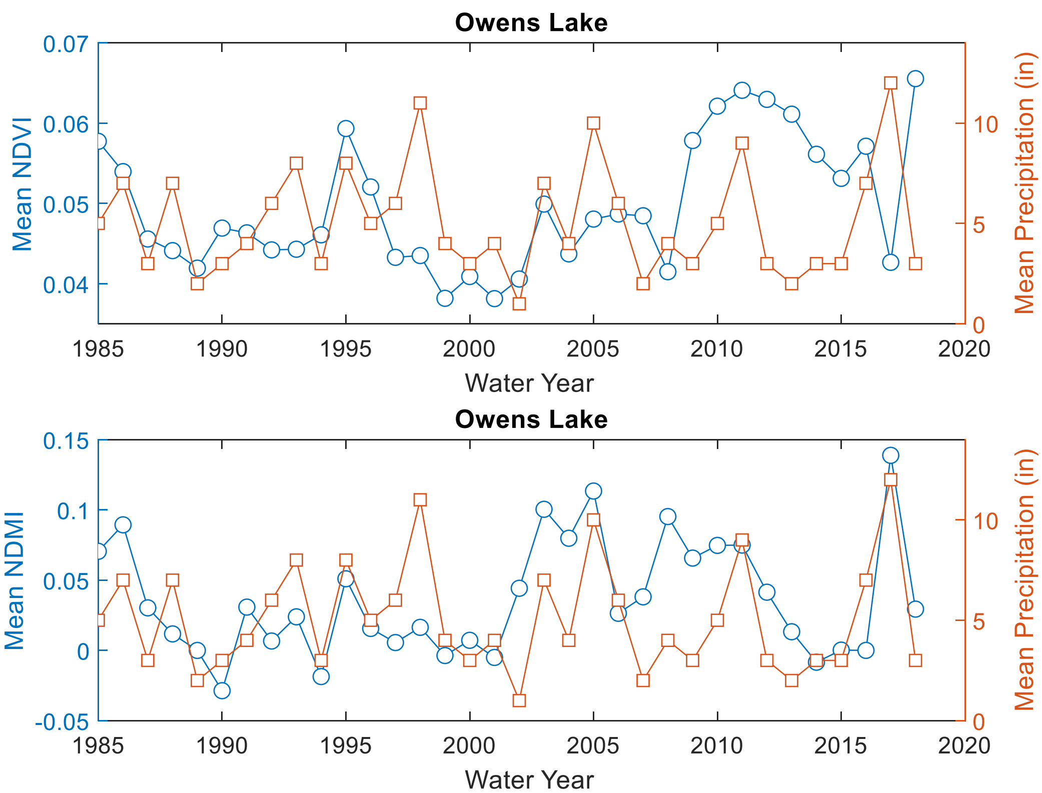

Figure 4.2-7. Weighted area mean NDVI (in blue) and mean precipitation (red) for the Owens Lake management area derived from the TNC pulse tool. The precipitation data was assembled by TNC from PRISM data.

One challenge for analyzing the changes in GDEs is that their area likely expands and contracts through time. The analysis presented here uses fixed maps of GDEs and tracks the changes through time within those fixed GDE areas or polygons. An alternative method would be to track changes in NDVI/NDMI through time in broader areas that could potentially contain GDEs. This method has the advantage of allowing the areal extent of GDEs patches to expand and contract, but it would struggle to define whether observed changes represent a change in the extent of GDEs versus plants that are not dependent on groundwater. Figure 4.2-8 shows the change in NDVI (represented as a regression slope for each pixel) with blue pixels showing areas where the NDVI increased and red pixels showing areas where NDVI decreased. This figure shows that NDVI has increased in some places while decreasing in others. A method that coupled change in NDVI/NDMI with assessment of the change in species composition and groundwater dependence through time would be more robust, but is beyond the scope of this assessment.

Planned restoration and land management actions at Owens Lake (Nuvis 2013) are likely to alter the extent and health of GDEs in the Owens Lake management area.

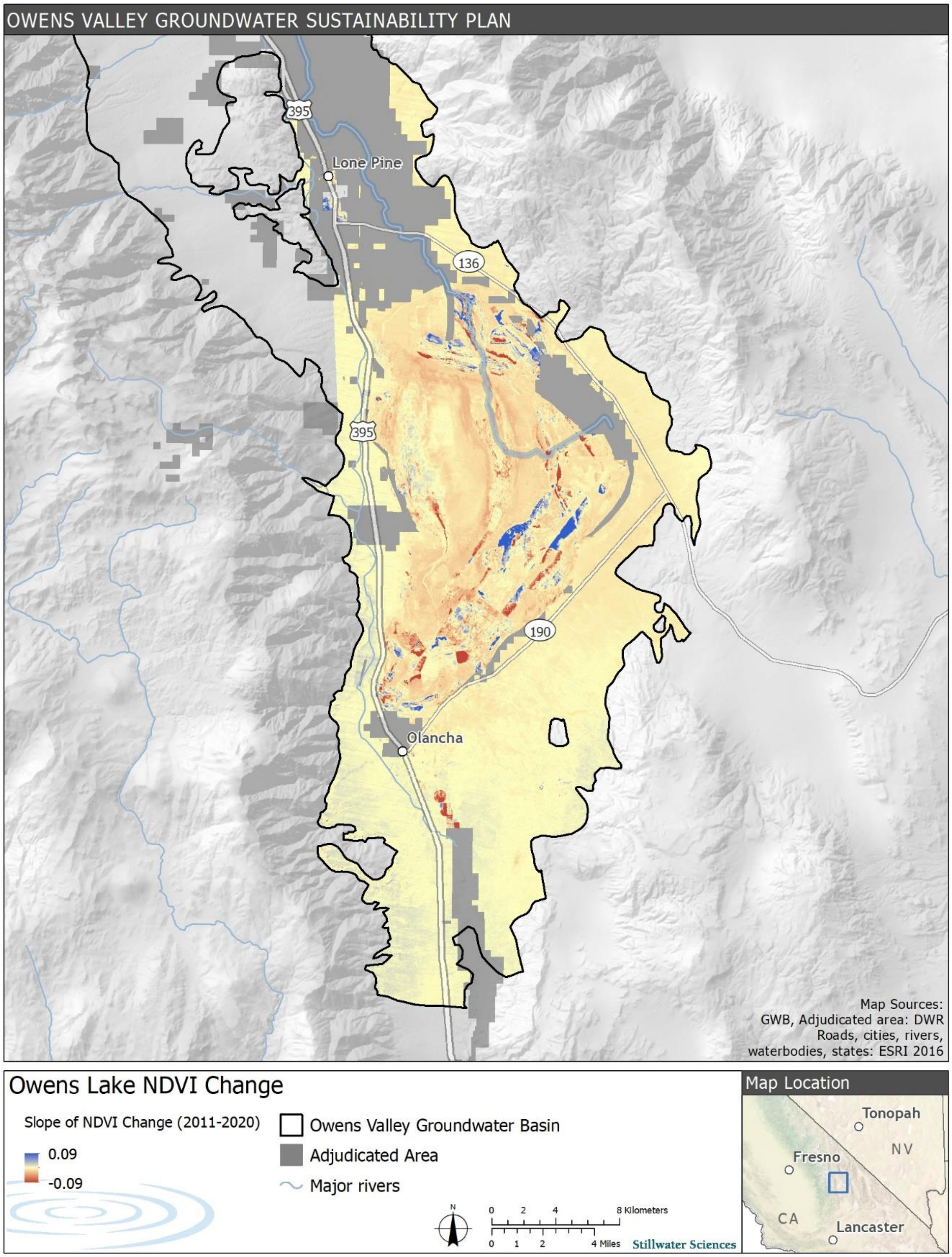

Figure 4.2-8. Slope of NDVI change for Owens Lake from 2011–2020. Data processed using code from Zach Nelson, ICWD.

4.2.3 **Tri-Valley** *management area*

The Tri-Valley management area had a mean NDVI of about 0.15, which is intermediate between Owens Lake and Fish Slough. NDVI ranges from 0.04 to 0.72 (Figure 4.2-9), while NDMI ranges from -0.16 to 0.39 (Figure 4.2-10). The NDMI and NDVI have been increasing since the early 2000s and did not decline during the drought. The high NDVI GDEs are classified as wet meadows, some of which could be influenced by agricultural runoff, although this hasn't been confirmed by field assessments. These wet meadow communities may be sensitive to changes in groundwater and should be monitored in the future to assess their health and connection to groundwater.

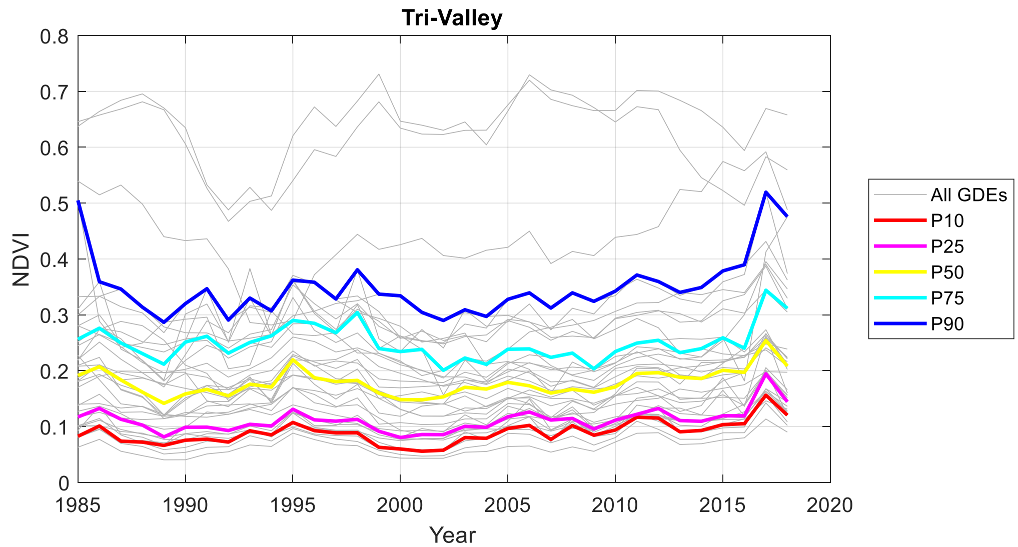

Figure 4.2-9. NDVI through time for the ICWD-corrected GDE polygons in the Tri-Valley management area (the grey lines). The color lines represent the 10th, 25th, 50th, 75th, and 90th percentile NDVI values for each year.

