TECHNICAL MEMORANDUM ◦ JANUARY 2022

Assessment of Groundwater Dependent Ecosystems for the Eel River Valley Basin Groundwater Sustainability Plan

PREPARED FOR

GHD
718 3rd Street
Eureka, CA 95501

PREPARED BY

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

Stillwater Sciences

Suggested citation:
Stillwater Sciences. 2022. Assessment of Groundwater Dependent Ecosystems for the Eel River Valley Basin Groundwater Sustainability Plan. Technical Memorandum. Prepared by Stillwater Sciences, Berkeley, California for GHD, Eureka, California.

Cover photos: Juvenile Chinook salmon

Table of Contents

Tables

Figures

Appendices

1 BACKGROUND AND SETTING

1.1 Background

This Technical Memorandum for the Eel River Valley Groundwater Sustainability Plan (GSP) addresses the extent and condition of groundwater dependent ecosystems (GDEs) in the Eel River Valley Basin (ERVB; Basin 1-010). As part of the California 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 (TNC) 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 or interconnected surface water for all or a portion of their water needs. SGMA defines interconnected surface water as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer" where "the overlying surface water is not completely depleted". Identifying riparian or terrestrial GDEs requires mapping vegetation communities that can tap groundwater through their root systems, assessing the elevation of groundwater relative to the rooting depth of that vegetation, and mapping the extent of surface water that is interconnected with groundwater (Rohde et al. 2018). Identifying the extent of aquatic GDEs requires mapping the extent of interconnected surface water, which changes based on season and water year type. Once the GDEs are mapped, the occurrence of special-status species can be used to assess the beneficial users of GDEs and the ecological 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 inform sustainable management criteria for each management unit.

Plants can rely on water infiltrating into the soil via local rainfall, groundwater, surface water, or other sources (Steinwand et al. 2006). In addition, fog drip is an important source of water in coastal areas like the ERVB (Azevedo and Morgan 1974). GDEs are linked to groundwater (and or the capillary fringe above the saturated groundwater zone) through plant roots or are direct users of interconnected surface water (Klausmeyer et al. 2018, Braudrick et al. 2018). Riparian plants, which are often present in GDEs, may be connected directly to groundwater or they may instead be connected to surface water, water in the capillary zone, or soil moisture through their roots. In the latter case, these plants may still be GDEs if the surface water they rely upon is interconnected with groundwater upstream of the GDE. Some phreatophytes may require more water than is available in the soil solely from rainfall and thus make use of groundwater when it is available (i.e., use groundwater opportunistically), but not actively require groundwater for survival (Steinwand et al. 2006). The presence of non-groundwater sources, such as surface water and soil moisture within and near a GDE, does not preclude the possibility that the GDE is supported by groundwater. A GDE is distinct from other riparian ecosystems in that it is either connected to a principal aquifer or is a beneficial user of a surface water or shallow/perched groundwater source that is connected to a principal aquifer. In general, assessing the source of water supporting potential GDEs is very difficult and requires focused studies linking groundwater changes and GDE health or direct measurements of water sources (typically via isotopic analysis) used by a potential GDE. Rohde et al. (2018) therefore recommend classifying phreatophytic vegetation as a GDE when groundwater is within 30 ft of the ground surface.

1.2 Physiography

The ERVB is a coastal basin in western Humboldt County, located at the downstream end of the Eel River watershed and extending from the Pacific Ocean upstream through the lower reaches of the Eel and Van Duzen River valleys (Figure 1.2-1). The valley floor comprises the majority of the basin's 73,700-acre surface area (DWR 2016) and ranges in elevation from 0 to 30 feet above sea level (ft asl). The foothills that mark the basin's inland perimeter reach elevations of up to 300 ft asl.

The ERVB occupies a westward-plunging syncline approximately 20 miles north of the Mendocino Triple Junction, where the Gorda, North American, and Pacific tectonic plates intersect. The subduction of the Gorda Plate below the North American Plate along the Cascadia Subduction Zone produces northeast-southwest compression, and the associated crustal deformation in the overriding North American Plate is expressed as a 90-km-wide fold and thrust belt (GHD 2021). The ERVB occupies the onshore portion of the Eel River syncline, a broad structural downwarp in the accreted terranes of the Franciscan Complex and overlying Wildcat Group sedimentary deposits (McLaughlin et al 2000).

The ERVB is bounded to the north by the Little Salmon Fault, an active, northwest-trending, northeast-dipping thrust fault that accommodates regional compression. The western boundary coincides with the Eel River Estuary. The ERVB is bounded to the south by the Wildcat Range, the southern limb of the Eel River syncline, and bounded to the east by uplifted, less permeable units of the Wildcat Group (DWR 2003). The Ferndale Fault runs along the southern edge of the ERVB, north of the Wildcat Range (McLaughlin et al., 2000), and the Goose Lake Fault runs through the terraces in the Yager Creek drainage (GHD 2021a).

.

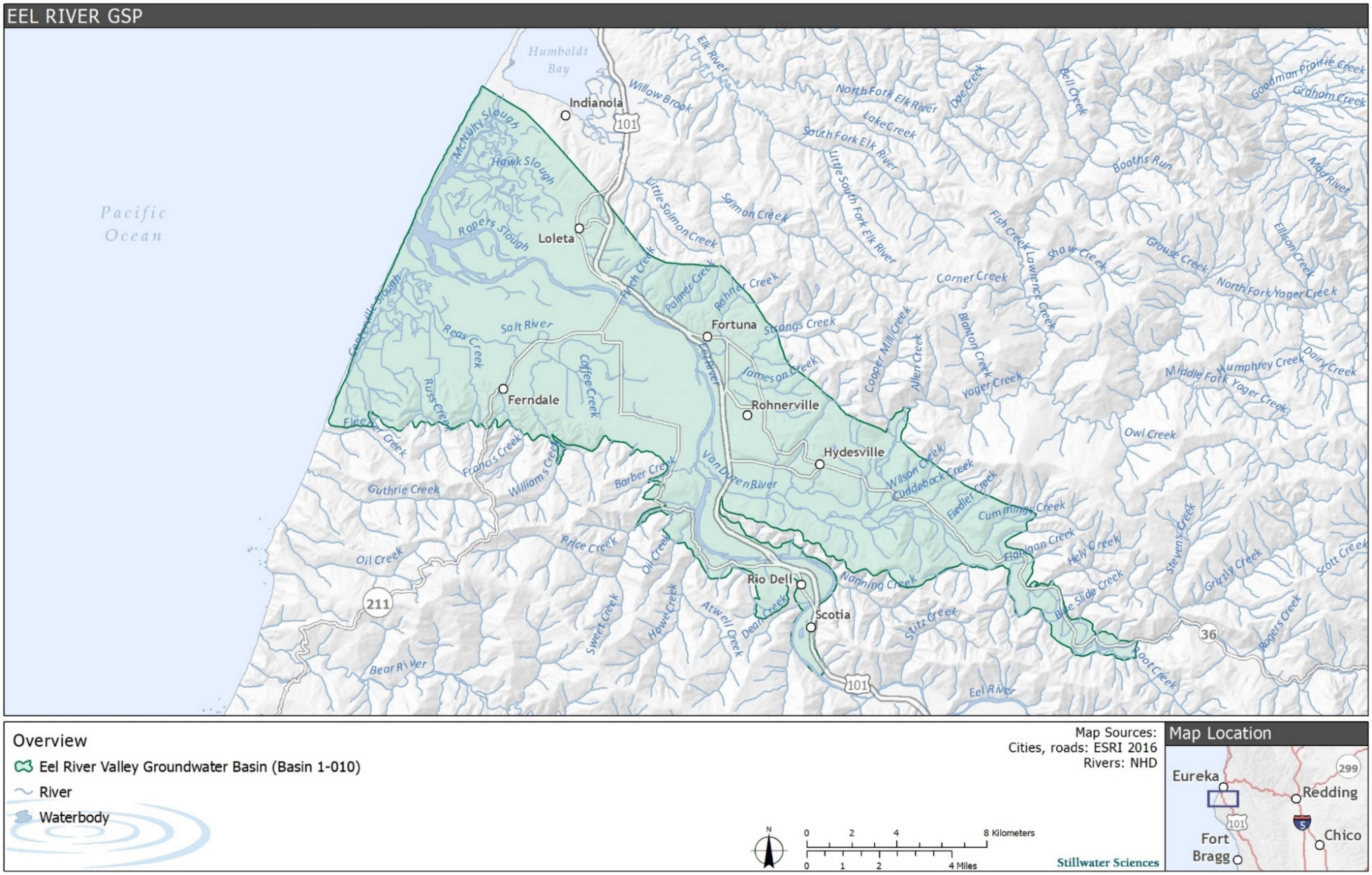


Figure 1.2-1. Eel River Valley Basin

1.3 Geology and Soils

The consolidated rocks of the Wildcat Group, deposited in the proto-basin during the late Miocene to Pleistocene (McLaughlin 2000), form the bottom of the contemporary basin. The Carlotta Formation is the uppermost unit of the Wildcat Group and is typically over 1,500 ft thick. An accumulation of unconsolidated alluvium up to 200 ft thick overlies the downwarped Carlotta Formation. The alluvium tends to be coarser (sands and gravels) near the Eel and Van Duzen channels and finer (silts and clays) on the extensive floodplain (GHD 2021a).

The Ferndale soil series covers much of the central part of the basin, grading from fine sandy loam along channels to silt loam on the floodplain (Watson et al 1925). The Ferndale soils are of alluvial origin, well drained, up to 60 inches thick, and slightly alkaline at depth (NRCS 2016). Coquille clay loam occurs on the floodplain near the coast. It is derived from tidal marsh deposits and is poorly drained. Bayside loam occurs on the foothills of the Wildcat Range along the southwestern edge of the ERVB and is intermediately drained. Willits clay loam occurs on the marine terraces and steep slopes north of Fortuna and is well drained. To the east, the Willits unit transitions to Rohnerville clay loam, a similar but deeper soil that occurs on level ground (Watson et al. 1925).

1.4 Hydrology

The primary aquifers in the ERVB are the Carlotta Formation in the Upper Wildcat Group and the sequence of overlying unconsolidated alluvial deposits. The Carlotta Formation is typically over 1,500 ft thick and may be up to 4,000 ft thick locally, but the maximum productive depth is not well defined. Groundwater in the formation is typically confined or semi-confined by silt and clay interbeds. Wells tapping the Carlotta Formation are between 200 and 400 ft deep; artesian conditions occur in wells near the foothills (GHD 2021a). The alluvial aquifer is up to 200 ft thick and unconfined, with high conductivity. Most wells in the alluvial aquifer are about 70 ft deep. Hydrologic connectivity between the alluvial aquifer and the Carlotta Formation is not well understood, but there is likely some connection between the two in the central part of the ERVB (GHD 2021a).

The alluvial aquifer is the primary water source for most agricultural wells (GHD 2021a). Irrigation is the primary groundwater use sector. Between 2011 and 2020, average annual groundwater extraction from the ERVB for irrigation was 14,077 acre-feet (acre-ft) (GHD 2021b). Average annual extraction for municipal, cannabis cultivation, and other uses was 1,733 acre-ft, 98 acre-ft, and 414 acre-ft, respectively (GHD 2021b).

Groundwater in the ERVB flows east to west, down the Eel and Van Duzen River valleys to the coast. Groundwater discharge occurs at springs and seeps into the upland areas and by subsurface flow to the tidal estuary (GHD 2021b). Both aquifers are hydraulically connected to the Pacific Ocean along approximately 10 miles of coastline. There is no evidence to suggest that the location of a freshwater-seawater transition zone has migrated landward since 1975 with the exception of modest salinity increases near the Salt River and Loleta (SHN. 2021a). North of the tidally, influenced reach of Eel River, most of the alluvial aquifer is naturally degraded by seawater (USGS 1978). South of the Eel River, elevated chloride concentrations (>100 mg/L) were detected in the alluvium along the coast where ground elevation was less than 10 ft asl. Chloride concentration increased with depth at a given distance from the coast. Substantial recharge to the groundwater system from the Eel River upstream of the tidally influenced reach sustains a seaward hydraulic gradient that moderates seawater intrusion in the area (USGS 1978).

During the dry season, tidal cycles produce fluctuations in surface water levels of as much as 1.5 ft, causing localized transitions between gaining and losing stream conditions (SHN 2019).

The Eel River is the third largest watershed in California, draining 3,684 square miles (California Department of Fish & Wildlife [CDFW] 2014). The mainstem Eel River is approximately 197 miles long, with headwaters in Mendocino County, 10 miles north of Lake Pillsbury. Upstream of the ERVB, the river is dammed at the Scott and Cape Horn dams, forming Lake Pillsbury and Van Arsdale Reservoir, respectively. Between 2010 and 2019, average annual discharge in the Lower Eel River near Scotia (USGS gage 11477000) ranged between 1,619 and 12,150 cubic feet per second (cfs); monthly average discharge ranged between 32 cfs (August 2014) and 54,201 cfs (February 2017) (USGS 2019). The Van Duzen River drains into the Eel River about 14 miles upstream of the Pacific Ocean. Other major tributaries include Yager Creek, which joins the Van Duzen below the town of Carlotta.

The tidally influenced reach of the Eel River extends approximately 12 miles inland from the river mouth, upstream of Fernbridge. The Eel River experiences very high levels of sedimentation (CDFW 2014). The Salt River, a remnant channel of the Eel River, has been significantly impacted by sedimentation; many of the Salt River's low-gradient tributaries have filled with sediment and do not convey significant surface flow. As of 2019, restoration efforts by the Humboldt County Resource Conservation District (HCRCD) have opened portions of the Salt River to tidal inundation and partial freshwater inputs (HCRCD 2021).

2 GROUNDWATER-DEPENDENT ECOSYSTEMS IDENTIFICATION

2.1 Vegetation Communities

Potential GDE units in the ERVB were identified using the California Department of Water Resources' (DWR) indicators of groundwater-dependent ecosystems (iGDE) database, which includes vegetation and wetland natural communities, is published online, and is referred to as the Natural Communities Commonly Associated with Groundwater dataset (DWR 2020). These data were reviewed and augmented with additional vegetation mapping datasets to produce a map of final GDE Units; additional information on vegetation community composition, aerial imagery, depth to groundwater, species distributions, salinity tolerance, and rooting depths was 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 (Klausmeyer et al. 2018) was reviewed in a geographic information system (GIS) and used to generate a preliminary map to serve as a guide for initial identification of potential GDEs in the ERVB.

For more precise identification of potential GDEs, a refined vegetation map was developed by adjusting Classification and Assessment with Landsat of Visible Ecology Groupings (CalVeg) to better match current National Agriculture Imagery Program (NAIP) imagery (U.S. Department of Agriculture [USDA] 2020). The refined vegetation map incorporates the following datasets:

- CalVeg – Forest Service (USDA 2014). *North Coast region: Imagery date: 2000–2007; Minimum mapping unit (MMU): 2.5-acre.*
- NAIP (USDA 2020). *Humboldt County: Imagery date: 2020; Resolution: 1 meter.*

In addition, other available vegetation assessments (H.T. Harvey & Associates 2015 and Golec and Miller 2017) were reviewed to further refine vegetation boundaries. The geomorphic description classification from the National Resources Conservation Service (NRCS)-USDA Soil Survey Geographic Database (SSURGO) (USDA 2021) was subsequently incorporated to assess the landscape position and likelihood of groundwater dependence for select vegetation types.

Maximum rooting depths from the literature are provided in Appendix A. Another way to explore the rooting depth of plants is to assess their elevation relative to the river channel surface (the relative elevation). Assuming that the groundwater elevation near the stream is similar to the stream elevation, we can assess the likely rooting depth of plants based on their relative elevation.

2.1.2 Procedure

The steps for defining and mapping GDEs outlined in Rohde et al. (2018) 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 the 23 CCR § 351(m) (State of California 2021) and Rohde et al. (2018). This decision tree, created to systematically and consistently address the range of conditions encountered, is summarized below; the term "unit" refers to an area with consistent vegetation and hydrology.

The unit is a GDE if groundwater is likely:

1. Interconnected with surface water in a stream channel;
2. An important hydrologic input to the unit during some time of the year;
3. Important to survival and/or natural history of inhabiting species; and
4. Associated with a principal aquifer used as a regionally important source of groundwater.

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

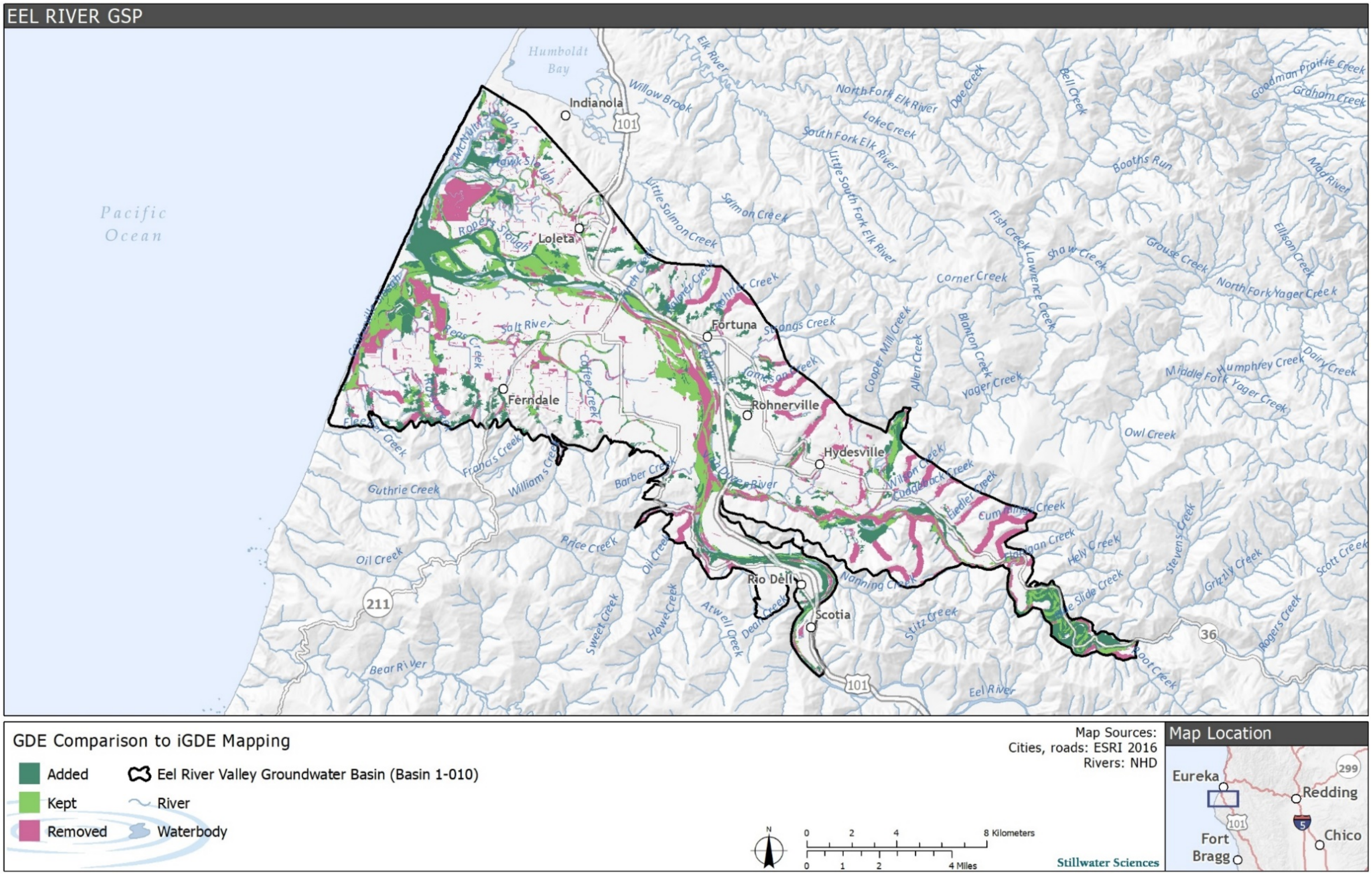
1. Surface discharge or drainage from an upslope human-made structure(s) with no connection to a principal aquifer (such as irrigation canal, irrigated fields, reservoir, cattle pond, or water treatment pond/facility); or
2. Precipitation inputs directly to the unit surface (this excludes vernal pools from being GDEs where units are hydrologically supplied by direct precipitation and very local shallow subsurface flows from the immediately surrounding area).

The initial potential GDE map was generated by editing the CalVeg (USDA 2014) dataset to better match NAIP 2020 imagery (USDA 2020), with a focus on the estuary, Eel River mainstem, and lower Van Duzen River areas. Surface water boundaries were reshaped, and vegetation types reassigned, to match extents in the imagery.

Several vegetation types were reviewed individually. Ponds and saltmarsh/mudflat habitats (e.g., pickleweed-cordgrass) were removed from the potential GDE map where aerial photographs suggested they were tidally connected. Irrigation ditches (e.g., straightened channels) were also removed from the potential GDE map. Based on aerial imagery and landform, some vegetated features were identified as semi-permanently inundated and were grouped into the river, stream, canal feature type. In addition, available information on maximum rooting depths was used as an additional filter to help ensure that non-GDE vegetation types were excluded.

Finally, SSUGRO landform data (USDA 2020) were overlaid and the potential GDE determination based on landform location for some vegetation types (e.g., redwood) was updated. The landform data were also used to remove agriculture and pasture areas located in backswamps, hillslopes, fan remnants, flood-plain steps, strath terraces, and natural levees from the potential GDE map.

The differences between the final GDE map and the iGDE map (DWR 2020) are shown in Figure 2.1-1. GDEs were added in the intertidal zone and along the upstream reaches of the Eel and Van Duzen Rivers based on refined mapping of open water features based on NAIP 2020 imagery. GDEs were removed in upstream tributaries based on landform data (i.e., GDEs along hillslopes and steeper tributaries) where groundwater gradients were likely to be steep and along the Eel mainstem and in the intertidal zone based on refined vegetation mapping.


EEL RIVER GSP
Humboldt Bay
Pacific Ocean
Indianola
Loleta
Fortuna
Ferndale
Rohnerville
Hydesville
Rio Dell
Scotia
101
211
36
Salt River
Eel River
Bear River
Elk River
Willow Brook
North Fork Elk River
South Fork Elk River
Little South Fork Elk River
Salmon Creek
Little Salmon Creek
Strongs Creek
Corner Creek
Yager Creek
North Fork Yager Creek
Middle Fork Yager Creek
Booths Run
Mad River
Owl Creek
Guthrie Creek
Oil Creek
Price Creek
Francis Creek
Barber Creek
Howe Creek
Atwell Creek
Stitz Creek
Nanning Creek
Grizzly Creek
Stevens Creek
Rogers Creek
Scott Creek
Goodman Prairie Creek
Graham Creek
Humphrey Creek
Dairy Creek
Ellison Creek
Grouse Creek
Shaw Creek
Fish Creek
Lawrence Creek
Cooper Mill Creek
Allen Creek
Blanton Creek
Bell Creek
Dye Creek
Lake Creek
Hely Creek
Coffee Creek
Williams Creek
Sweet Creek
GDE Comparison to iGDE Mapping
Added
Kept
Removed
Eel River Valley Groundwater Basin (Basin 1-010)
River
Waterbody
Map Sources:
Cities, roads: ESRI 2016
Rivers: NHD
0 2 4 8 Kilometers
0 1 2 4 Miles
Stillwater Sciences
Map Location
Eureka
Redding
Fort Bragg
Chico
299
101
5

2.2 Special-status Species

As part of the ecological inventory, special-status species and sensitive natural communities that are potentially associated with GDEs in the ERVB were identified. For the purposes of this document, 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 Bureau of Land Management (BLM) sensitive;
- Designated as endangered or rare under the California Native Plant Protection Act (CNPPA); and/or
- Taxa that meet the criteria for listing as described in Section 15380 of the CEQA Guidelines, including species listed on CDFW's *Special Vascular Plants, Bryophytes, and Lichens List* (CDFW 2021) or plants with a California Rare Plant Rank (CRPR) of 1, 2, 3, or 4.

Sensitive natural communities are defined as those natural community types (e.g., legacy natural communities in CDFW's California Natural Diversity Database [CNDDB], vegetation alliances and/or associations) with a state ranking of S1 (critically imperiled), S2 (imperiled), S3 (vulnerable), or an unranked association that is considered sensitive on CDFW's *California Sensitive Natural Communities List* (CDFW 2020) or in the CNDDB (CDFW 2021b).

2.2.1 Data sources

Spatial database queries included potential GDEs plus a one-mile buffer. This buffer accounts for spatial uncertainty in the data sources. Tests with different buffer sizes showed that larger buffers incorporated too many upland species unlikely to occur in the groundwater basin. Databases queried included:

- California Natural Diversity Database (CNDDB) (CDFW 2020);
- eBird (2021);
- TNC freshwater species lists generated from the California Freshwater Species Database (CAFSD) (TNC 2021);
- National Marine Fisheries Service (NMFS) California Species List tools (NMFS 2021); and
- Consortium of California Herbaria (CCH 2021) (queried from CCH1 Berkeley Mapper and CalFlora).