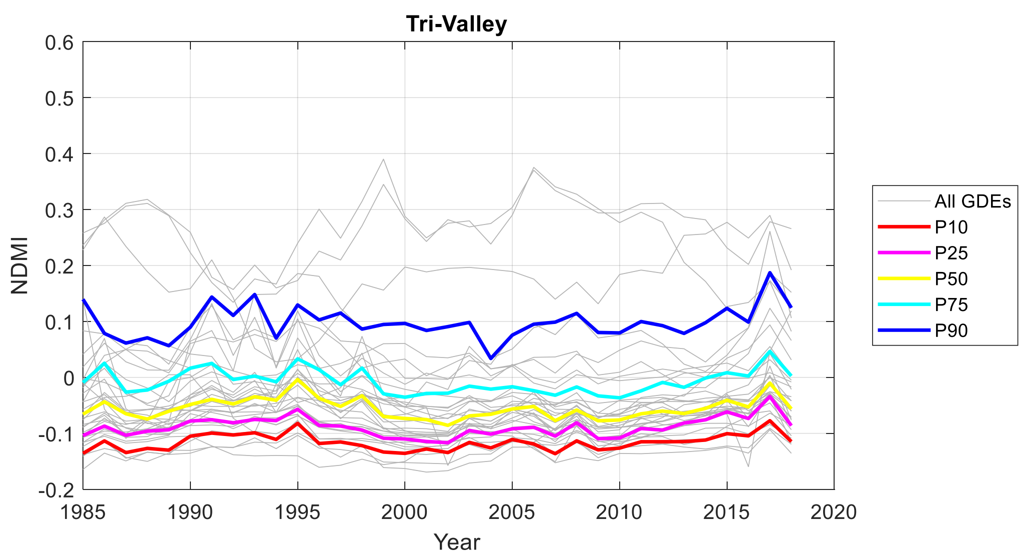

Figure 4.2-10. NDMI through time for the ICWD-corrected GDE polygons in the Tri-Valley management area (the grey lines). The color lines represent the 10th, 25th, 50th, 75th, and 90th percentile NDVI values for each year.

The average NDVI and NDMI decreased from 1986 through 1990 and then was quasi stable until increasing from 1993-1995. The NDVI then gradually decreased until 2002 (Figure 4.2-11). Since 2002 the average NDVI and NDMI have gradually increased, with a large one-year peak in the wet 2017 water year. The average NDVI and NDMI vary slightly with differences in precipitation, but the long-term gradual increases are independent of precipitation.

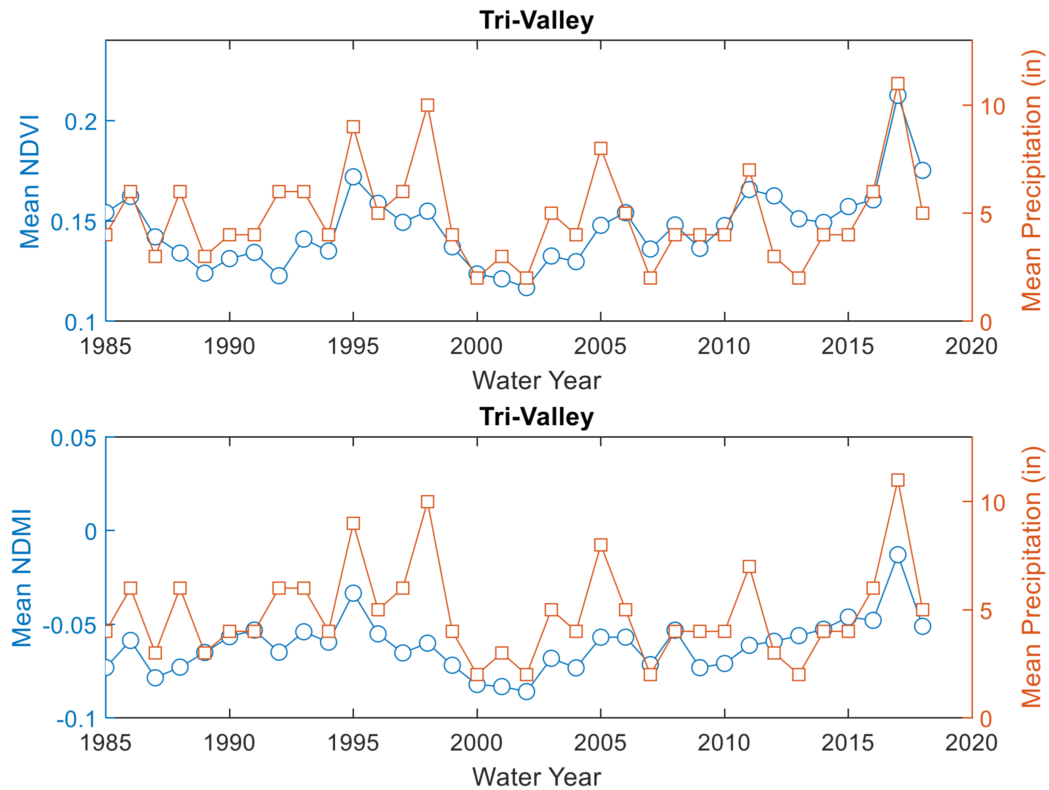

Figure 4.2-11. Area-weighted Mean NDVI (in blue) and mean precipitation (red) for the Owens Lake management area derived from the TNC pulse tool. The precipitation data was assembled by TNC from PRISM data.

4.2.4 Fish Slough

Groundwater dependent vegetation in the Fish Slough management area has an area-weighted average NDVI of 0.22 over the period of record and area-weighted average NDMI of 0.026 (Figure 4.2-1). Both of these values are less than the mean NDVI and NDMI values for Owens Valley GDEs and are greater than Tri-Valley and Owens Lake GDEs (Figure 4.2-1). Overall, the NDVI values in the Fish Slough management area range from <0.1 to 0.72 (the grey lines in Figure 4.2-12). The NDMI values range from -0.13 to 0.45 (the grey lines in Figure 4.2-13).

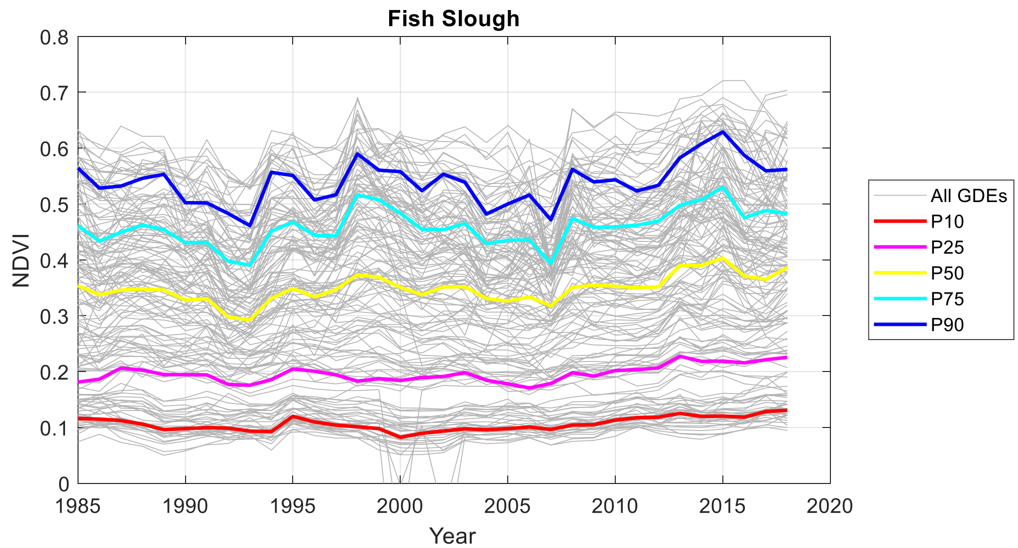

Figure 4.2-12. NDVI through time for the ICWD-corrected GDE polygons in the Fish Slough management area (the grey lines). The color lines represent the 10th, 25th, 50th, 75th, and 90th percentile NDVI values for each year.

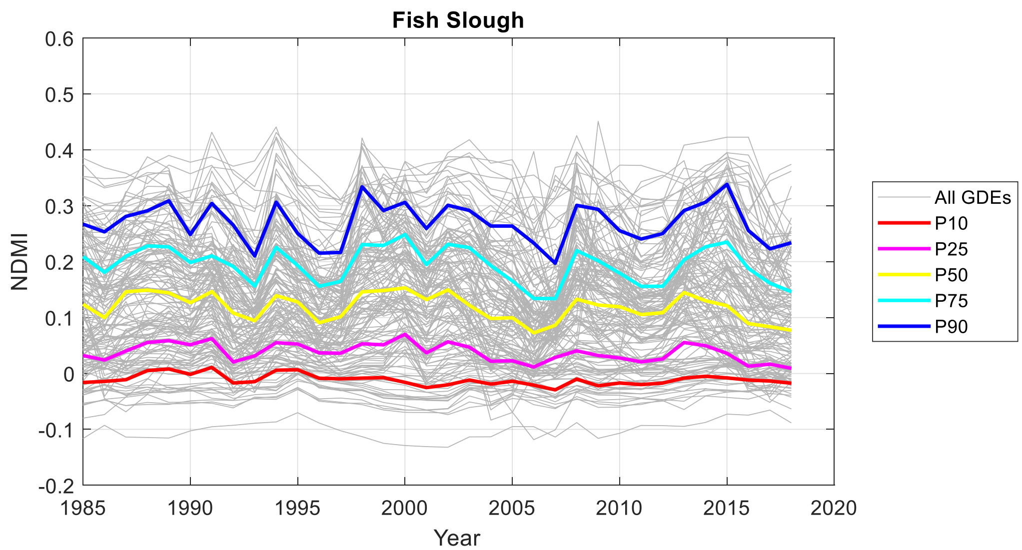

Figure 4.2-13. NDMI through time for the ICWD-corrected GDE polygons in the Fish Slough management area (the grey lines). The color lines represent the 10th, 25th, 50th, 75th, and 90th percentile NDMI values for each year.

From 1994 to 2005, NDVI and NDMI of GDEs in Fish Slough varied with precipitation, with NDVI increases during wetter years, and decreases during drier years (Figure 4.2-14). Starting around 2005, mean NDVI started to increase in the Fish Slough management area through 2011 or 2012. During the 2012–2016 drought the NDVI was relatively constant from 2012–2015 but decreased during 2016 (Figure 4.2-14). The mean NDVI in 2017 (a wet year) increased from 2016, but was still a bit lower than in 2013–2015 during the drought.