2.2.2 Procedure

Database query results were reviewed while special-status species and sensitive habitats that may occur within or be associated with the vegetation and aquatic communities in or immediately adjacent to potential GDEs were identified. These special-status species and sensitive community types were then consolidated into a list, 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, juvenile steelhead in dry season)
- 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

Sensitive natural communities were classified as either likely or unlikely to depend on groundwater based on species composition using the same methodology as vegetation communities (Section 2.1). Plant species were evaluated for potential groundwater dependence based on their habitat (Jepson Flora Project 2020) and association with vegetation communities classified as GDEs. Special-status plant GDE associations were assigned one of three categories: likely, possible, or unlikely. The "possible" category was included to classify plant species with limited habitat data or where a species may have an association with a vegetation community identified as a GDE.

Database query results for local and regional special-status species occurrences were combined with their known habitat requirements to develop a list of groundwater-dependent special-status species (Section 4) that satisfy the following criteria: 1) the species has been documented to occur within the GDE unit, or 2) is known to occur in the region and suitable habitat is present in the GDE unit.

2.3 GDE Units

Four (4) GDE units were identified within the ERVB (Figure 2.3-1, Table 2.3-1):

- Intertidal Zone and Tributaries: Intertidal reach downstream of Fernbridge
- Middle Eel River: Fernbridge to Eel/Van Duzen rivers' confluence
- Upper Eel River: Eel/Van Duzen rivers' confluence to Scotia
- Van Duzen River and Tributaries: Lower Van Duzen River

Table 2.3-1. GDE Unit acreages in the Eel River Valley Basin

GDE unit	Area (acres)
Intertidal Zone and Tributaries	5,981
Middle Eel River	3,809
Upper Eel River	1,136
Van Duzen River and Tributaries	2,878
Total	**13,804**

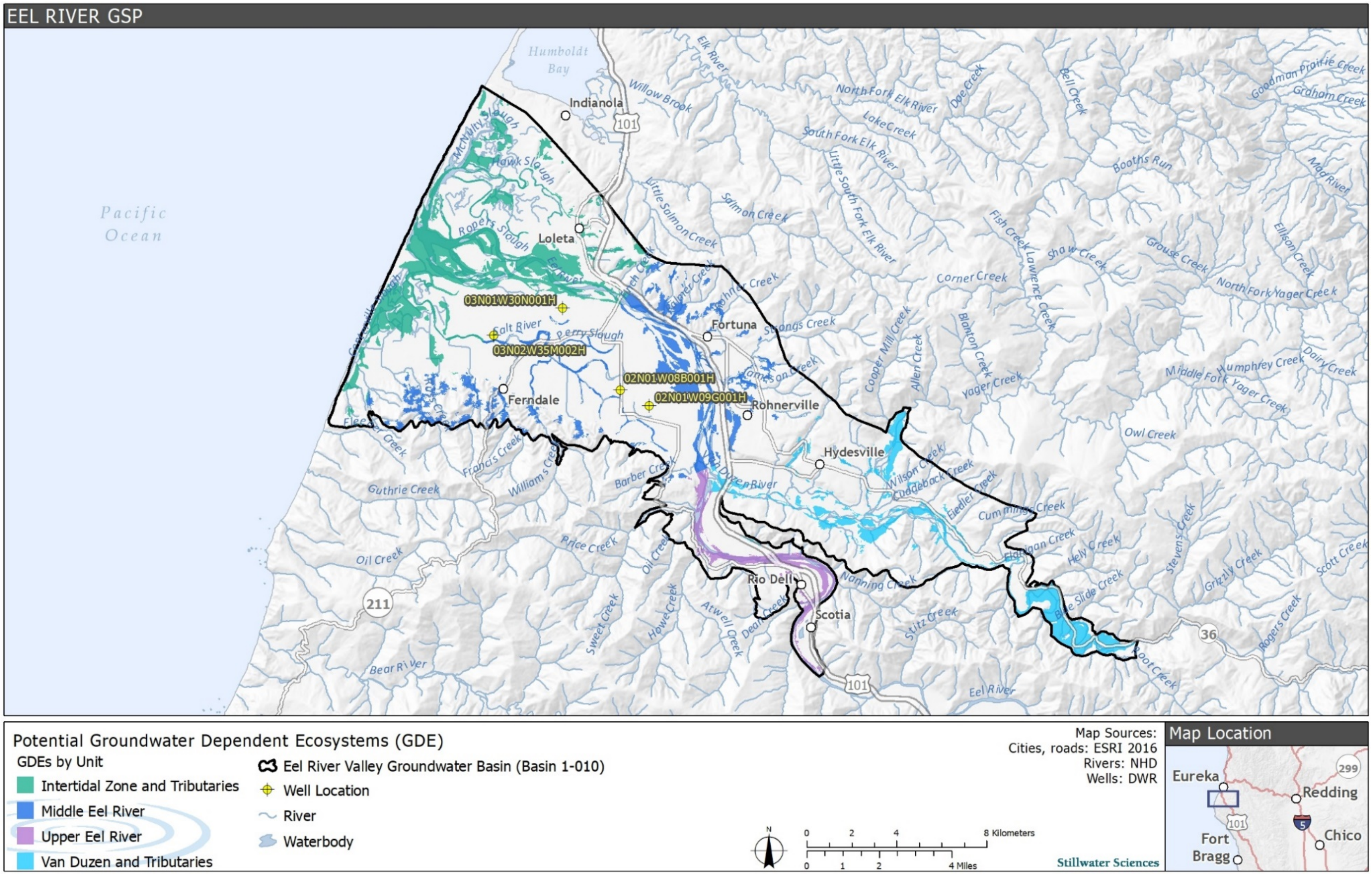


Figure 2.3-1. Potential GDE units and long-term groundwater monitoring well locations

3 HYDROLOGY

The following section (3.1) features a general description of shallow groundwater elevation in the ERVB and uses long-term monitoring well data to assess temporal trends in groundwater elevation for GDE units where well data are available. Section 3.2 covers groundwater quality and its potential effect on GDEs. Section 3.3 assesses the extent of interconnected surface water and spatial trends in interconnected surface water that can later be used to assess potential impacts of groundwater management on GDEs.

3.1 Groundwater Levels

Wet and dry season groundwater elevation contours from 2017, provided by GHD, show that groundwater elevation increases with increasing distance from the coast. Consequently, groundwater generally flows down the Eel and Van Duzen valleys from east to west. Groundwater gradients are typically shallow on the alluvial plain, increasing significantly within about 500 ft of the uplands that bound the alluvial plain to the northeast and southwest. Similarly, gradients steepen at the uplands that bound the lower Eel and Van Duzen river valleys, in which longitudinal groundwater elevation gradients are substantially steeper than in the alluvial plain, but roughly reflect the increase in land surface slope. These contours included data from 44 wells, 14 of which were installed since 2016, while the remainder are older.

Long-term records of shallow groundwater are sparse for the ERVB. This Technical Memorandum presents data from four (4) wells with a data record of shallow groundwater elevation extends from at least 2000 to 2017. Wells located on the alluvial plain, where most GDEs are located, were selected to best characterize shallow groundwater conditions at GDEs. Wells are associated with the nearest GDE unit; two (2) are associated with the Intertidal Zone and tributaries, and two (2) with the Middle Eel River (Figure 2.3-1). In general, shallow groundwater elevations have remained stable since 1990 at all four (4) wells.

There are no long-term shallow groundwater data for the Upper Eel and Van Duzen rivers, nor for tributaries units. In 2017, Humboldt County installed nine (9) new groundwater monitoring wells with pressure transducers (and installed transducers in several existing private wells), expanding the monitoring network into these upstream units (GHD 2021c). As was done for the Intertidal Zone and tributaries and Middle Eel analysis, shallow wells were sought within river valleys to provide rough constraints on shallow groundwater conditions. No suitable wells were found in the Upper Eel GDE unit; existing monitoring points either do not show shallow groundwater (<30 ft below ground surface [bgs]) or are located on terraces over 30 ft above nearby GDEs. In the Van Duzen and tributaries GDE unit, no increasing or decreasing trends in shallow groundwater levels are apparent in the minimal data available.

The wells considered in this analysis all tap the shallow alluvial aquifer, but these depths may not accurately represent the shallow groundwater used by GDEs for GDEs that are far from the well or use other sources of water. Additionally, ground elevation, and therefore depth to water (DTW), at a monitoring well site may differ from ground elevation at the GDEs it represents. A digital elevation model (DEM) from the USGS 2018 LiDAR survey (OCM Partners 2021) was used to extract ground elevations every 10 ft along a 0.5-mile long transect perpendicular to the valley axis and centered at the well location. The range of ground elevation at potential GDEs (indicated by the green box in Figures 3.1-1–3.1-5) provides a rough estimate of the groundwater depth relative to the GDE. GDEs are typically located closer to the channel and at lower elevations than their associated wells. On the alluvial plain, where groundwater gradients are shallow, DTW at these GDEs is likely to be shallower than at the well. Plants access groundwater via their root system, and likely use groundwater when the groundwater is less than the maximum rooting depth below the ground surface beneath the GDE. The rooting depths of the dominant plant species that make up the GDEs are provided in Appendix B and discussed in Section 4.1, for species where rooting depth data was available.

The following sections assess long-term groundwater elevation changes for the Intertidal Zone and Tributaries and Middle Eel GDE units in sections 3.1.1 and 3.1.2, respectively. Groundwater elevation from 2016-2019 in the Van Duzen and Tributaries GDE Unit are assessed in Section 3.1.3 because of the propensity of the lower Van Duzen to go dry. Due to sparse data groundwater elevations were not assessed in the Upper Eel GDE Unit. Considering the limited number of long-term monitoring wells, the groundwater elevation data presented in this section are intended to illustrate general trends only and explore trends in groundwater elevation through time.

3.1.1 Intertidal Zone and Tributaries

Well 03N01W30N001H is an active irrigation well installed in 1973 and screened between 20 and 45 ft bgs (Table 3.1-1). The well is located on the alluvial plain 0.5 miles south of the Eel River channel, 4.8 miles from the coast (Figure 2.3-1). From 1989 to present, DTW has been stable, typically between 14 and 22 ft bgs, with seasonal fluctuations typically between 3 and 5 ft (Figure 3.1-1). Figures 3.1-1 to 3.1-4 show (in green) the range of ground elevation within GDEs within 0.5 miles of the well, as described above. Ground elevation at nearby GDEs ranges from 2 to 15 ft below the well site, approximately 3 to 16 ft above the long-term average water level in the well.

Table 3.1-1. Characteristics of wells used for groundwater level assessment. The locations of the wells are shown on Figure 2.3-1.

Well	GDE Unit	Well depth (ft bgs)	Screen depth (ft bgs)	Water level data available
03N01W30N001H	Intertidal Zone and Tributaries	50	20–45	1973–2020
03N02W35M002H	Intertidal Zone and Tributaries	42	Unknown	1973–2020
02N01W08B001H	Middle Eel River	40	Unknown	1952–2017
02N01W09G001H	Middle Eel River	30	25-30	1986–2020
MW-9s	Van Duzen River and Tributaries	25	Unknown	2016–2019

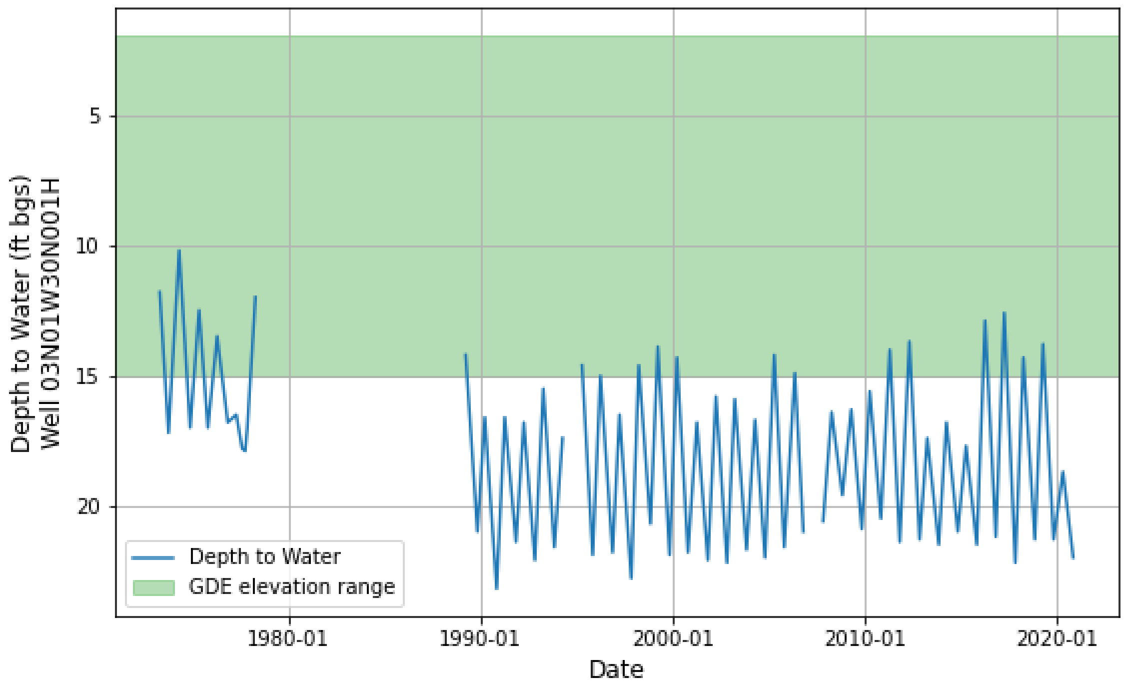


Figure 3.1-1. Depth to groundwater and land surface elevation range at GDEs on well transect, Well 03N01W30N001H, associated with the Intertidal Zone and Tributaries GDE Unit. Well site elevation is assumed to be 0 ft bgs.

Well 03N02W35M002H is an active irrigation well installed in 1973 with unknown screen depth (Table 3.1-1). The well is located on the alluvial plain north of the Salt River channel, 3.3 miles from the coast (Figure 2.3-1). From 1989 to present, DTW has been stable, typically between 4 and 11 ft bgs, with seasonal fluctuations typically between 3 and 5 ft (Figure 3.1-2). Ground elevation at nearby GDEs ranges from 8 ft below to 3 ft above the well site, approximately 0.5 to 11 ft above the long-term average water level in the well.

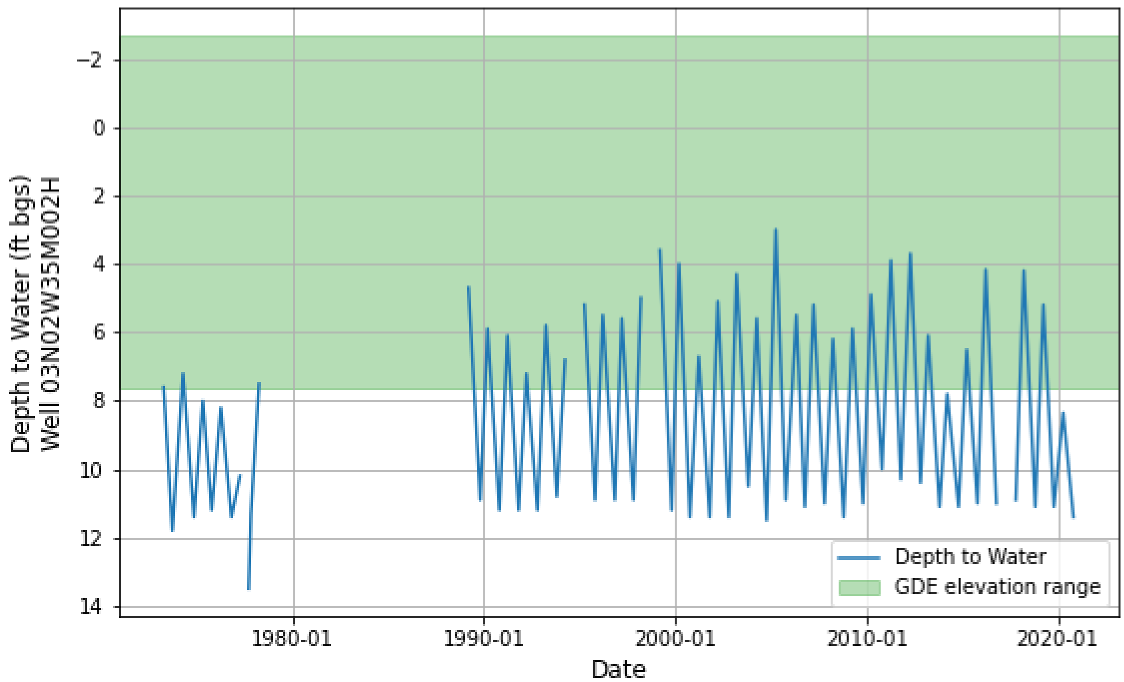


Figure 3.1-2. Depth to groundwater and ground elevation range at GDEs on well transect, Well 03N02W35M002H, associated with the Intertidal Zone and Tributaries GDE Unit. Well site elevation is assumed to be 0 ft bgs.

3.1.2 Middle Eel River

Well 02N01W08B001H is an active irrigation well installed in 1952 with unknown screen depth (Table 3.1-1). The well is located on the alluvial plain south of the Salt River Channel, 7 miles from the coast (Figure 2.3-1). At Well 02N01W08B001H, depth to water declined gradually from an annual average of approximately 17 ft bgs in 1965 to approximately 23 ft bgs in 1986. Since 1986, groundwater elevation has remained stable, typically between 10 and 27 ft bgs, with seasonal fluctuations typically between 5 and 15 ft. (Figure 3.1-3). Ground elevation at nearby GDEs ranges from 5 to 7 ft below the well site, approximately 13 to 15 ft above the long-term average water level in the well.

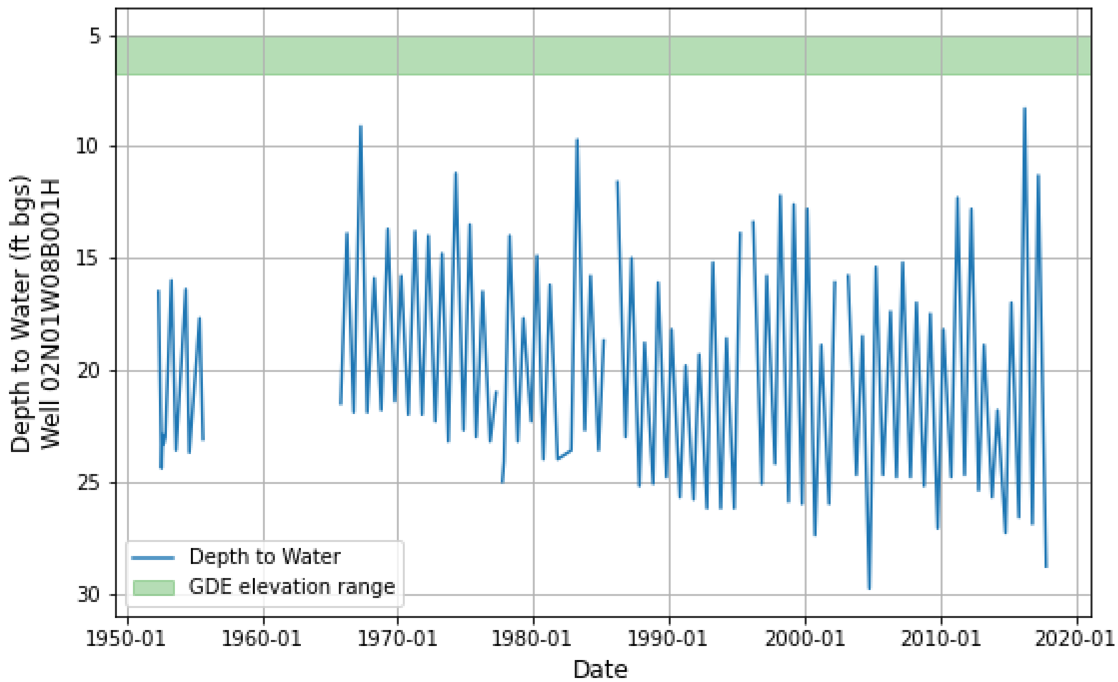


Figure 3.1-3. Depth to groundwater and ground elevation range at GDEs on well transect, Well 02N01W08B001H, associated with the Middle Eel River GDE Unit. Well site elevation is assumed to be 0 ft bgs.

Well 02N01W09G001H is an active residential well installed in 1986 and screened between 25 and 30 ft bgs. The well is located on the alluvial plain 1.5 miles west of the Eel River channel, 1.5 miles downstream of the Eel-Van Duzen confluence (Figure 2.3-1). At Well 02N01W09G001H, depth to water has remained stable since 1986, between 15 and 30 ft bgs, with seasonal fluctuations typically between 5 and 10 ft. (Figure 3.1-4). Ground elevation at nearby GDEs ranges from 7 ft below to 1 ft above the well site, approximately 17 to 19 ft above the long-term average water level in the well.

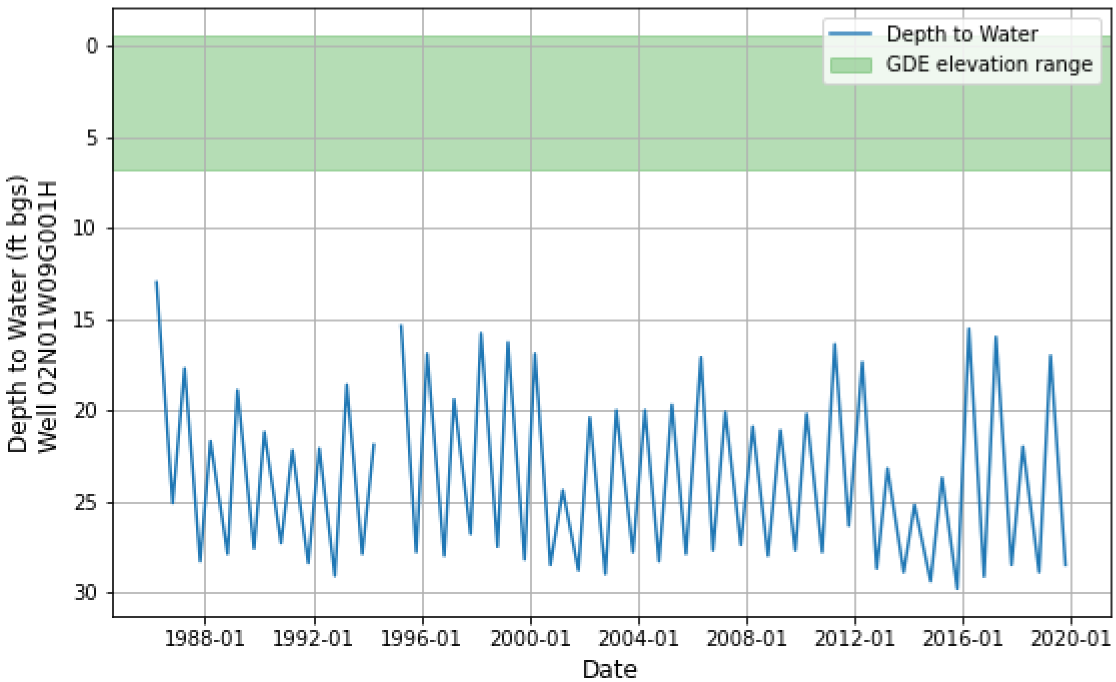


Figure 3.1-4. Depth to groundwater and ground elevation range at GDEs on well transect, Well 02N01W09G001H, associated with the Middle Eel River GDE Unit. Well site elevation is assumed to be 0 ft bgs.

The two long-term wells on the Middle Eel (02N01W08B001H and 02N01W09G001H) are located along the upper portions of Salt Creek (Figure 2.3-1). Groundwater in Figures 3.1-3 and 3.1-4 is within the 30 ft cutoff used to define GDEs, but is generally (but not always) deeper than the rooting depth of species found near the GDEs (generally <15 ft see below). Additional data may be required to better understand the role of groundwater for potential GDEs in this portion of the basin. Groundwater elevations are typically shallower along the Eel River.

3.1.3 Van Duzen River and Tributaries

MW-9s is an active shallow observation well, installed in 2016 (Table 3.1-1). Its DTW ranged from 4.5 ft bgs in Spring 2017 to 11 ft bgs in Fall 2018 (Figure 3.1-5). No long-term trends in depth to groundwater are apparent over the three-year period of record. Ground elevation at nearby GDEs ranges from 13 ft below to 1 ft above the well site, approximately 7 ft below to 7 ft above the long-term average water level in the well.