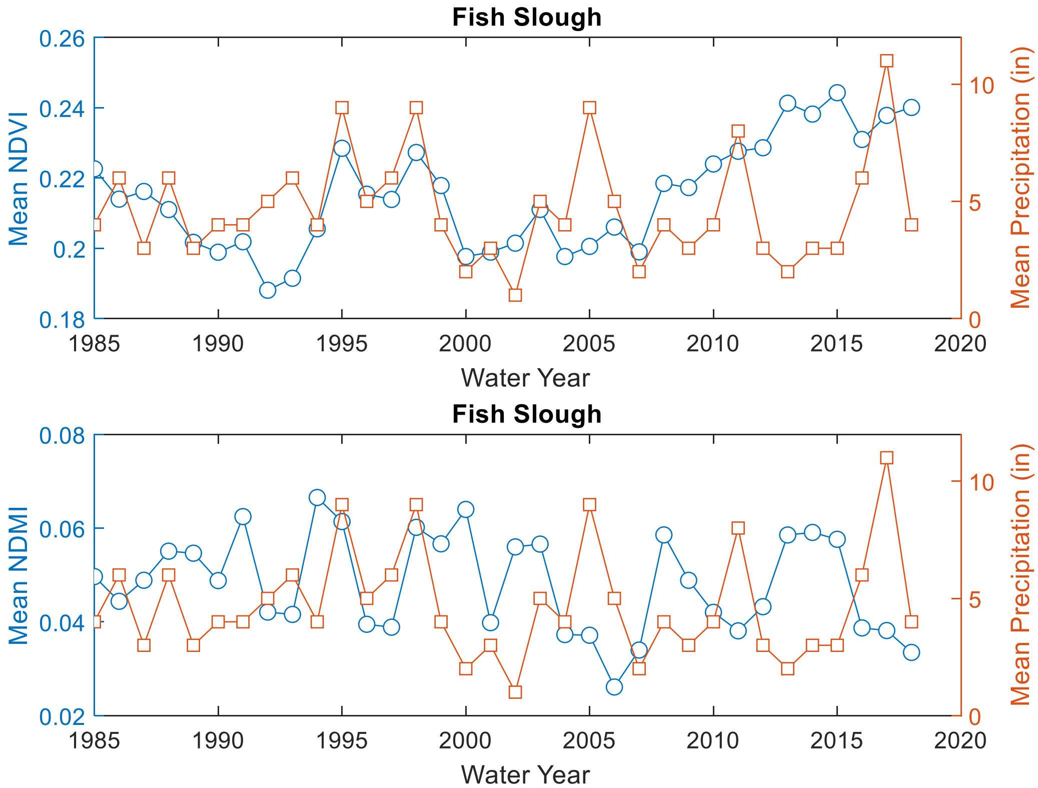

Figure 4.2-14. Area-weighted Mean NDVI (in blue) and mean precipitation (red) for the Fish Slough management area derived from the TNC pulse tool. The precipitation data was assembled by TNC from PRISM data.

GDEs with mean NDVI between 0.1–0.2 were relatively stable over the period of record. These GDEs include *Sarcobatus vermiculatus* (greasewood), *Atriplex parryi* (Parry's saltbush), *Ivesia kingi* (alkali ivesia), *Ericameria albida* (white-flowered rabbitbrush), *Distichlis spicata* (salt grass), *Juncus arcticus* var. *balticus* (Baltic rush), and *J. arcticus* var. *mexicanus* (Mexican rush).

Figure 4.2-15 shows the slope of NDVI change from 2011-2020 and the vegetation map for the Fish Slough Management Area. The NDVI data was obtained using Google Earth Engine using a modified code written by Zach Nelson of ICWD. The patterns of change from 2011-2018 (not shown) is similar to the change from 2011-2020. The most significant changes in NDVI occurred in the eastern half of the management unit. Declines in NDVI typically occurred in tule-cattails adjacent to the channel. Increases in NDVI typically occurred in alkaline mixed grasses and forbs and, to a lesser extent, sections on the edge of the Tule-Cattail in the northwestern limb of the management unit. The cattails and tules (*Schoenoplectus acutus*, *S. americanus*, and *Typha* species) are located near the channel and have high water demands and relatively shallow rooting depths ranging from approximately 0.9-2.1 ft (Appendix C).

In general, the plants with higher NDVI (i.e., tules and cattails) can vary more than plant species and communities with lower NDVI, but that does not automatically suggest that smaller changes represents less important ecological changes. The tules and cattails could be affected by declining flows shown in Section 1.3. The general increases in NDVI since 2005 have occurred throughout

Fish Slough and may reflect changes in the composition and extent of vegetation through time, possibly due to revised water management by the custodial agencies. The GDE pulse tool shows that declines in NDVI and NDMI occur along the mapped wetted channel in the Fish Slough management area, and this decline could reflect decreasing flows. Arresting the decrease in flows is likely crucial to managing GDEs in Fish Slough, but requires additional study to assess the cause of change.

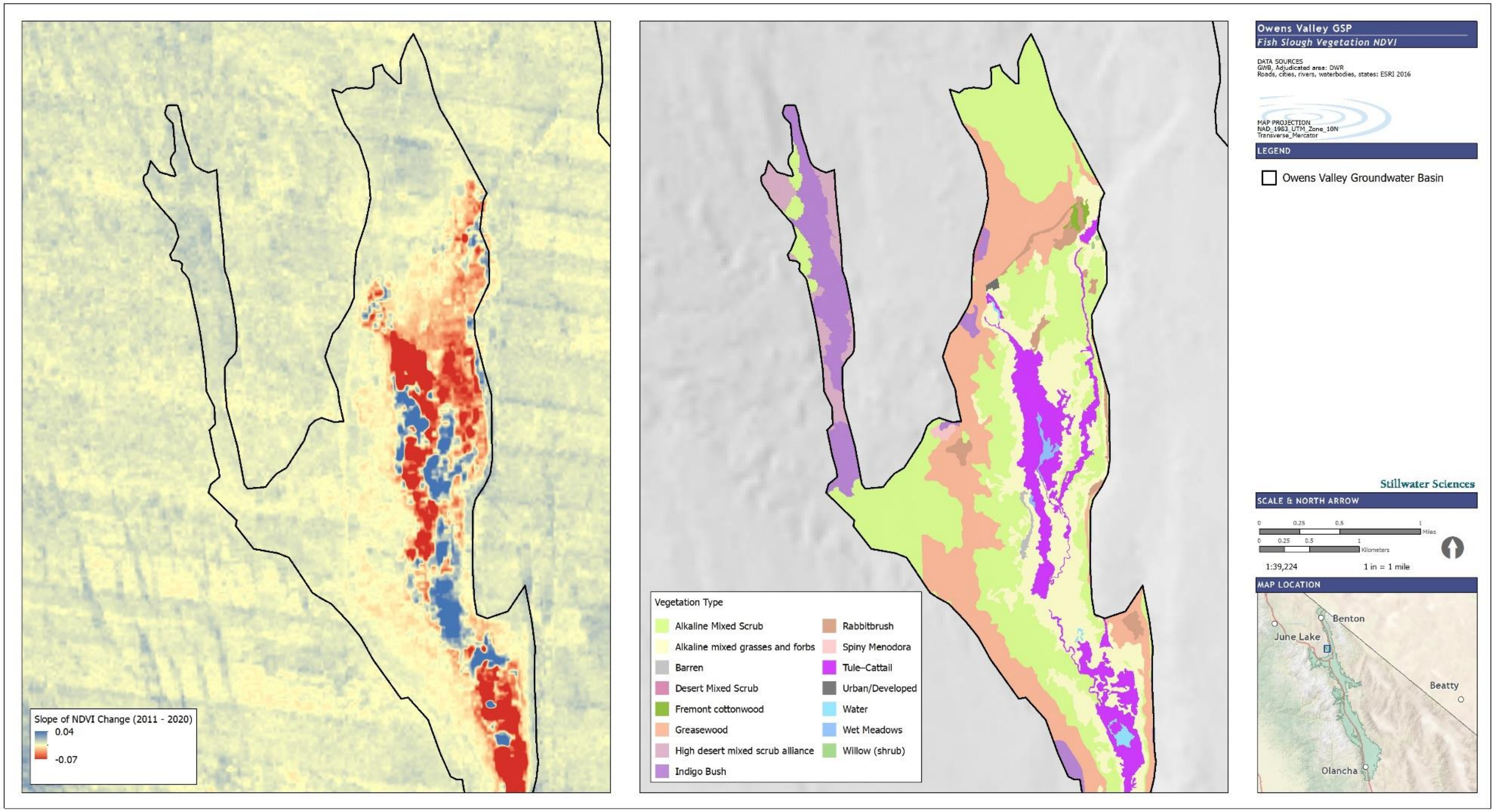

Figure 4.2-15. Comparison of NDVI change from 2011-2020 (left) and the vegetation map of Fish Slough (right) mapped in 2010.

4.3 Climate Change Effects

In Technical Appendix 10 Water Budget, DBS&A used a simple land system water budget to assess potential changes to the annual groundwater budget due to climate change from 2015–2045 and compared that with model results from the historical period (1986–2018). The water groundwater budget is also being assessed for 2056–2085. Climate simulation models contained in the USGS Basin Conceptual Model (BCM) were used to assess predicted changes in precipitation, potential evapotranspiration (PET), surface water runoff, and groundwater recharge. This water budget did not include a groundwater flow model and thus does not account for any future changes in groundwater pumping or interconnected surface water. The BCM predicts the annual water budget for the groundwater basin and its contributing area. The climate model predicts that precipitation will increase by 6% relative to the historical period, while ET will increase by 19%. Further, the climate model predicts that surface runoff will decrease by 5.7% and groundwater recharge will increase by 2.5%. These results are summed for the contributing area and groundwater basin and do not account for changes in vegetation that may co-occur with a warming climate. This assessment does not account for any changes to water diversions or changes in the timing of flows.

Because the climate is projected to be warmer, the proportion of total precipitation in the watershed falling as rain is likely to increase while snow is likely to decrease, and snowmelt is likely to occur earlier in the year compared to current conditions. This is likely to result in decreased baseflows during the summer months in the tributaries from the Sierra Nevada and the White/Inyo mountains. The impacts of flow timing on groundwater elevations have not been explored in the study area. Future changes to interconnected surface waters in Fish Slough may be less affected by changes in flow timing than other waterbodies in the basin because it is spring-fed but the total discharge and outflow from Fish Slough may decline in response to climate change. In addition, climate models suggest that over the next century California is likely to have more frequent, intense precipitation events, while also being subject to more frequent droughts (Swain et al. 2018).

4.4 Summary of Potential Effects

Potential effects on each of the four management areas are summarized here based on three primary criteria:

1. Ecological value (high, moderate, low), as described in Section 3.1.4.
2. Ecological condition of the GDEs within each unit (good, fair, poor), based on the information summarized in Sections 3.1.1 through 3.1.3 and the NDVI/NDMI data presented in Section 4.2.
3. Susceptibility to changing groundwater conditions (high, moderate, low) based on available hydrologic data, climate change projections, and the GDE susceptibility classifications summarized in Table 4.1-1.