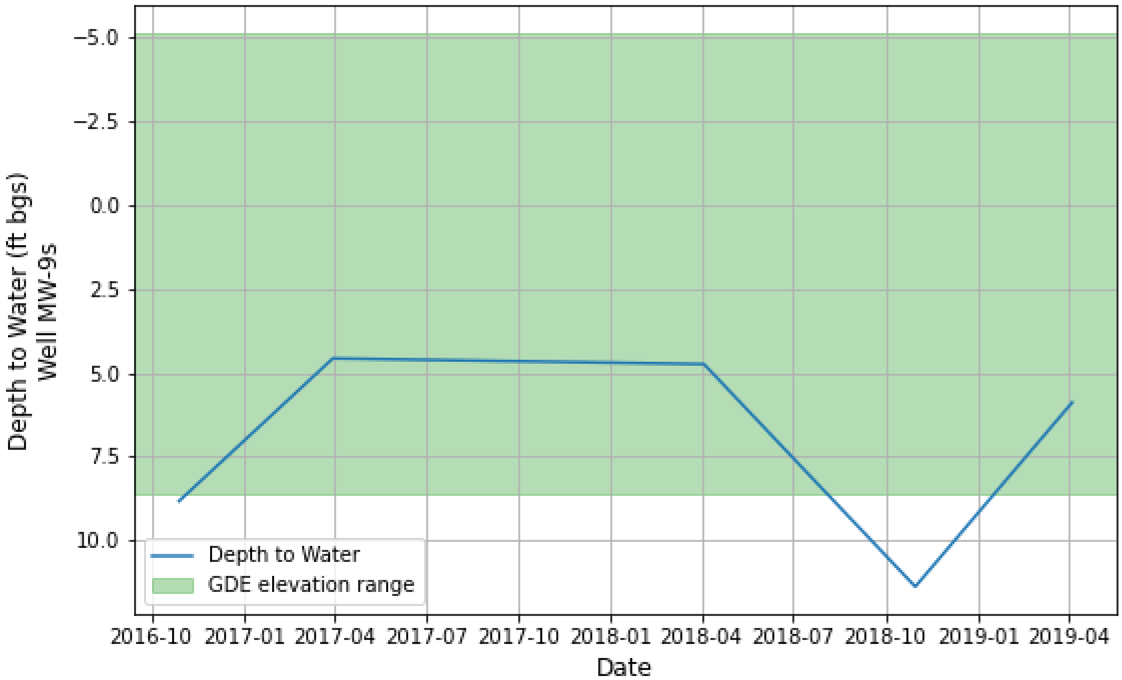


Figure 3.1-5. Depth to groundwater and ground elevation ranges at GDEs on well transect, MW-9s, associated with the Van Duzen River and Tributaries GDE Unit. Well site elevation is assumed to be 0 ft bgs.

3.2 Groundwater Quality

Fifteen (15) County wells were sampled in 2021 for constituents of concern including metals, nutrients, salts, pesticides, herbicides, Volatile organic compounds (VOCs), Semivolatile organic compounds (SVOCs), microbial, radioactive, polychlorinated biphenyl (PCB), and physical contaminants (SHN 2021b). Analytical results for five (5) of the 15 wells have been received and all results have been below primary maximum contaminant levels (MCLs), except for alkalinity.

SHN (2021b) included review of historic data and found that water quality throughout the ERVB is of good quality for its intended uses. Four (4) constituents of concern—totally dissolved solids (TDS), nitrate, manganese, and iron—were identified based on the historical data review and are discussed below.

Nutrients (e.g., nitrate) and TDS have been reported near the Ferndale area of the ERVB at levels near or above primary and secondary MCLs for drinking water (SHN 2021a). A long-term water quality monitoring program is planned to involve the sampling of nitrate and TDS on an annual basis at a subset of wells across the ERVB, with a focus on the Ferndale area to assess spatial trends in these contaminants.

Metals (e.g., iron and manganese) have been reported by the Palmer Creek Community Services District (CSD), Del Oro Water Company, and Loleta CSD at levels above primary MCLs (SHN 2021b). These metals are thought to occur naturally due to the geologic formations comprising the aquifers, and therefore are considered background concentrations.

Recent chloride concentration data from the shallow aquifer indicate no significant migration in the landward edge of the freshwater-seawater transition zone (defined as chloride concentrations exceeding 100 mg/L) between 1975 and 2021 (SHN 2021a).

3.3 Interconnected Surface Water

Surface water systems are strongly connected to the shallow alluvial aquifer (SHN 2019). Preliminary groundwater model river discharge results provided by GHD show gaining conditions on the Van Duzen River upstream of Yager Creek. Downstream of Yager Creek, losing conditions are more prevalent. For example, the Van Duzen goes dry most years in the vicinity of Highway 101, a losing reach. Continuous coupled groundwater and surface water monitoring initiated by Humboldt County in 2016 indicate that subsurface contributions from the Van Duzen strongly influence surface-groundwater connections on the east bank of the Eel River downstream of the Van Duzen confluence (SHN 2019). Due to the steep groundwater gradient toward the Eel River from the east, gaining stream conditions are thought to occur year-round in this reach, consistent with preliminary model results. Monitoring on the west bank of the Eel River between the Van Duzen River confluence and Fortuna shows losing conditions near the confluence, particularly during the dry season, transitioning to gaining conditions downstream that typically occur during the wet season (SHN 2019). Preliminary model results indicate that a slight gaining reach occurs downstream at Fortuna due to subsurface contributions from Strongs Creek and Rohner Creek losses. Gaining conditions also occur at Fernbridge and along much of the Salt River. Model results show slight losing conditions on some tributaries of the Van Duzen (Fox Creek) and Salt River (Williams, Francis, and Reas creeks).

The shallow aquifer is hydraulically connected with the ocean along approximately 10 miles of coastline. In the Eel River, tidal influence extends upstream of Fernbridge, approximately 12 miles inland from the river mouth (SHN 2021a).

4 GDE CONDITION

This section characterizes the GDE units based on their hydrologic and ecological conditions, then assigns a relative ecological value to each unit by evaluating its ecological assets and its vulnerability to changes in groundwater (Rohde et al. 2018).

4.1 Vegetation Communities and GDE Habitats

There were seven (7) dominant vegetation communities associated with groundwater in the Lower ERVB. These vegetation communities are mostly affiliated with the North Coast riparian forest and shrubland habitats within the riparian and floodplain zone along the Eel and Van Duzen rivers. The most prevalent vegetation communities (top five [5]) within each GDE unit are provided in Figures 4.1-1 through 4.1-4. All dominant vegetation communities—including their common species assemblages, typical landform position, and stand characteristics—are described in this section. In addition to these vegetation communities, the ERVB's GDE habitat encompasses areas that are frequently inundated. These features are characterized as River/Stream/Canal and are included in Figures 4.1-1 through 4.1-4.

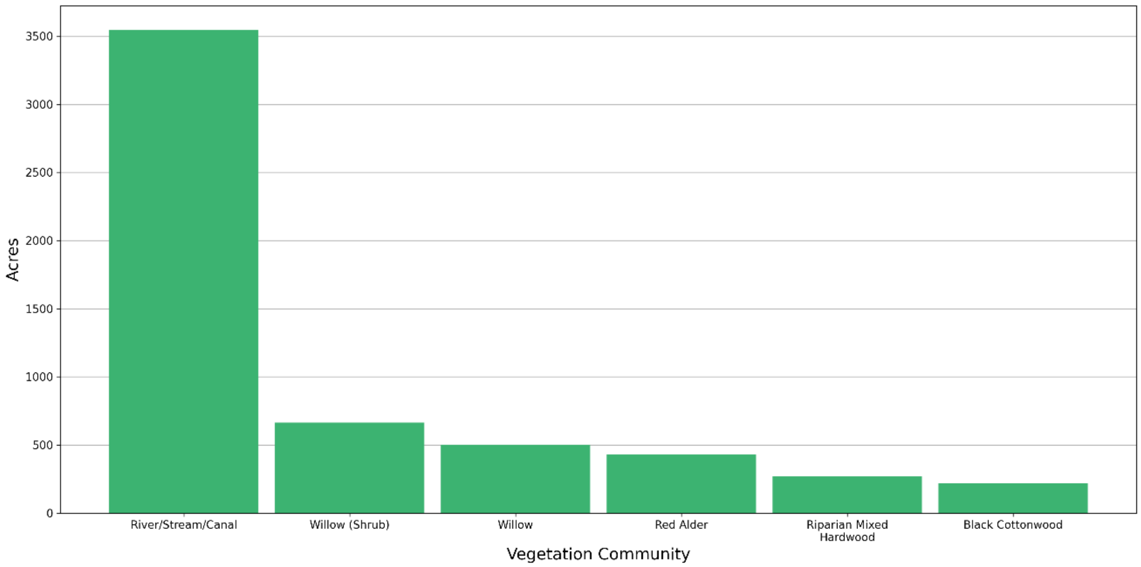


Figure 4.1-1. Dominant vegetation communities within Intertidal Zone and Tributaries GDE Unit

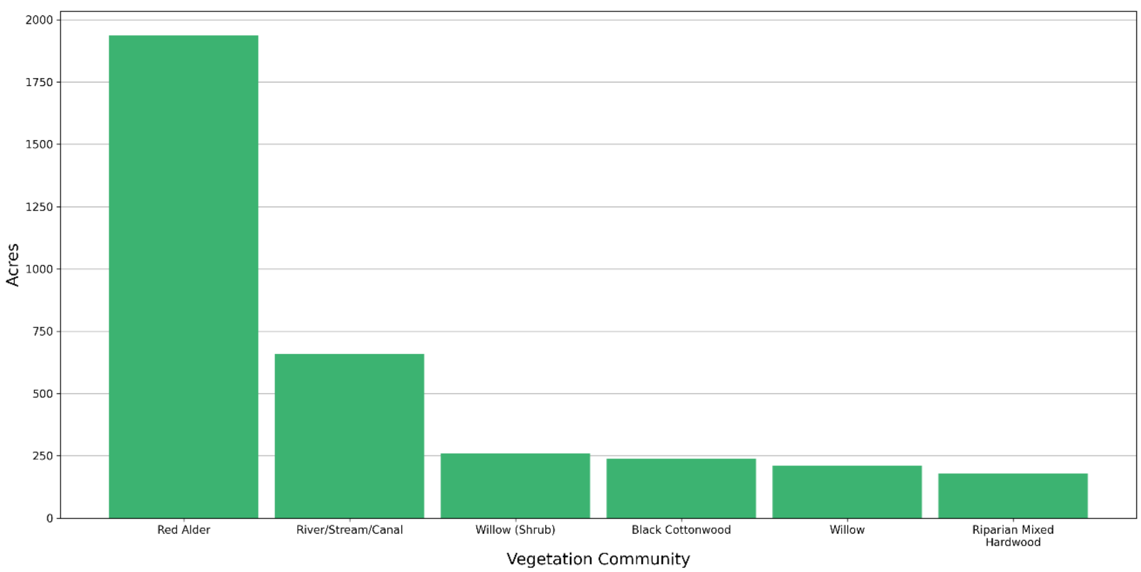


Figure 4.1-2. Dominant vegetation communities within Middle Eel River GDE Unit

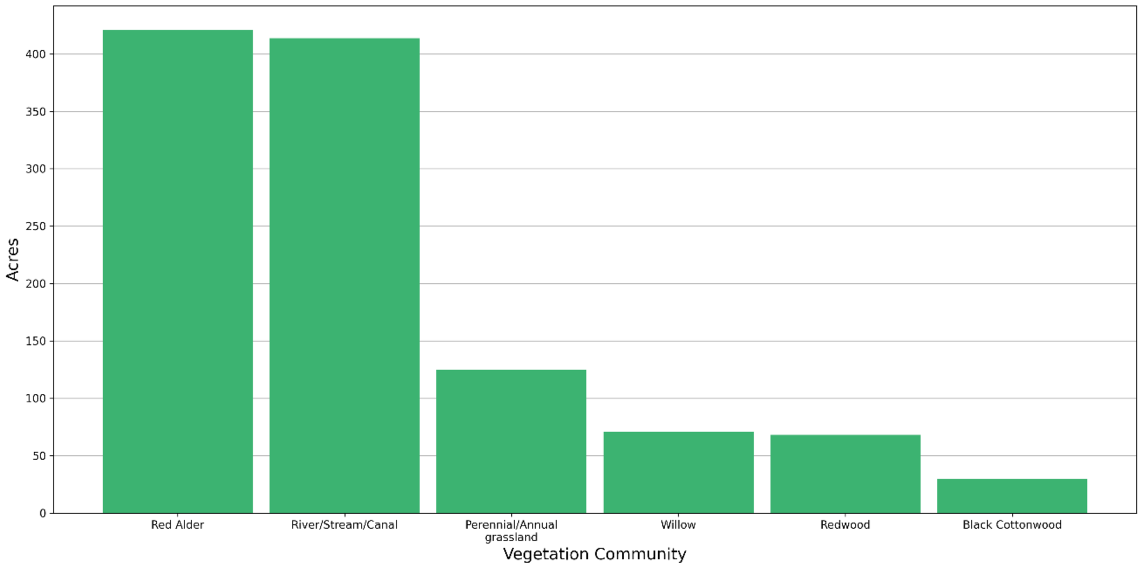


Figure 4.1-3. Dominant vegetation communities within the Upper Eel River GDE Unit