4.4.1 Owens Valley

Ecological Value: **High**

- The Owens Valley management area supports a relatively large number of special-status species and ecological communities, some of which are directly dependent on groundwater.

- The management area includes designated critical habitat for four federally listed species.
- The management area supports species and ecological communities that are vulnerable to changes in groundwater levels.

Ecological Condition: **Good**

- NDVI/ NDMI trends from 1985–2018 show minimal change in the management area and indicate vegetation responds mainly to precipitation and runoff. The vegetation structure and functions are relatively intact and within the range of natural variability, and adverse impacts are not likely occurring in the management area as a result of current groundwater management.
- Although the majority of native, special-status fishes have declined or been extirpated from aquatic habitats in the Owens Valley management area due largely to introduced species, suitable habitat is present for most special-status species with likelihood to occur in the management area.
- Ongoing and planned restoration is intended to expand vegetation and wildlife habitat including GDEs.
- Groundwater dependent vegetation contributes to the ecological function, habitat value, and beneficial uses of many of the creeks within the management area.

Susceptibility to Changing Groundwater Conditions: **Moderate**

- Shallow groundwater conditions outside the Adjudicated Area are not well known and thus groundwater conditions in the management area are assessed based on conditions in the adjacent Adjudicated Area. Current shallow groundwater conditions (since 2015) in the Adjudicated Area are within the range of variability since 1980; fluctuations coincide with wet/dry precipitation periods and no trends in groundwater levels over time are observed.
- Future changes in groundwater conditions in the management area related to increased groundwater production or climate change could cause groundwater levels to fall below the baseline range and result in potential effects on GDEs.
- Streams in the management area may be connected to groundwater at their downstream ends, but interconnected surface waters are likely rare for the majority of streams outside the Adjudicated Area.

Potential for Effects

Available data indicate little or no effect on GDEs related to groundwater management in the Owens Valley Management Area since 1985, when Landsat data became available. However, GDEs are moderately susceptible to potential future changes in groundwater conditions (i.e., increased groundwater extractions) in the management area and the synergistic effects of climate change, which in combination could cause groundwater levels to fall below the baseline range and result in potential effects on GDEs.

Monitoring of ecological conditions and trends in vegetation-dominated GDEs and interconnected surface waters, if present, is recommended to document potential adverse impacts related to future groundwater management and identify projects and management actions that can be implemented to avoid or minimize significant and unreasonable impacts to GDEs.

4.4.2 Owens Lake

Ecological Value: **High**

- The Owens Lake management area supports a relatively large number of special-status species and ecological communities, some of which are directly dependent on groundwater.
- The management area includes designated critical habitat for one federally listed species.
- The management area supports species and ecological communities that are vulnerable to changes in groundwater levels.
- The management area contains 83% of the total GDE acreage in the OVGA Assessment Area.

Ecological Condition: **Undetermined**

- NDVI/NDMI trends in the Owens Lake management area from 1985–2018 show minimal change and indicate that vegetation likely responds mainly to surface water inflows to the lake. The long-term decline in the 90th percentile NDMI and considerable long-term fluctuation in the 75th percentile NDMI value cannot be clearly attributed to groundwater management, precipitation, surface water management related to dust control, or other known factors. There is currently little groundwater extraction in this management unit. The variable NDMI values and very low NDVI values make assessing trends difficult using these polygons and indices alone. Assessment of NDVI changes of the Lake as a whole from 2011-2020 show areas of increase and decrease, suggesting that the overall trends depicted by NDVI in the iGDE polygons may not capture changes in GDE health including the expansion and/or contraction of GDEs. Interpreting NDVI/NDMI values is difficult due to poor map quality in the iGDE database, and could be resolved by analyzing the NDVI/NDMI of the updated GDE map and tracking change for the unit as a whole to allow for adjustments in the extent of GDEs. Consequently, it is uncertain whether vegetation structure and functions will remain intact and within the range of natural variability if pumping projects at Owens Lake proceed.
- Availability and suitability of habitat for those special-status species with likelihood to occur in the management area has varied considerably in response to changes in water management and dust control practices affecting Owens Lake. Ongoing and planned habitat restoration projects should help to maintain or enhance habitat conditions.

Susceptibility to Changing Groundwater Conditions: **Moderate**

- Current shallow groundwater conditions in the Owens Lake Management Area have remained relatively stable, with variations of < 2 ft. Prior fluctuations since 1980 appear related to the extent and duration of surface water on the lakebed.
- Future changes in groundwater conditions in the management area related to increased groundwater production, changes in dust management practices, or climate change could cause groundwater levels to fall below the baseline range. Continued management of the lake to maintain botanical and wildlife habitat should reduce the likelihood of adverse effects.
- There are few surface waterbodies in the management area and only the surrounding springs and seeps are considered to be interconnected surface waters.

Potential for Effects

Available data show that groundwater elevation has been relatively stable and while GDE conditions have been dynamic, there is no clear long-term trend in GDE health in the Owens Lake management area. The susceptibility of GDEs in the management area to future changes in groundwater conditions and climate change is considered moderate, and data are insufficient to predict potential effects on GDEs.

Continued monitoring of shallow groundwater, ecological conditions, and trends in vegetation-dominated GDEs and interconnected surface waters, if present, is recommended to document linkages and potential adverse impacts related to future groundwater management and identify projects and management actions to avoid or minimize impacts to GDEs.

4.4.3 Tri-Valley

Ecological Value: **Low**

- The Tri-Valley management area supports a relatively small number of special-status species and ecological communities and few species that are directly dependent on groundwater.
- The management area includes no designated critical habitat for federally-listed species.
- The management area has few species or ecological communities that are vulnerable to changes in groundwater levels.

Ecological Condition: **Fair**

- NDVI/ NDMI trends from 1985–2018 show small fluctuations in the average NDVI and NDMI related to differences in precipitation and a gradual increase since 2002 that appears unrelated to precipitation. GDEs in the management area with high NDVI values are mostly classified as wet meadows, some of which may be influenced by agricultural runoff. These patterns suggest that vegetation structure and functions are relatively intact and within the range of natural variability, and adverse impacts are not likely occurring in the management area as a result of current groundwater management.
- Suitable habitat is present for those special-status species with likelihood to occur in the management area.

Susceptibility to Changing Groundwater Conditions: **Low**

- Depth to water in monitoring wells in the Tri-Valley management area are typically greater than 85 feet below the ground surface, and the presence of shallow groundwater is not known or monitored, although springs and seeps have been mapped in the management area.
- Due to the depth of groundwater in the management area, future changes in groundwater conditions related to increased groundwater production or climate change are unlikely to affect GDEs.
- There are few surface waterbodies and no interconnected surface waters in the management area.~~, and therefore there are no GDEs associated with surface waters are minimal~~.

Potential for Effects

Available data indicate little or no effect on GDEs related to groundwater management in the Tri-Valley management area. The susceptibility of GDEs in the management area to future changes in groundwater conditions and climate change is low, largely because the depth of groundwater far exceeds the rooting depth of phreatophytic vegetation.

Monitoring of ecological conditions and trends in vegetation-dominated GDEs ~~and the few interconnected surface waters~~ is recommended to document potential adverse impacts related to future groundwater management and identify projects and management actions that can be implemented to avoid or minimize impacts to GDEs. The wet meadow communities in this management area are likely sensitive to changes in groundwater and should be included in future monitoring.

4.4.4 Fish Slough

Ecological Value: **High**

- The Fish Slough management area supports a moderate number of special-status species and ecological communities, some of which are directly dependent on groundwater.
- The management area includes critical habitat for one federally listed species.
- The management area supports species and ecological communities that are vulnerable to changes in groundwater levels.
- A high proportion (74%) of the management area's total area is composed of GDEs.
- Fish Slough provides critically important habitat for at-risk populations of endemic fish and plants.

Ecological Condition: **Fair**

- Groundwater dependent vegetation and spring-fed aquatic habitats in the management area provide crucial ecological function and habitat for native aquatic species, terrestrial species, and plants, as well as ecological communities and designated beneficial uses in and adjacent to the management area.
- The extent and suitability of habitat for those special-status species with likelihood to occur in the management area has likely been reduced as groundwater levels and discharge of springs feeding Fish Slough have declined.
- NDVI/ NDMI trends from 1985–2018 show considerable long-term fluctuation in the management area, some of which appears to be related to wet/dry precipitation periods. A general increase in NDVI since 2005 may reflect changes in the composition and extent of vegetation over time, but NDVI decreases in the patches of tules and cattails during the drought have persisted through 2020. The decline of tules and cattails may be related to declining groundwater or interconnected surface water. BLM has conducted some minor vegetation management in Fish Slough (Nick Buckmaster, personal communication), but to our knowledge it is less extensive than the tule and cattail areas where NDVI declined.
- The vegetation structure and functions in the management area appear relatively intact and within the range of natural variability, but adverse impacts may be occurring as a result of current groundwater management.

Susceptibility to Changing Groundwater Conditions: **High**

- Fish Slough is a spring-complex with interconnected surface water that is primarily sourced from groundwater.
- Depth to water in monitoring wells in the Fish Slough management area and discharge in the springs that feed Fish Slough have experienced long-term declines.
- Declines in NDVI and NDMI along the wetted channel in the Fish Slough management area could reflect decreasing flows.
- Persistence and recovery of special-status fishes and other aquatic and terrestrial groundwater dependent species in the management area are highly dependent on maintaining or increasing shallow groundwater levels and spring discharge.
- Future changes in groundwater conditions in the management area related to increased groundwater production or climate change could cause groundwater levels to fall below the baseline range and exacerbate effects on GDEs.

Potential for Effects

Available data indicate potential effects on GDEs related to groundwater management in the Fish Slough management area. GDEs in the management area are highly susceptible to future changes in groundwater conditions and the synergistic effects of climate change, which in combination could drive further reduction of spring discharge and groundwater levels and exacerbate adverse effects on GDEs. Arresting the reduction in spring flows is likely crucial to maintaining the health of GDEs in Fish Slough.

Monitoring of ecological conditions and trends in aquatic habitats (interconnected surface waters) and vegetation-dominated GDEs is recommended to document potential adverse impacts related to future groundwater management and identify projects and management actions that can be implemented to avoid or minimize impacts to GDEs.

5 GDE MONITORING

The health of GDEs has been monitored extensively in the Adjudicated Area of the Basin by ICWD using remote sensing of vegetation coupled with targeted field verification. Applying a similar approach to GDEs outside the Adjudicated Area would allow the OVGA to efficiently monitor GDEs.

The Fish Slough management area includes both declining interconnected surface water flows since the 1960s (Figure 1.3-1) and declining groundwater levels since the 1980s (Figure 1.3-2). The declining interconnected surface flows pose a threat to aquatic and riparian species. The health of GDEs can be monitored by analyzing remotely gathered NDVI and NDMI. In Fish Slough, pairing monitoring of groundwater levels and interconnected surface water discharge with remote sensing of GDEs would allow the OVGA to monitor the likely driver of GDE decline and correlate it with vegetation response.

The Owens Valley GDE has relatively stable shallow groundwater that falls during droughts and rises during wetter periods, although well data are sparse outside of the Adjudicated Area. The GDEs are distributed along the relatively long management area and would require numerous monitoring wells to track spatial changes in shallow groundwater. Remote sensing could be used to target GDEs that are declining relative to historical conditions. Updating the remote sensing analysis to incorporate the new vegetation maps in the southern portion of the Owens Valley management area would allow the vegetation health indicators to be tracked more accurately.

The Owens Lake GDE has relatively stable shallow groundwater that falls during droughts and rises during wetter periods, but shallow groundwater levels are generally within 15 feet of the ground surface. Assessment of the GDE condition through time in this management unit is complicated by the poor map quality in the iGDE database, but updating maps to include the Great Basin wetland map and the Jawbone Canyon and Owens Valley vegetation map should remove the large patches of relatively low NDVI data that skews the results. Continued monitoring of existing wells and remote sensing of vegetation should identify any declines in GDE health.

The Tri-Valley management area has declining groundwater levels, but the presence or changes to shallow groundwater are unknown. Continued monitoring of vegetation using remote sensing with NDVI and NDMI can be used to assess changes with time.

Assessing the groundwater dependence for much of the Owens Valley and Tri-Valley management units requires better quantifying the groundwater dependence of potential GDE polygons mapped in the units. Long-term monitoring, including surveying the presence and distribution groundwater dependent special-status species within the mapped GDEs, should be incorporated into future GDE management plans. Many of the animal species that likely occur within mapped GDEs are categorized as indirectly dependent on groundwater. The extent that the species require groundwater for survival within these GDE units is unknown, particularly in the Owens Valley and Tri-Valley management units. Monitoring of special-status species alongside monitoring GDE health would provide information regarding species dependence on groundwater within the Owens Valley Basin as well as inform the effect on population trends from management activities of these species over time. A focal species approach would be used to understand broader ecosystem linkages so that management actions directed to benefit these species will also benefit the larger ecosystem. This long-term species' monitoring would be used to evaluate the potential effects of changing groundwater, interconnected water supply, and associated GDE vegetation communities on special-status species populations.

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Appendices

Appendix 9-A

GDE Vegetation Communities in Owens Valley Management Areas

Table A-1. Certain and Likely GDE Vegetation types (by source) in Owens Valley management areas.

Vegetation type	Area (acres)				
	Fish Slough	**Owens Lake**	**Owens Valley**	**Tri-Valley**	**Total**
Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG)					
Alkaline mixed grasses and forbs alliance			24.6		**24.6**
Alkaline Mixed Scrub Alliance	136.2	27.4	131.4	782.9	**1,077.9**
Annual Grasses and Forbs Alliance			1.3		**1.3**
Barren			60.9		**60.9**
Bitterbrush Alliance			9.3		**9.3**
Black Cottonwood Alliance			36.2	3.0	**39.3**
Canyon Live Oak Alliance		0.0			**0.0**
Desert Mixed Shrub Alliance			5.6		**5.6**
Eastside Pine Alliance			34.6		**34.6**
Ephedra Alliance			1.9		**1.9**
Fremont Cottonwood Alliance		17.8	250.0	1.1	**268.9**
Grain and Crop Agriculture			1.2		**1.2**
Greasewood Alliance			0.1		**0.1**
Great Basin – Desert Mixed Scrub Alliance			22.2		**22.2**
Great Basin Mixed Scrub Alliance			5.5		**5.5**
High Desert Mixed Scrub Alliance			9.7		**9.7**
Horsebrush Alliance			1.1		**1.1**
Indigo Bush Alliance			0.1		**0.1**
Perennial Grass/Forb Alliance			6.0		**6.0**
Playas (desert basin features)			1.4		**1.4**
Quaking Aspen Alliance		0.2	140.4		**140.6**
Riparian Mixed Hardwood Alliance		6.8	323.5		**330.3**
Saltbrush Alliance			24.1		**24.1**
Shadescale Alliance			2.4		**2.4**
Shrub Willow Alliance		1588.0	1,149.8	110.3	**2,848.1**
Singleleaf Pinyon Pine Alliance		5.3	25.3		**30.6**
Tule - Cattail Alliance		233.6	11.4		**244.9**
Water			4.4		**4.4**
Water Birch Alliance		4.8	245.9		**250.7**
Wet Meadow Alliance		13.6	1,082.7	112.8	**1,209.1**
Willow Alliance		52.8	392.7		**445.5**
Fire and Resource Assessment Program's (FRAP)					
Alkali Desert Scrub		29.9	0.5		**30.4**
Barren		0.0			**0.0**
Desert Riparian		0.0			**0.0**
Desert Scrub		0.0			**0.0**
Montane Riparian		18.7	6.4		**25.2**
Sagebrush		1.6	45.4		**47.0**
Great Basin Unified Air Control District (GBUACD)					
Wetland		158.2	1.0		**159.3**

Vegetation type	Area (acres)				
	Fish Slough	**Owens Lake**	**Owens Valley**	**Tri-Valley**	**Total**
Indicators of Groundwater Dependent Ecosystems (iGDE) – National Hydrography Dataset (NHD)					
Seep or Spring		2.5	7.2	4.1	**13.8**
iGDE – National Wetland Inventory (NWI)					
Lacustrine, Littoral, Unconsolidated Shore, Seasonally Flooded		0.2			**0.2**
Palustrine, Emergent, Persistent, Seasonally Flooded		0.8	174.5	0.5	**175.8**
Palustrine, Emergent, Persistent, Seasonally Saturated		4.0	59.4	2.6	**66.1**
Palustrine, Forested, Broad-Leaved- Evergreen, Seasonally Saturated		0.8			**0.8**
Palustrine, Forested, Seasonally Flooded			15.5		**15.5**
Palustrine, Forested, Seasonally Saturated			22.0		**22.0**
Palustrine, Scrub-Shrub, Broad-Leaved-Evergreen, Seasonally Flooded			0.3		**0.3**
Palustrine, Scrub-Shrub, Broad-Leaved-Evergreen, Seasonally Saturated		4.8	56.3		**61.1**
Palustrine, Scrub-Shrub, Seasonally Flooded		8.8	113.6	13.8	**136.2**
Palustrine, Scrub-Shrub, Seasonally Saturated		0.1	59.4	0.9	**60.4**
Palustrine, Unconsolidated Bottom, Permanently Flooded			0.1		**0.1**
Palustrine, Unconsolidated Shore, Seasonally Flooded			2.9		**2.9**
Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded			0.7		**0.7**
Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded		1.2	50.1	1.4	**52.8**
Riverine, Upper Perennial, Rock Bottom, Permanently Flooded		7.2	16.0		**23.2**
Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded			6.4		**6.4**
Vegetation Classification and Mapping Program (VegCAMP) – Fish Slough					
Alkaline Mixed Grasses and Forbs	547.1		17.1		**564.2**
Alkaline Mixed Scrub	574.2		44.4		**618.6**
Big Sagebrush			4.3		**4.3**
Fremont Cottonwood	7.5				**7.5**
Greasewood	573.0		62.6		**635.6**
Rabbitbrush	54.7		1.1		**55.8**
Tule-Cattail	276.1		17.6		**293.7**
Water	9.6				**9.6**
Wet Meadows	10.1				**10.1**
Willow (shrub)	2.0				**2.0**

Vegetation type	Area (acres)				
	Fish Slough	Owens Lake	Owens Valley	Tri-Valley	Total
VegCAMP – Jawbone Canyon Region and Owens Valley					
Ambrosia dumosa		8.0	35.6		**43.6**
Ambrosia salsola – Bebbia juncea Alliance			2.4		**2.4**
Anemopsis californica		39.3			**39.3**
Anthropogenic Areas of Little or No Vegetation		0.5	1.1		**1.6**
Arid West Freshwater Emergent Marsh Group		11.2			**11.2**
Artemisia tridentata		17.2	122.0		**139.2**
Atriplex canescens		<0.1	1.5		**1.5**
Atriplex confertifolia		5.8	11.5		**17.3**
Atriplex lentiformis		1.3	6.2		**7.5**
Atriplex polycarpa		55.5	27.3		**82.8**
Baccharis sergiloides		1.8			**1.8**
Betula occidentalis		5.5	221.9		**227.4**
Bolboschoenus maritimus, Schoenoplectus americanus		130.8			**130.8**
Built-up & Urban Disturbance		21.9	29.6		**51.5**
Chorizanthe rigida – Geraea canescens Desert Pavement Sparsely Vegetated		8.2			**8.2**
Coleogyne ramosissima		9.3	25.6		**34.9**
Dicoria canescens – Abronia villosa		1.1			**1.1**
Distichlis spicata		5,367.9	9.7		**5,377.6**
Ephedra nevadensis – Lycium andersonii – Grayia spinosa		11.2	219.1		**230.3**
Ericameria nauseosa		26.1	32.2		**58.3**
Ericameria nauseosa – Atriplex lentiformis Mapping Unit		15.5	18.8		**34.3**
Eriogonum fasciculatum – (*Viguiera parishii*) Alliance		2.8	15.1		**17.9**
Eucalyptus spp. – *Ailanthus altissima – Robinia pseudoacacia*		3.2	11.6		**14.8**
Exotic Trees			6.4		**6.4**
Forestiera pubescens			0.6		**0.6**
Irrigated Pastures		3.3	27.6		**30.9**
Juncus arcticus (var. *balticus, mexicanus*)		108.9	2.7		**111.6**
Larrea tridentata – Ambrosia Dumosa		20.4			**20.4**
Major Canals and Aqueducts		0.1			**0.1**
Non-woody Row and Field Agriculture		3.6			**3.6**
North American Warm Desert Dunes and Sand Flats Group		0.2			**0.2**
Perennial Stream Channel			0.7		**0.7**
Pinus jeffreyi Alliance			3.3		**3.3**
Pinus monophyla			1.2		**1.2**
Populus fremontii		82.6	5.0		**87.6**
Populus trichocarpa		1.3	5.0		**6.3**
Psorothamnus fremontii – Psorothamnus polydenius		11.3	0.4		**11.7**
Purshia tridentata			19.7		**19.7**