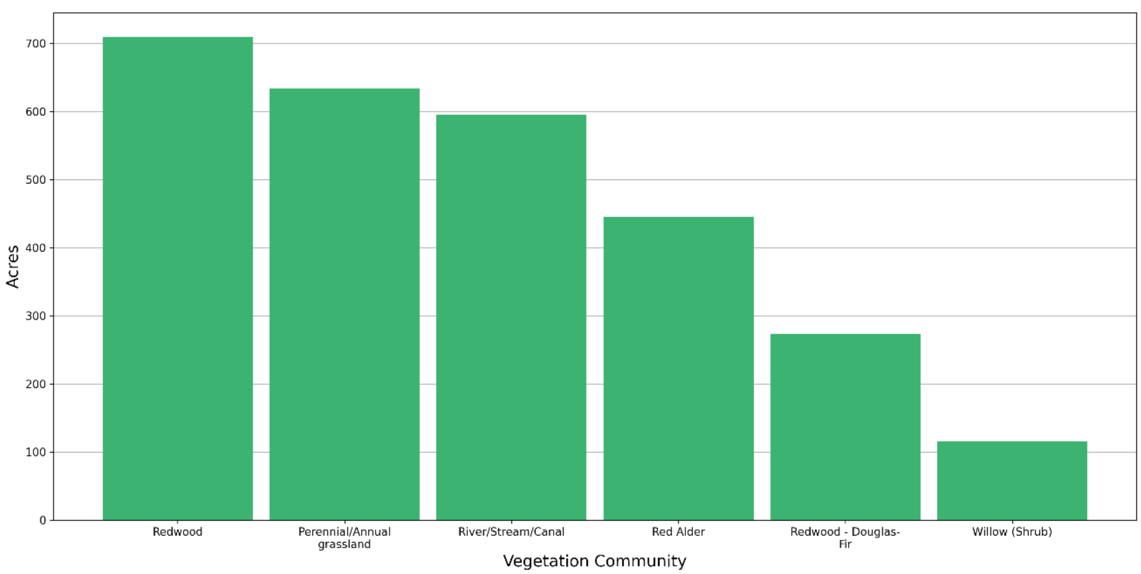


Figure 4.1-4. Dominant vegetation communities within Van Duzen River and Tributaries GDE Unit

4.1.1 River/Stream/Canal

Permanently or semi-permanently flooded areas, both bare and vegetated areas with a fresh or brackish water regime, were included in the River/Stream/Canal cover type. Some brackish and freshwater marshes and grasslands were included within this GDE habitat type based on their landform position and high inundation rate. Emergent herbaceous species found within these areas typically have a maximum rooting depth of 1 to 2 ft, such as broad-leaved cattail (*Typha latifolia*), saltmarsh bulrush (*Bolboschoenus maritimus*), various rushes *(Juncus* spp.)*,* pale spike rush (*Eleocharis macrostachya*), and various bulrush (*Scirpus* spp.). High marsh and wet grassland species included reed canary grass (*Phalaris arundinacea*), salt grass (*Distichlis spicata*), tufted hairgrass (*Deschampsia cespitosa*), creeping bent grass *(Agrostis stolonifera*), and Pacific silverweed (*Potentilla anserina* subsp. *Pacifica*). This group is found most often in drainages, low depressions, wetlands adjacent to drainages and saltmarsh, and concave isolated wetlands in active floodplains that are inundated most of the year. This GDE habitat is distributed throughout all GDE units of the ERVB and totals 5,212 acres of the mapped GDE habitat.

4.1.2 Red alder

Red alder (*Alnus rubra*) forest community is the most prevalent GDE habitat in the ERVB, composing 23% (or 3,231 acres) of the total mapped GDE habitats. Red alder, a native deciduous hardwood, is dominant in this forest community type with greater than 50% relative tree cover. The community's mostly mature and continuous tree canopy, aside from red alder, features low cover by other hardwoods and conifers such as bigleaf maple (*Acer macrophyllum*), Pacific willow (*Salix lasiandra*), California bay laurel (*Umbellularia californica*), black cottonwood (*Populus trichocarpa*), and Sitka spruce (*Picea sitchensis*). The sparse to intermittent shrub layer may include various willows (*Salix* spp.), salmonberry (*Rubus spectabilis*), and thimbleberry (*Rubus parviflorus*), while the herbaceous layer comprises various ferns (western sword fern [*Polystichum munitum*], lady fern [*Athyrium filix-femina*]) and forbs (stinging nettle [*Urtica dioica*], pig-a-back plant [*Tolmiea diplomenziesii*], and candy flower [*Claytonia sibirica*]). Red alder stands often occur along stream and river backwaters, banks, bottoms, flood plains, mouths, terraces, and slopes of all aspects (California Native Plant Society [CNPS] 2021). This riparian forest community is best characterized by the *Alnus rubra* Forest Alliance and has an estimated maximum rooting depth of 13.1 ft. (Appendix A). It is distributed within all ERVB GDE units and is the predominant community in the Middle Eel River, Upper Eel River, and Van Duzen River and Tributaries GDE units, totaling 1,937 acres, 421 acres, and 445 acres, respectively (Figures 4.1-2–4.1-4).

4.1.3 Willow shrub

Willow shrub is a prevalent vegetation community in the ERVB (~8% or 1,039 acres) that establishes along high-flow river bars, banks, and riparian wash areas. This vegetation community recruits on exposed riverbanks, initially forming a sparse, patchy shrub layer that develops into a fairly dense shrub-dominant stand type. These recruited areas are mostly attributed to two native willow shrubs that are clonal by root-shoots: Hinds' willow (*Salix exigua* var. *hindsiana*) and dusky willow (*Salix melanopsis*). These stands are common to sandy gravel and active floodplains with an intermittent to continuous shrub layer, a minor tree component attributed to some riparian species recruitment, and a variable herbaceous layer that consists of a mixture of forbs and annual grasses. This community type also includes arroyo willow (*Salix lasiolepis*), Sitka willow (*Salix sitchensis*), and coastal willow (*Salix hookeriana*) shrubland stands, which typically occur on stream banks and benches, slope seeps, stringers along drainages, deflation plains and swales, and floodplains (CNPS 2021). They form a continuous canopy composed of species that are less than 30 ft in height with low cover by emergent trees. The willow shrub vegetation community is characterized by the *Salix exigua* Shrubland Alliance and has a maximum rooting depth of approximately 7 ft. It is distributed in the Intertidal Zone and Tributaries, Middle Eel River, and Van Duzen River and Tributaries GDE units, where it composes 664 acres, 260 acres, and 116 acres, respectively (Figures 4.1-1, 4.1-2, 4.1-4).

4.1.4 Willow

The willow vegetation community is characterized by a complex of variously established willow stands that vary in species dominance but primarily form riparian forested habitat. It occurs along banks and benches and on low-gradient depositions along rivers and streams. Tree canopy is less than 65 ft in height and is intermittent to continuous with a sparse to intermittent shrub layer. Dominant cover is attributed to Pacific willow (*Salix lasiandra*), Sitka willow, and Scouler's willow (*Salix scouleriana*). Arroyo willow and coastal willow contribute to the midstory canopy. Other native riparian hardwoods and shrub species observed in this stand type include red alder, bigleaf maple, black cottonwood, and red elderberry (*Sambucus 23larkia23*). This riparian forest community is characterized by the *Salix lucida* ssp. *Lasiandra* Forest and Woodland Alliance, a sensitive natural community on CDFW's *California Sensitive Natural Communities List* (CDFW 2020) with a state rarity ranking of S3 (vulnerable in the state due to a restricted range, relatively few populations [often 80 or fewer], recent and widespread declines, or other factors making it vulnerable to extirpation). Maximum rooting depth is typically up to 6.9 ft. It is distributed within all GDE units, totaling 783 acres or 6% of the total mapped GDE habitats in the ERVB (Figures 4.1-1–4.1-4).

4.1.5 Black cottonwood

Black cottonwood stands form a dominant riparian hardwood forest and woodland type in the ERVB (5% [655 acres] of the mapped GDE habitats), occurring in seasonally flooded and permanently saturated soils on stream banks and alluvial terraces (CNPS 2021). Black cottonwood is dominant within the tree canopy, intermittent to continuous and reaching to 100 ft in height. The shrub layer is open to continuous and the herbaceous understory varies from sparse to abundant. Other hardwoods present in this community include red alder, wax myrtle (*Morella californica*), Oregon ash (*Fraxinus latifolia*), various willows, and bigleaf maple. This riparian forested community is characterized by the *Populus trichocarpa* Forest and Woodland Alliance, a sensitive natural community (S3) on CDFW's *California Sensitive Natural Communities List* (CDFW 2020). Black cottonwood has a maximum rooting depth of 9.8 ft. It is distributed in all GDE units, though is most prevalent within the Intertidal Zone and Tributaries and Middle Eel River GDE units, where it totals 219 acres and 352 acres, respectively (Figures 4.1-1 and 4.1-2).

4.1.6 Annual/perennial grassland

This group is composed of a mixture of herbaceous annual forbs, perennial herbs, and naturalized annual and perennial grasses. This community type has a high percent cover of facultative and facultative-wetland grasses with low to moderate cover by herbaceous forbs. Cover within this grassland community type is mostly attributed to non-native naturalized species (e.g., reed canary grass, tall fescue [*Festuca arundinacea*], creeping bent [*Agrostis stolonifera*], common velvet grass [*Holcus lanatus*], Kentucky blue grass [*Poa pratensis* subsp. *Pratensis*], rye grass [*Festuca perenne*], meadow foxtail [*Alopecurus pratensis*], and low manna grass [*Glyceria 23larkia23i*]). There is low recruitment by shrub and tree species in these grasslands, while land use involves historically diked pastureland, various agriculture, areas near development, and open space. This group typically occurs in topographically flat areas on active or other floodplains. Soil saturation and inundation vary at these locations, but these grasslands indicate typically moist conditions for at least a portion of the year. These non-native grasslands area associated with the *Phalaris aquatica – Phalaris arundinacea*, *Holcus lanatus – Anthoxanthum odoratum, Poa pratensis – Agrostis gigantea – Agrostis stolonifera*, and *Lolium perenne* Herbaceous Semi-Natural Alliances. Maximum rooting depths of these grasslands generally range from 3.2 to 4 ft. The grassland vegetation community occurs in all GDE units and is most prevalent in the Van Duzen River and Tributaries GDE Unit, where it totals 634 acres (Figures 4.1-1–4.1-4).

4.1.7 Riparian mixed hardwood

The riparian mixed hardwood vegetation community typically consists of an intermittent to continuous multi-layered tree canopy with a varied understory, composed of various riparian evergreen and deciduous tree species, including a combination of evergreen conifers (e.g., coast redwood [*Sequoia sempervirens*], Douglas-fir [*Pseudotsuga menziesii*], Sitka spruce, and grand fir [*Abies grandis*]), with a shared overstory and midstory by deciduous hardwoods (red alder, black cottonwood, Oregon ash, various willows). The shrub layer is intermittent with various *Rubus* spp., willow, and twinberry (*Lonicera 24larkia24ine*). Common ferns in the understory comprise western sword fern and lady fern. The vegetation community is located primarily on convex low-flow streambanks, active floodplains, and flat or undulating floodplains and terraces. Multiple riparian forest alliances with a state rank of S3 on CDFW's *California Sensitive Natural Communities List* are included in this complex. As such, the riparian mixed hardwood is considered a sensitive natural community in the Lower ERVB. Maximum rooting depth ranges from 2.4 to 6.9 ft. This community is predominant in the Intertidal Zone and Tributaries and the Middle Eel River GDE units, where it composes 267 acres and 179 acres of the total mapped GDE habitat, respectively (Figures 4.1-1 and 4.1-2).

4.1.8 Redwood

The redwood vegetation community is associated with coniferous forest stands dominated by coast redwood, located along raised stream terraces, benches, alluvial floodplains, and sloped regions along the floodplain. Redwood forests of the Eel River alluvial terraces are mostly pure stands of coast redwood (Sawyer 2007). Along the slopes, the redwood forest encompasses other conifers and hardwoods and forms more open canopy. Forests along the alluvial flats are dense-canopied. Some evergreen conifers associated with redwood forests include Sitka spruce, western hemlock (*Tsuga heterophylla*), red incense cedar (*Thuja plicata*), grand fir, and shore pint (*Pinus contorta* subsp. *Contorta*), while hardwoods comprise bigleaf maple, black cottonwood, and red alder. Understory species vary from continuous to dense cover by shrubs (huckleberry [*Vaccinium* spp.], salal [*Gaultheria shallon*]) and ferns (sword fern, lady fern). This forest type is characterized as the sensitive natural community *Sequoia sempervirens* Forest and Woodland Alliance (S3 on CDFW's *California Sensitive Natural Communities List*). Maximum rooting depth ranges from 8.5 to 16 ft. The redwood forest community forms the dominant GDE habitat in the Van Duzen River and Tributaries Unit, where it totals 709 acres (Figure 4.1-4).