Vegetation type	Area (acres)				
	Fish Slough	**Owens Lake**	**Owens Valley**	**Tri-Valley**	**Total**
Quercus chrysolepis		14.3			**14.3**
Quercus wislizeni			5.5		**5.5**
Restoration		3,562.2			**3,562.2**
Rosa woodsii			6.4		**6.4**
Salix exigua		16.4	53.1		**69.5**
Salix gooddingii – Salix laevigata Alliance		11.8	26.1		**37.9**
Salix lasiolepis		10.5	63.9		**74.4**
Sarcobatus vermiculatus		10,578.3	200.5		**10,778.8**
Schoenoplectus (*acutus*, *californicus*)		502.8	1.5		**504.3**
Sparsely Vegetated Playa (Ephemeral Annuals)		5,477.8	11.0		**5,488.8**
Sparsely Vegetated Recent Burned Areas			15.3		**15.3**
Sporobolus airoides		103.2	55.3		**158.5**
Suaeda moquinii – Isocoma acradenia Alliance		2,396.1			**2,396.1**
SW North American Riparian/Wash Scrub Group			2.3		**2.3**
Tamarix spp.		151.1	0.2		**151.3**
Typha (*angustifolia*, *domingensis*, *latifolia*) Alliance		18.9	3.7		**22.6**
Unvegetated Wash and River Bottom		0.2	1.4		**1.6**
Vancouverian and Rocky Mountain Naturalized Annual Grassland Group		22.2	12.0		**34.2**
Warm Semi-Desert/Mediterranean Alkali-Saline Wetland Macrogroup		1,777.7			**1,777.7**
Water		1.9	0.9		**2.8**
Water Impoundment Feature		165.5			**165.5**
Yucca brevifolia		1,521.4			**1,521.4**
VegCAMP – Mojave					
Big Sagebrush		223.3			**223.3**
Iodine Bush-Bush Seepweed		4,753.4			**4,753.4**
Joshua Tree		935.1			**935.1**
Shadscale		2,625.4	1.3		**2,626.7**
White Burrobush		3,094.8			**3,094.8**
Total	**2,190.5**	**46,129.2**	**6,114.7**	**1,033.4**	**55,468.2**

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Appendix 9-B

Special-status Wildlife and Aquatic Species from Database Queries

Table B-1. Special-status terrestrial and aquatic animal species with known occurrence, or presence of suitable habitat in the Owens Valley Groundwater Authority (OVGA) Assessment Area.

Common name *Scientific name*	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Mammals					
California wolverine *Gulo gulo*	FPT, FSS/ST, SFP	Likely (limited distribution)	CNDDB	No known reliance on groundwater	Dense mixed-conifer forest in North Coast and Sierra Nevada mountains of California; uses caves, hollows, logs, rock outcrops, and burrows for cover. Nocturnal, solitary, species which are primarily scavengers. Wolverines will also prey on small to medium sized mammals. Individuals have very large home ranges, and they are known to travel great distances, occasionally in daylight. Females require dens that are excavated in snow deeper than 5 feet. Occurring in North Coast at 1,600–4,800 feet and in Sierra Nevada mountains at 4,300–10,800 feet. Documented in the vicinity of Owens Valley management area east of Seven Pines (CDFW 2019).
Long-legged myotis *Myotis volans*	BLMS/–	Likely	CNDDB	Indirect	Most common in woodland and forest habitats above 4000 feet, but also found in chaparral, coastal scrub, Great Basin shrub habitats, from sea level to 11,400 feet. Feeds on flying insects, primarily moths, over water and open habitats. Documented in Owens Valley management areas near Laws and in the vicinity of the Owens Lake management area (CDFW 2019). Drinks water, feeds over water, and may be found in riparian habitat. Facultatively groundwater dependent (TNC 2019a).

Common name ***Scientific name***	**Status[1]** **Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Mohave ground squirrel *Xerospermophilus mohavensis*	BLMS/ST	Likely	CNDDB	Indirect	Prefers desert scrub (e.g., open and alkali) and Joshua tree communities with sandy to gravelly soils and flat to moderately hilly terrain. Typically documented at 1,800 and 5,000 feet elevation. Relies on groundwater-dependent vegetation for forage (Rhode et al. 2019). Documented in Owens Lake management area (CDFW 2019).
Owens Valley vole *Microtus californicus vallicola*	BLMS/SSC	Likely	CNDDB	Indirect	Nocturnal short-tailed vole with limited range in Owens Valley and Fish Slough, most common in native meadows. Much of their time is spent underground in burrows; foraging takes place on above-ground runways connecting burrows. Feeds on stems and leaves of forbs and grasses. Documented in Owens Valley, Owens Lake, Fish Slough, and Tri-Valley management areas (CDFW 2019).
Pallid bat *Antrozous pallidus*	FSS, BLMS/ SSC	Likely	CNDDB	No known reliance on groundwater	Roosts in rock crevices, tree hollows, mines, caves, and a variety of vacant and occupied buildings; feeds in a variety of open woodland habitats. Habitat and prey (e.g., insects and arachnids) not associated with aquatic ecosystems. Documented in Owens Valley, Owens Lake, and Fish Slough management areas (CDFW 2019).
Sierra Nevada bighorn sheep *Ovis canadensis sierrae*	FE/SE	Likely	CNDDB	Indirect	Prefer open arid habitat including alpine meadows, summit plateaus, and hanging meadows fed by springs. It relies on groundwater-dependent herbaceous plants, grasses, and shrubs (Rhode et al. 2019). Typically found at high elevations in the summer (10,000–14,000 ft) and lower elevations in the winter (5,000–9,000 feet). USFWS critical habitat overlaps with the Owens Lake and Owens Valley management areas.

Common name *Scientific name*	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Sierra Nevada red fox *Vulpes vulpes necator*	FPE, FSS/ST	Likely	CNDDB	Indirect	Depends on ground-water dependent vegetation for its habitat and foraging habitat (Rhode et al. 2019). Prefers wet meadows to forested areas; high-elevation conifer forest, and sub-alpine woodlands; dense vegetation and rocky areas for den sites. Preys on small mammals and lagomorphs (e.g., rabbits and pikas). Elevational distribution is 5,000 to 7,000 ft. Documented in Owens Valley management area, including vicinity of Bishop and 1.8 miles west of Rovanna (CDFW 2019).
Spotted bat *Euderma maculatum*	BLMS/SSC	Likely	CNDDB	Indirect	Highly associated with cliffs and rock crevices, although may occasionally use caves and buildings; inhabit arid deserts, grasslands, and mixed coniferous forests. Feeds on moths over water and along washes. Drinks water. Documented in Owens Valley management area, in the vicinity of Bishop, and throughout the Owens Lake management area (CDFW 2019).
Townsend's big-eared bat *Corynorhinus townsendii*	FSS, BLMS/SSC	Likely	CNDDB	Indirect	Most abundant in mesic habitats, also found in oak woodlands, desert, vegetated drainages, caves or cave-like structures (including basal hollows in large trees, mines, tunnels, and buildings) and riparian communities. Feeds on moths, beetles, and sofeet-bodied insects and drinks water. Documented in Owens Valley, Owens Lake, and Fish Slough management areas (CDFW 2019).
Western small-footed myotis *Myotis ciliolabrum*	BLMS/–	Likely	CNDDB	Indirect	Found in arid, upland habitats and prefers open stands in forests and woodlands as well as brushy habitats near water. Utilize caves, buildings, mines, and crevices for cover. Prey includes small flying insects. Forages among trees and over water. Drinks water. Documented in Owens Valley management area (CDFW 2019).

Common name ***Scientific name***	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Western white-tailed jackrabbit *Lepus townsendii townsendii*	–/SSC	Likely	CNDDB	No known reliance on groundwater	Nocturnal solitary species with most activity occurring near dusk. Found in plains, prairies, sagebrush, and alpine meadows with scattered coniferous trees, up to 14,000 ft in elevation (Hall 1991). Feeds on grasses and shrubs. Documented in Owens Valley management area near Bishop (CDFW 2019).
Yuma myotis *Myotis yumanensis*	BLMS/–	Likely	CNDDB	Indirect	Use a variety of habitats including riparian, agriculture, shrub, urban, desert, , open forests and woodlands. Distribution is strongly associated with water; drinks water and forages near or over waterbodies. Documented in Owens Lake management area (CDFW 2019).
Birds					
American white pelican *Pelecanus erythrorhynchos*	–/SSC (nesting colonies)	Likely	CAFSD, eBird	Indirect	Salt ponds, large lakes, and estuaries; loafs on open water during the day; roosts along water's edge at night. Forages for small fish in shallow water on inland marshes. Owens Valley and Fish Slough are both used during pre-breeding migration; breeding likely occurs in areas of Fish Slough (eBird 2020). Occurrences in Owens Lake, Owens Valley and Fish Slough management areas (eBird 2020).
Bald eagle *Haliaeetus leucocephalus*	FD, BGEPA, BLMS/SE, SFP	Likely	CNDDB, CAFSD, eBird	Indirect	Large bodies of water or rivers with abundant fish, uses snags or other perches; nests in advanced-successional conifer forest near open water (e.g., lakes, reservoirs, rivers). Bald eagles are reliant on surface water that may be supported by groundwater and/or groundwater-dependent vegetation (Rhode et al. 2019). Occurrences in Owens Lake, Tri-Valley (eBird 2020), and Owens Valley management areas (eBird 2020, CDFW 2019).

Common name *Scientific name*	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Bank swallow *Riparia riparia*	BLMS/ST	Likely	CNDDB, CAFSD, eBird	Indirect	Nests in vertical bluffs or banks, usually adjacent to water (i.e., rivers, streams, ocean coasts, and reservoirs), where the soil consists of sand or sandy loam. Feeds on caterpillars, insects, frog/lizards, and fruit/berries. Relies on surface water that may be supported by groundwater (Rohde et al 2019). Occurrences in Owens Valley (CDFW 2019, eBird 2020), Fish Slough, Tri-Valley, and Owens Lake management areas (eBird 2020).
Black tern *Chlidonias niger*	–/SSC	Likely	CAFSD, eBird	Indirect	Nests semi-colonially in protected areas of marshes with floating nests. Feeds on insects. Owens Valley and Fish Slough are used for pre-breeding and post-breeding migration (eBird 2020). Occurrences in Owens Lake, Owens Valley, and Fish Slough management areas (eBird 2020).
Burrowing owl *Athene cunicularia*	BLMS/SSC	Likely	CNDDB, eBird	No known reliance on groundwater	Level, open, dry, heavily grazed or low- stature grassland or desert vegetation with available burrows. Preys on invertebrates and vertebrates. Occurrences in Owens Valley, Fish Slough (CDFW 2019, eBird 2020), and Owens Lake management areas (eBird 2020).
Golden eagle *Aquila chrysaetos*	BGEPA, BLMS/SFP	Likely	CNDDB, eBird	No known reliance on groundwater	Open woodlands and oak savannahs, grasslands, chaparral, sagebrush flats; nests on steep cliffs or medium to tall trees. Primary prey are small to medium mammals and birds; also scavenge and catch fish. Occurrences in Fish Slough (CDFW 2019, eBird 2020), Owens Valley, Owens Lake, and Tri-Valley management areas (eBird 2020).
Le Conte's thrasher *Toxostoma lecontei*	BLMS/SSC	Likely	CNDDB, eBird	No known reliance on groundwater	Desert scrub, mesquite, tall riparian brush and, chaparral. Preys on insects and spiders; also feeds on seeds and berries. Occurrences in Owens Lake (CDFW 2019, eBird 2020), Owens Valley, and Fish Slough management areas (eBird 2020).

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in GDE management areas	Query source[2]	GDE association[3]	Habitat and documented occurrences in management areas
Least Bell's vireo *Vireo bellii pusillus*	FE/SE	Unlikely	CNDDB, CAFSD	Indirect	Nests in dense vegetative cover of riparian areas; often nests in willow or mulefat; forages in dense, stratified canopy. This species relies on groundwater-dependent vegetation in riparian areas, particularly during breeding periods (Rohde et al 2019). Eats insects, fruits, and berries. Occurrences in Owens Valley and Owens Lake management areas are presumed extirpated (CDFW 2019).
Least bittern *Ixobrychus exilis*	FSS/SSC	Likely	CNDDB, CAFSD, eBird	Indirect	Freshwater and brackish marshes with dense aquatic or semiaquatic vegetation interspersed with clumps of woody vegetation and open water. Prey includes fish, frogs, crayfish, crustaceans, insects, and small rodents. Occurrences in Owens Lake management area (CDFW 2019, eBird 2020), and in the vicinity of Owens Valley management area (CDFW 2019, eBird 2020).
Loggerhead shrike *Lanius ludovicianus*	–/SSC	Likely	CNDDB, eBird	No known reliance on groundwater	Open shrubland or woodlands with short vegetation and and/or bare ground for hunting; some tall shrubs, trees, fences, or power lines for perching; typically nest in isolated trees or large shrubs. Feeds on insects, amphibians, reptiles, small mammals, and birds. Occurrences in Owens Lake (CDFW 2019, eBird 2020), Owens Valley, Fish Slough, and Tri-Valley management areas (eBird 2020).
Long-eared owl *Asio otus*	BLMS/SSC	Likely	CNDDB, eBird	Indirect	Riparian habitat; nests in dense vegetation close to open grassland, meadows, riparian, or wetland areas for foraging. Prey on small mammals. Occurrences in Owens Valley (CDFW 2019, eBird 2020), Owens Lake Fish Slough, and Tri-Valley management areas (eBird 2020).
Lucy's warbler *Oreothlypis luciae*	–/SSC	Likely	CAFSD, eBird	Indirect	Breeds in riparian mesquite woodlands. Preys on aquatic organisms including insects, crustaceans, zooplankton, and invertebrates. Owens Valley, Owens Lake area, and southern areas of Fish Slough are used for breeding (eBird 2020). Occurrences in Owens Valley and Owens Lake management areas (eBird 2020).
Mountain plover *Charadrius montanus*	FPT, BLMS/SSC	Likely	CNDDB, eBird	No known reliance on groundwater	Occupies open plains or rolling hills with short grasses or very sparse vegetation; nearby bodies of water are not needed; may use newly plowed or sprouting grain fields. Preys on insects.

Common name ***Scientific name***	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
					Occurrences in Owens Valley and Owens Lake management areas (CDFW 2019, eBird 2020).
Northern goshawk *Accipiter gentilis*	FSS/SSC	Likely	CNDDB, CAFSD, eBird	No known reliance on groundwater	Mature and old-growth stands of coniferous forest, middle and higher elevations; nests in dense part of stands near an opening. May hunt in riparian corridors. Preys on birds, mammals, and reptiles. Occurrences in the vicinity of Fish Slough (eBird 2020) and Owens Valley management areas (CDFW 2019, eBird 2020).
Northern harrier *Circus hudsonius*	–/SSC	Likely	CNDDB, eBird	Indirect	Nests, forages, and roosts in wetlands or along rivers or lakes, but also in grasslands, meadows, or grain fields. Eats small mammals, amphibians, reptiles, and birds. Occurrences in Owens Valley (CDFW 2019, eBird 2020), Owens Lake, Fish Slough and Tri-Valley management areas (eBird 2020).
Redhead *Aythya americana*	–/SSC	Likely	CAFSD, eBird	Indirect	Freshwater emergent wetlands with dense stands of cattails (*Typha* spp.) and bulrush (*Schoenoplectus* spp.) interspersed with areas of deep, open water; forage and rest on large, deep bodies of water. Summer resident in southern California. Owens Valley management area used during pre-breeding migration and occasionally for breeding. Occurrences in Owens Lake, Owens Valley, and historical sightings in Fish Slough management areas (eBird 2020).
Southwestern willow flycatcher *Empidonax traillii extimus*	FE/SE	Likely	CNDDB, CAFSD	Indirect	Dense brushy thickets within riparian woodland often dominated by willows and/or alder, near permanent standing water. Reliant on groundwater-dependent riparian vegetation, including for nest sites that are typically located near slow-moving streams, or side channels and marshes with standing water and/or wet soils (Rohde et al 2019). Feeds on insects, fruits, and berries. Occurrences in Fish Slough and Owens Valley management areas (CDFW 2019).

Common name *Scientific name*	Status[1] Federal/State	Potential to occur in GDE management areas	Query source[2]	GDE association[3]	Habitat and documented occurrences in management areas
Summer tanager *Piranga rubra*	–/SSC	Likely	CAFSD, eBird	Indirect	Open mixed lowland forests, nesting in mature riparian cottonwood forests. Feed on bees, wasps, and other insects. Owens Valley and Fish Slough management areas are used for breeding. Occurrences documented in Owens Valley management area, and in the vicinity of Owens Lake management area (eBird 2020).
Swainson's hawk *Buteo swainsoni*	–/ST	Likely	CNDDB, eBird	Indirect	Nests in oaks or cottonwoods in or near riparian habitats; forages in grasslands, irrigated pastures, and grain fields. Swainson's hawks rely on groundwater-dependent vegetation in riparian woodland areas for nesting (Rohde et al 2019). Preys on mammals and insects. Occurrences in Owens Valley, Tri-Valley (CDFW 2019, eBird 2020), Owens Lake, Fish Slough, management areas (eBird 2020).
Tricolored blackbird *Agelaius tricolor*	–/ST	Unlikely	CAFSD	Indirect	Feeds in grasslands and agriculture fields; nesting habitat components include open accessible water with dense tall emergent vegetation, a protected nesting substrate (including flooded or thorny vegetation), and a suitable nearby foraging space with adequate insect prey. Relies on groundwater dependent ecosystems for breeding and roosting (Rohde et al 2019). No listed occurrences in management areas, outside of the species' range (eBird 2020).
Western snowy plover *Charadrius alexandrinus nivosus*	–/SSC	Likely	CNDDB	Indirect	Barren to sparsely vegetated beaches, barrier beaches, salt-evaporation pond levees, and shores of alkali lakes; also nests on gravel bars in rivers with wide flood plains; needs sandy, gravelly, or friable soils for nesting. Western snowy plovers can nest near wetlands that may be supported by groundwater, including near freshwater wetlands (Rhode et al. 2019). Occurrences in Owens Valley and Owens Lake management areas (CDFW 2019).

Common name ***Scientific name***	**Status[1]** **Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Western yellow-billed cuckoo *Coccyzus americanus occidentalis*	FT, FSS, BLMS/SE	Likely;	CNDDB, CAFSD	Indirect	Summer resident of valley foothill and desert riparian habitats; nests in open woodland with clearings and low, dense, scrubby vegetation. Reliant on groundwater-dependent riparian vegetation for habitat (Rhode et al. 2019). Documented in the vicinity of Owens Valley management area (CDFW 2019). USFWS Critical habitat overlaps with Owens Valley management areas.
Yellow-breasted chat *Icteria virens*	–/SSC	Likely	CNDDB, CAFSD, eBird	Indirect	Early-successional riparian habitats with a dense shrub layer and an open canopy. Foraging in dense vegetation for insects and berries. Owens Valley, Owens Lake area, and Fish Slough are heavily used for breeding and migration. Occurrences in Owens Lake, Owens Valley (CDFW 2019, eBird 2020), and Fish Slough management areas (eBird 2020).
Yellow-headed blackbird *Xanthocephalus xanthocephalus*	–/SSC	Likely	CAFSD, eBird	Indirect	Breeds almost entirely in open marshes with relatively deep water and tall emergent vegetation, such as bulrush (*Schoenoplectus* spp.) or cattails (*Typha* spp.); nests are typically in moderately dense vegetation, in colonies; forage within wetlands and surrounding grasslands and croplands. Feeds primarily on insects and seeds, foraging in marshes, fields, or sometimes catching prey in the air. Owens Valley and Fish Slough are used during breeding season, and pre- and post- breeding migration (eBird 2020). Occurrences in Owens Valley, Owens Lake, and Fish Slough management areas (eBird 2020).
Reptiles					
Desert tortoise *Gopherus agassizii*	FT/ST	Likely	CNDDB	Indirect	Prefers arid desert climates including sandy flats and rocky foothills to alluvial fans, washes, and canyons. May rely on groundwater-dependent vegetation for food sources (e.g., grasses, wildflowers, wild fruit, and herbs) and water intake from these food sources (Rhode et al. 2019). Occurrences in Owens Valley and Owens Lake management areas (CDFW 2019).