4.2 Beneficial Uses

The Water Quality Control Plan (Basin Plan) for the North Coast Region (North Coast Regional Water Quality Control Board [NCRWQCB] 2018) identifies the surface waters in the GDE management units as having a variety of beneficial uses pertaining to fish, wildlife, humans, and GDEs 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]).

The ERVB includes the Ferndale, Scotia, Hydesville, and Bridgeville Hydrologic Subareas (NCRWQCB 2018). The boundaries of these subareas do not necessarily match the GDE boundaries. The beneficial uses for these hydrologic units are provided in Table 4.2-1, which includes fish, wildlife, GDE, and human uses: RARE; cold freshwater habitat (COLD); wildlife habitat (WILD); migration of aquatic organisms (MIGR); spawning, reproduction, and/or early development (SPAWN); and warm freshwater habitat (WARM).

Table 4.2-1. Beneficial uses designated within the ERVB hydrologic units

Beneficial use—Definition	Hydrologic unit			
	Ferndale	Scotia	Hydesville	Bridgeville
MUN (Municipal and Domestic Supply) – Uses of water for community, military, or individual water supply systems, including, but not limited to, drinking water supply	E	E	E	E
AGR (Agricultural Supply) – Uses of water for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing	E	E	E	E
IND (Industrial Service Supply) – Uses of water for industrial activities that do not depend primarily on water quality, including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization	E	E	E	E
GWR (Groundwater Recharge) – Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers	E	E	E	E
FRSH (Freshwater Replenishment) – Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity)	E	E	E	E
NAV (Navigation) – Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels	E	E	E	E
REC-1 (Water Contact Recreation) – Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible, including, but not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, whitewater activities, fishing, or use of natural hot springs	E	E	E	E
REC-2 (Non-contact Water Recreation) – Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible, including, but not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities	E	E	E	E
COMM (Commercial and Sport Fishing) – Uses of water for commercial or recreational (sport) collection of fish, shellfish, or other aquatic organisms, including, but not limited to, uses involving organisms intended for human consumption or bait purposes	E	E	E	E
COLD (Cold Freshwater Habitat) – Uses of water that support cold-water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates	E	E	E	E
WILD (Wildlife Habitat) – Uses of water that support terrestrial ecosystems, including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources	E	E	E	E

Beneficial use—Definition	Hydrologic unit			
	Ferndale	**Scotia**	**Hydesville**	**Bridgeville**
RARE (Rare, Threatened, or Endangered Species) – Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered	E	E	E	E
MIGR (Migration of Aquatic Organisms) – Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish	E	E	E	E
SPWN (Spawning, Reproduction, and/or Early Development) – Uses of water that support high-quality aquatic habitats suitable for reproduction and early development of fish	E	E	E	E
SHELL (Shellfish Harvesting) – Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes	E			
EST (Estuarine Habitat) – Uses of water that support estuarine ecosystems, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds)	E			
CUL (Native American Culture) – Uses of water that support the cultural and/or traditional rights of indigenous people, such as subsistence fishing and shellfish gathering, basket weaving and jewelry material collection, navigation to traditional ceremonial locations, and ceremonial uses	E		E	
PRO (Industrial Process Supply) – Uses of water for industrial activities that depend primarily on water quality	P	P	P	P
POW (Hydropower Generation) – Uses of water for hydropower generation	P	P	P	E
MAR (Marine Habitat) – Uses of water that support marine ecosystems, including, but not limited to, preservation or enhancement of marine habitats and vegetation such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds)	P			
AQUA (Aquaculture) – Uses of water for aquaculture or mariculture operations, including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes	P	P	P	P
WARM (Warm Freshwater Habitat) – Uses of water that support warm-water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates			E	E

Data Source: NCRWQCB 2018
E=Existing; P=Potential, habitat may not be currently present.

4.3 Special-status Species

The ERVB is ecologically important and provides habitat for numerous wildlife species that are groundwater-dependent. Within the groundwater basin, six (6) natural communities, as well as 17 plant, 21 wildlife, and 7 fish species, were identified as indirectly or directly groundwater-dependent and may occur within the ERVB. Appendix B provides information for special-status terrestrial and aquatic wildlife species identified in the database queries that were subsequently determined to be not dependent on groundwater and/or unlikely to occur in the GDE units, information that includes each species' regulatory status, habitat associations, and documented occurrences in the groundwater basins.

The ERVB GDEs feature designated critical habitat for seven federally listed species: marbled murrelet (*Brachyramphus marmoratus*), tidewater goby (*Eucyclogobius newberryi*), western snowy plover (*Charadrius alexandrinus nivosus*), California Coast (CC) evolutionarily significant unit (ESU) Chinook salmon (*Oncorhynchus tshawytscha*), Southern Oregon/Northern California Coast (SONCC) ESU coho salmon (*Oncorhynchus kisutch*), and Northern California Coast steelhead (*Oncorhynchus mykiss*) (U.S. Fish & Wildlife Service [USFWS] 2016, USFWS 2013, USFWS 2012a,b, USFWS 2020, NMFS 2005). The amount of critical habitat for each species within the GDE units within the ERVB is summarized in Table 4.3-1 and shown in Figure 4.3-1 and Figure 4.3-2.

Table 4.3-1. USFWS and NMFS designated critical habitat[1] within the ERVB

Common name *Scientific name*	**Intertidal Zone and Tributaries**	**Middle Eel River**	**Upper Eel River**	**Van Duzen River and Tributaries**
USFWS critical habitat (acres)				
Marbled murrelet *Brachyramphus marmoratus*	--	--	--	278
Tidewater goby *Eucyclogobius newberryi*	21	--	--	--
Western snowy plover *Charadrius nivosus*	71	488	60	29
All species	92	488	60	307
NMFS critical habitat (miles)				
Chinook salmon *Oncorhynchus tshawytscha* (CC ESU)	12	6	8	10
Coho salmon[2] *Oncorhynchus kisutch* (SONCC ESU)	3	6	9	17
Steelhead *Oncorhynchus mykiss* (NC DPS)	3	6	9	17
All species	18	18	26	44

Notes:
CC= California Coast; ESU= evolutionarily significant unit
SONCC = Southern Oregon/Northern California Coast
[1] Data sources: USFWS 2012, USFWS 2013, USFWS 2016, USFWS 2020, NMFS 2005
[2] Critical habitat for coho salmon includes all waters accessible for coho salmon downstream of long-standing impassable barriers. Coho salmon NMFS critical habitat was estimated using the extent of steelhead critical habitat.

The following habitat management and special-status species recovery plans have been implemented in the ERVB and include protections for special-status species and associated habitats: *Recovery Plan for the Tidewater Goby* (USFWS 2005), *Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon* (NMFS 2014), *Coastal Multispecies Recovery Plan* (NMFS 2016), and *Eel River Action Plan* (Eel River Forum 2016).