Common name *Scientific name*	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Panamint alligator lizard *Elgaria panamintina*	BLMS, FSS/SSC	Likely	CNDDB	Indirect	Secretive species inhabiting rocky, sagebrush, canyon bottoms near streams and springs of the pinyon-juniper zone. Endemic to California, found in desert mountain ranges (elevation 2,500–7,500 feet), including Panamint Mountains, the White Mountains, the Inyo Mountains, the Nelson Mountains, and the Cosos Mountains. Occurrences in Owens Valley and the vicinity of Fish Slough management areas (CDFW 2019).
Amphibians					
Inyo Mountains slender salamander *Batrachoseps campi*	FSS, BLMS/SSC	Likely	CNDDB	Direct	Lungless, nocturnal salamander; inhabiting springs, seeps, and surrounding riparian areas in dry mountain habitats of Inyo Mountains. Breeding occurs terrestrially in moist environments. Typical elevation range of 1,800–8,600 feet. Occurrences in the vicinity of Owens Valley and Owens Lake management areas (CDFW 2019).
Northern leopard frog *Lithobates pipiens*	–/SSC	Unlikely	CNDDB, CAFSD	Direct	Native to Northern California and Owens Valley (California native populations thought to be extinct, introduced populations in central valley, Southern California coast, and Northern California); inhabits grasslands, wet meadows, forests, woodlands, and other locations with permanent water below 6,500 feet. Breeding and hibernation both occur aquatically in a variety of permanent and semi-permanent water bodies. Historical Occurrences documented in Owens Valley management area, most recent occurrence is dated 1994 (CDFW 2019).
Sierra Nevada yellow-legged frog *Rana sierrae*	FE, FSS/ST	Likely;	CNDDB, CAFSD	Direct	Found in high elevation lakes, ponds, and streams in montane riparian, lodgepole pine, subalpine conifer, and wet meadow habitats. Typical elevation range from 984 feet. to over 12,000 feet. elevation. Distribution and USFWS critical habitat within the Owens Valley management area.

Common name ***Scientific name***	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Southern mountain yellow-legged frog *Rana muscosa*	FE, FSS/SE	None	CNDDB, CAFSD	Direct	Inhabits high elevation lakes, ponds, marshes, meadows and streams. Tadpoles take two to four years to reach metamorphosis. Typical elevation range from 4,500 to 12,000 feet. Distribution, USFWS critical habitat, and observations outside of groundwater basin.
Yosemite toad *Anaxyrus canorus*	FE/SSC	None	CAFSD	Direct	Inhabits high-elevation wet mountain meadows, willow thickets, boarders of forests, and areas with permanent water sources. Found in the Sierra Nevada Mountains from Ebbets Pass south to Spanish Mountains, between 4,800 to 12,000 feet elevation. Breeds in shallow pools, margins of lakes, and quite streams. Diet consists of small invertebrates, including beetles, ants, siders, bees, wasps, flies, and millipedes. Distribution, USFWS critical habitat, and observations outside of groundwater management areas.
Fish					
Owens pupfish *Cyprinodon radiosus*	FE/SE, SFP	Likely	CNDDB	Direct	Occupies springs, marshes, sloughs, and other wetland-type habitats with a silt or sand bottom and aquatic vegetation where they form small schools and feed primarily on aquatic insects. The Owens pupfish is directly dependent on spring-fed pools and other surface waters that are largely supported by groundwater (Rohde et al. 2019). Likely occurs in the Owens Lake and Fish Slough management areas (CDFW 2019).
Owens tui chub *Siphateles bicolor snyderi*	FE/SE	Unlikely	CNDDB	Direct	The Owens tui chub lives in low-velocity waters with abundant submerged vegetation for cover, habitat, and food. Aquatic vegetation provides important food web support for its macroinvertebrate prey, as well as cover from predators and refuge from high water velocities. Owens tui chub is considered directly dependent on groundwater, as groundwater provides water to most of the isolated springs and headwater streams in which it occurs (Rhode et al. 2019). Occurrence in Owens Lake management area, last verified in 2008 (CDFW 2019)).
Owens speckled dace *Rhinichthys osculus ssp.*	BLMS/SSC	Likely	CNDDB	Direct	Owens speckled dace are habitat generalists, occupying a variety of habitat types including coldwater streams, irrigation ditches, and hot springs. They feed opportunistically on a variety of aquatic

Common name *Scientific name*	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
					invertebrates. The Owens speckled dace is directly dependent on groundwater, which feeds many of the springs and other aquatic habitats it occupies. Occurrences in Fish Slough management area (CDFW 2019, Moyle et al. 2015).
Owens sucker *Catostomus fumeiventris*	–/SSC	Unlikely	CNDDB	Indirect/ uncertain	The Owens sucker prefers aquatic stream habitats. Feed by scraping algae, invertebrates, and detritus from rocky substrates. Owens suckers may be vulnerable to groundwater pumping and diversion of surface water, which have reportedly lowered the water table and may have affected riparian vegetation in the Owens Valley (Zektser et al. 2005, as cited in Moyle et al. 2015). Occurrences are outside management areas (CDFW 2019).
Mollusks					
California floater *Anodonta californiensis*	FSS/–	Likely	CNDDB, CAFSD	Direct	Lakes and slow, large rivers on soft substrates (mud-sand). Occurrence in the vicinity of Owens Valley management area (CDFW 2019).
Owens Valley springsnail *Pyrgulopsis owensensis*	FSS/–	Likely	CNDDB	Direct	Freshwater springsnail that is endemic to eight springs along the Inyo Mountain and White Mountain escarpments on the east side of the Owens Valley. Typically found on bits of travertine, stone, or watercress (Hershler 1989). Occurrences in Fish Slough, Tri-Valley, and Owens Valley management areas (CDFW 2019).
Wong's springsnail *Pyrgulopsis wongi*	FSS/–	Likely	CNDDB, CAFSD	Direct	Habitat includes seeps and stream fed streams, common in watercress, on small bits of travertine, or on stone. Inhabits Owens Valley; along eastern escarpment of Sierra Nevada (from pine creek south to Little Lake), along western side of the valley (French Spring to Marble Creek), also found in a few sites in Long, Adobe, and Deep Springs (Hershler 1989). Occurrences in Owens Valley, Owens Lake, Fish Slough, and Tri-Valley management areas (CDFW 2019).

Common name ***Scientific name***	**Status[1] Federal/State**	**Potential to occur in GDE management areas**	**Query source[2]**	**GDE association[3]**	**Habitat and documented occurrences in management areas**
Insects					
Crotch bumble bee *Bombus crotchii*	–/SCE	Likely	CNDDB	No known reliance on groundwater	Inhabits open grassland and scrub habitats in Coastal California east towards the Sierra-Cascade Crest. Nests are often located underground in abandoned rodent burrows, or above ground in tufts of grass, rock piles, or tree cavities. Occurrences in Owens Valley and Owens Lake management areas (CDFW 2019).
San Emigdio blue butterfly *Plebulina emigdionis*	FSS/–	Likely	CNDDB	Indirect	Occurs locally in Southern California, south San Joaquin Valley and Mojave Desert to Victorville and Owens Valley. Inhabits dry river courses, streamsides, and adjacent flats. Known hostplant is *Atriplex canescens*, caterpillars consume *A.canescens*, while adults are nectarivores. Occurrence in Owens Lake management area (CDFW 2019).
Crustaceans					
Vernal pool fairy shrimp *Branchinecta lynchi*	FT/–	Unlikely	CAFSD	Direct	Vernal pools; also found in sandstone rock outcrop pools. Critical habitat is outside of groundwater basin. No listed occurrences in groundwater management areas.

[1] **Status codes:**

Federal
- FE = Listed as endangered under the federal Endangered Species Act
- FT = Listed as threatened under the federal Endangered Species Act
- FD = Federally delisted
- FPE = Federally proposed as endangered
- FPT = Federally proposed as threatened
- BGEPA = Federally protected under the Bald and Golden Eagle Protection Act
- FSS = Forest Service Sensitive Species
- BLMS = Bureau of Land Management Sensitive Species

State
- S = Sensitive
- SE = Listed as Endangered under the California Endangered Species Act
- ST = Listed as Threatened under the California Endangered Species Act
- SCE = State Candidate Endangered
- SSC = CDFW species of special concern
- SFP = CDFW fully protected species

[2] **Query source:**
CAFSD: California Freshwater Species Database (TNC 2019a)
CNDDB: California Natural Diversity Database (CDFW 2019)
eBird: (eBird 2019)

[3] **Groundwater Dependent Ecosystem (GDE) association:**
Direct: Species directly dependent on groundwater for some or all water needs
Indirect: Species dependent upon other species that rely on groundwater for some or all water needs

Appendix 9-C

Rooting Depth of Common Plants in Fish Slough

Table C-1. Rooting depth of species in vegetation map units in the Fish Slough management area. Data from The Nature Conservancy (2020).

Vegetation type	Species	Maximum Rooting depth (ft)	Data Source
Alkaline Mixed Grasses and Forbs	Anemopsis californica	0.39	Stromberg (2013)
Alkaline Mixed Grasses and Forbs	Distichlis spicata	1.97	Stromberg (2013)
Alkaline Mixed Grasses and Forbs	Eleocharis rostellata	0.82	Stromberg (2013)
Alkaline Mixed Grasses and Forbs	Ivesia kingii	n/a	n/a
Alkaline Mixed Grasses and Forbs	Juncus arcticus (var. balticus, mexicanus)	0.69	Stromberg (2013)
Alkaline Mixed Grasses and Forbs	Muhlenbergia asperifolia	n/a	n/a
Alkaline Mixed Grasses and Forbs	Poa secunda	1.51	Spence (1937), as cited in Fan et al. (2017)
Alkaline Mixed Grasses and Forbs	Spartina gracilis	n/a	n/a
Alkaline Mixed Grasses and Forbs	Sporobolus airoides	n/a	n/a
Alkaline Mixed Scrub	Allenrolfea occidentalis	5.91	Naumovich (2017)
Alkaline Mixed Scrub	Atriplex canescens	39.37	Stromberg (2013)
Alkaline Mixed Scrub	Atriplex confertifolia	39.37	Canadell et al. (1996)
Alkaline Mixed Scrub	Atriplex parryi	n/a	n/a
Alkaline Mixed Scrub	Ericameria albida	n/a	n/a
Alkaline Mixed Scrub	Grayia spinosa	7.05	Link et al. (1994), as cited in Fan et al. (2017)
Alkaline Mixed Scrub	Suaeda moquinii	n/a	n/a
Big Sagebrush	Artemisia tridentata	9.84	Link et al. (1995), as cited in Fan et al. (2017)
Fremont Cottonwood	Populus fremontii	6.89	Stromberg (2013)
Greasewood	Sarcobatus vermiculatus	13.12	Donovan et al. (1996), as cited in Fan et al. (2017)
Rabbitbrush	Ericameria nauseosa	13.12	Stromberg (2013)
Tule-Cattail	Phragmites australis	8.20	Kohzu et al. (2003), as cited in Fan et al. (2017)
Tule-Cattail	Schoenoplectus acutus	1.97	Stromberg (2013)
Tule-Cattail	Schoenoplectus americanus	2.13	Stromberg (2013)
Tule-Cattail	Typha (angustifolia, domingensis, latifolia)	0.89	Stromberg (2013)
Willow (shrub)	Salix spp.	2.62	Pulling (1918), as cited in Fan et al. (2017)

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