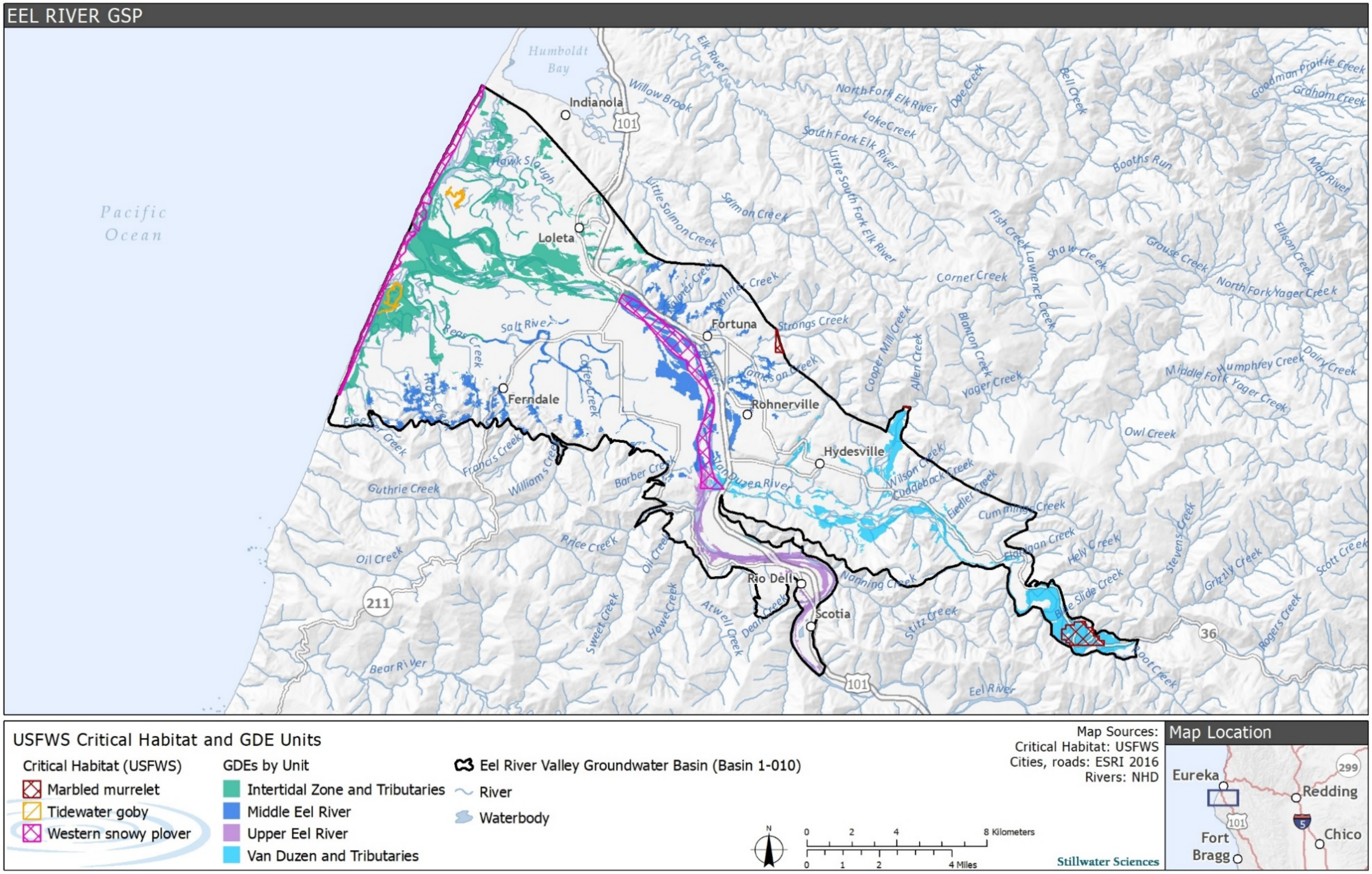


Figure 4.3-1. USFWS Critical Habitat within the ERVB

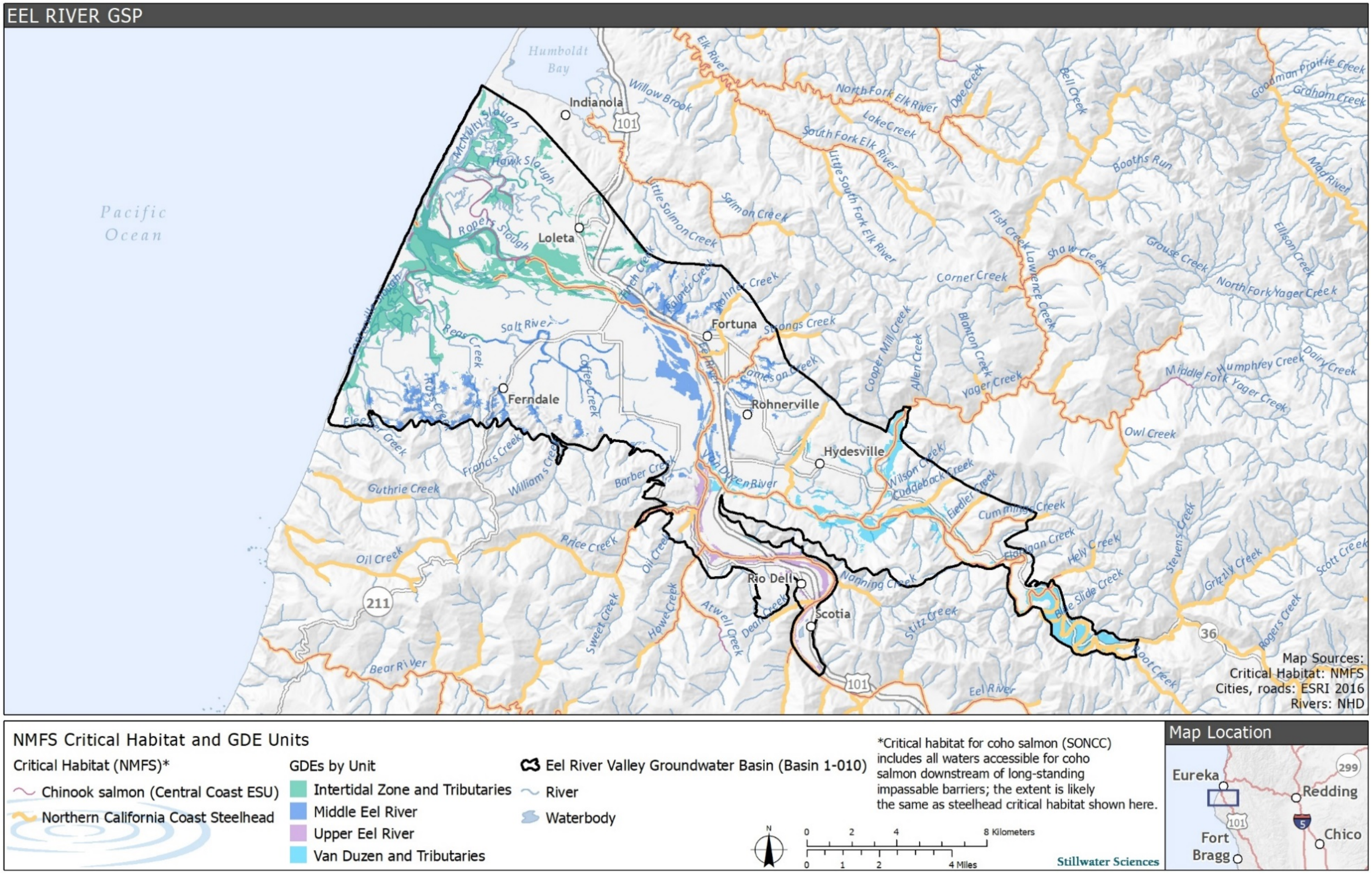


Figure 4.3-2. NMFS Critical Habitat within the ERVB

4.3.1 Plants and Natural Communities

Seventeen (17) potentially groundwater-dependent special-status plant species were documented in the ERVB. Details on these species, including their suitable habitat and the associated GDE unit(s) they have potential to occur within (based on known occurrences within the basin), are provided in Table 4.3-2.

Six (6) potentially groundwater-dependent sensitive natural communities were documented in the ERVB:

- Black cottonwood *(Populus trichocarpa)* Forest and Woodland Alliance (S3)
- Coast redwood *(Sequoia sempervirens)* Forest and Woodland Alliance (S3)
- Pacific willow (*Salix lucida* subsp. *Lasiandra)* Forest and Woodland Alliance
- Coastal Willow (*Salix hookeriana)* Shrubland Alliance (S3)
- California bay laurel *(Umbellularia californica* Forest and Woodland Alliance (S3)
- Sitka spruce *(Picea sitchensis)* Forest and Woodland Alliance (S2)

All sensitive communities are associated with riparian habitat and are distributed throughout all GDE units in the basin (see Section 4.1 for detailed descriptions).

Table 4.3-2. Special-status plant species with known occurrences in the Lower ERVB

Common name *Scientific name*	**Status (Federal, State CRPR)[1]**	**Association with GDE**	**GDE Unit**	**Source[2]**	**Habitat and occurrence**
Seacoast angelica *Angelica lucida*	None, None, 4.2	Possible, occurs in mostly coastal upland habitats (upland levee banks), though there are known occurrences associated with a potential GDE	Intertidal Zone and Tributaries, Middle Eel	CCH	Coastal bluff scrub, coastal dunes, coastal scrub, and coastal salt marshes and swamps; known occurrences observed along mouth of Eel River and within the Humboldt Bay NWR along levee of the Hookton Slough trail
Northern clustered sedge *Carex arcta*	None, None, 2B.2	Likely, habitat and known occurrences associated with a potential GDE	Van Duzen River and Tributaries	CNDDB	Bogs and fens (wetlands supported by almost constant groundwater inflow) and mesic North Coast coniferous forest
Lyngbye's sedge *Carex lyngbyei*	None, None, 2B.2	Likely, habitat and known occurrences associated with a potential GDE	Intertidal Zone and Tributaries	CNDDB	Brackish and freshwater marshes and swamps; occurs along brackish slough margins near Eel River mouth
Tracy's collomia *Collomia tracyi*	None, None, 4.3	Possible, occurs in mostly upland forested habitat, though there are known occurrences associated with a potential GDE	Van Duzen River and Tributaries	CCH	Broadleafed upland forest, lower montane coniferous forest; known occurrences along sand bar and bed of Van Duzen River near Carlotta
Cascade downingia *Downingia willamettensis*	None, None, 2B.2	Likely, habitat and known occurrences associated with a potential GDE	Middle Eel River, Van Duzen River and Tributaries	CNDDB	Lake margins in cismontane woodland and valley and foothill grassland, also vernal pools
Pacific gilia *Gilia capitata* subsp. *Pacifica*	None, None, 1B.2	Likely, habitat and known occurrences associated with a potential GDE	Van Duzen River and Tributaries, Upper Eel River	CNDDB	Coastal bluff scrub, openings in chaparral, coastal prairie, and valley and foothill grassland
Tracy's tarplant *Hemizonia congesta* subsp. *Tracyi*	None, None, 4.3	Possible, occurs in mostly upland habitat, though there are known occurrences associated with a potential GDE	Middle Eel River, Van Duzen River and Tributaries	CCH	Coastal prairie, lower montane coniferous forest, and North Coast coniferous forest; known occurrences along Eel River and on a river bar along Eel River near the Van Duzen River confluence

Common name ***Scientific name***	**Status (Federal, State CRPR)[1]**	**Association with GDE**	**GDE Unit**	**Source[2]**	**Habitat and occurrence**
Glandular western flax *Hesperolinon adenophyllum*	None, None, 1B.2	Possible, occurs in mostly upland habitat, though there is a known occurrence associated with a potential GDE	Middle Eel River, Upper Eel River	CCH	Chaparral, Cismontane woodland, and valley and foothill grassland; known occurrence on an Eel River gravel bar
Harlequin lotus *Hosackia gracilis*	None, None, 4.2	Likely, habitat and known occurrences associated with a potential GDE	Intertidal Zone and Tributaries, Middle Eel River	CCH	In water, springy areas, shores, meadows, and roadside ditches within broadleafed upland forest, coastal bluff scrub, closed-cone coniferous forest, cismontane woodland, coastal prairie, coastal scrub, meadows and seeps, marshes and swamps, North Coast coniferous forest, and valley and foothill grassland
Western lily *Lilium occidentale*	FE, CE, 1B.1	Likely, habitat and known occurrences associated with a potential GDE	Intertidal Zone and Tributaries, Middle Eel River	CNDDB, USFWS	Bogs and fens, coastal bluff scrub, coastal prairie, coastal scrub, freshwater marshes and swamps, and openings in North Coast coniferous forest
Purple flowered Washington lily *Lilium washingtonianum* subsp. *Purpurascens*	None, None, 4.3	Possible, occurs in mostly upland habitat, though there is a known occurrence associated with a potential GDE	Van Duzen River and Tributaries	CCH	Chaparral, lower montane coniferous forest, and upper montane coniferous forest; one known occurrence near Yager southeast of Eureka known from a Craig 1941 collection
Running-pine *Lycopodium clavatum*	None, None, 4.1	Likely, habitat and known occurrences associated with a potential GDE	Van Duzen River and Tributaries, Upper Eel River	CNDDB	Mesic lower montane coniferous forest, marshes and swamps, and mesic North Coast coniferous forest
Howell's montia *Montia howellii*	None, None, 2B.2	Possible, often occurs in seasonally wet sites and there are known occurrences associated with a potential GDE	Van Duzen River and Tributaries, Upper Eel River	CNDDB	Meadows and seeps, North Coast coniferous forest, and vernal pools; multiple known occurrences within forested habitats and roadsides

Common name ***Scientific name***	**Status (Federal, State CRPR)[1]**	**Association with GDE**	**GDE Unit**	**Source[2]**	**Habitat and occurrence**
Seacoast ragwort *Packera bolanderi* var. *bolanderi*	None, None, 2B.2	Unlikely, occurs in upland habitats and known occurrences are associated with forested habitats	Van Duzen River and Tributaries, Upper Eel River	CNDDB	Coastal scrub and North Coast coniferous forest; one known occurrence within coniferous forest habitat near the Van Duzen River and within an upland forested region along Eel River
Sierra gooseberry *Ribes roezlii* var. *Amictum*	None, None, 4.3	Possible, occurs in mostly upland habitat, though there is a known occurrence associated with a potential GDE	Van Duzen River and Tributaries	CCH	Broadleafed upland forest, cismontane woodland, lower montane coniferous forest, and upper montane coniferous forest; known occurrences located near Carlotta and Hydesville along the Van Duzen River
Maple-leaved checkerbloom *Sidalcea malachroides*	None, None, 4.2	Likely, habitat and known occurrences associated with a potential GDE	Van Duzen River and Tributaries	CNDDB	Broadleafed upland forest, coastal prairie, coastal scrub, North Coast coniferous forest, and riparian woodland
Siskiyou checkerbloom *Sidalcea malviflora* subsp. *Patula*	None, None, 1B.2	Possible, occurs in mostly upland coastal habitat, though there are known occurrences associated with a potential GDE	Van Duzen River and Tributaries	CNDDB	Coastal bluff scrub, coastal prairie, and North Coast coniferous forest; multiple known occurrences along Highway 36 near Alton.

[1] Status codes:
Federal
FE= Listed as endangered under the federal Endangered Species Act
State
SE= Listed as Endangered under the California Endangered Species Act
California Rare Plant Rank (CRPR)
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] Sources:
CNDDB: (CDFW 2020)
CCH: Data provided by the participants of the Consortium of California Herbaria (ucjeps.berkeley.edu/consortium/) (CCH 2020),
USFWS: USFWS (2012)

4.3.2 Terrestrial and aquatic wildlife

Twenty-one (21) potentially groundwater-dependent special-status terrestrial and aquatic wildlife species were identified as having the potential to occur within the ERVB: one (1) mollusk species, five (5) amphibian species, one (1) reptile species, and 14 bird species. Additional information on these species, including regulatory status, habitat associations, and documented occurrences in the groundwater basin, is provided in Table 4.3-3. Fifteen (15) of the groundwater-dependent special-status species were documented in the Intertidal Zone and Tributaries GDE unit, 15 in the Middle Eel River GDE Unit, 8 in the Upper Eel River GDE Unit, and 11 were documented in the Van Duzen River and Tributaries GDE Unit.

Invertebrate species (California floater [*Anodonta californiensis*]), amphibian species (foothill yellow-legged frog [*Rana boylii*], northern red-legged frog [*Rana aurora*], southern torrent salamander [*Rhyacotriton variegatus*], and California giant salamander [*Dicamptodon ensatus*]), and reptile species (western pond turtle [*Emys marmorata*]) are likely present (i.e., documented occurrences) in the ERVB GDE units and are classified as directly groundwater-dependent due to their association with stream and lentic habitats (Table 4.3-3). The GDE habitat these species may use within the groundwater basin include intermittent lake or pond, perennial lake or pond, and river/stream/canal habitats. One special-status amphibian species, Pacific tailed frog (*Anaxyrus californicus*), is possibly present in the ERVB, though its habitat is generally not present within the GDE units (Table 4.3-3).

Indirectly groundwater-dependent bird species use a variety of habitats within the basin's GDE units for foraging, nesting, and migratory habitat (Table 4.3-3). These GDEs include riparian (e.g., willow, cottonwood, mixed riparian alliances), wetland (e.g., pickleweed-cordgrass), aquatic (e.g., perennial lake or pond, river/stream/canal, California bay), and forest (e.g., redwood, coastal mixed hardwood) vegetation communities. Critical habitat for marbled murrelet and western snowy plover also overlap with ERVB GDE units (Table 4.3-3). One mammal species (Townsend's big-eared bat [*Corynorhinus townsendii*]) was classified as indirectly groundwater-dependent due to its association with riparian communities (Table 4.3-3).

Table 4.3-3. Groundwater-dependent special-status terrestrial and aquatic wildlife species with known occurrence or suitable habitat in the ERVB

Common name *Scientific name*	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Mollusk						
California floater *Anodonta californiensis*	FSC/–	Likely	Upper Eel River	CAFSD[5]	Direct	Lakes and slow, large rivers on soft substrates (mud-sand); observed in 2021 within the Eel River at Rio Dell, downstream of Scotia (Stillwater Sciences 2020)
Amphibian						
California giant salamander *Dicamptodon ensatus*	–/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River Van Duzen and Tributaries	CAFSD	Direct	Wet coastal forests in or near clear, cold permanent and semi-permanent streams and seepages; present in tributaries to the Eel and Van Duzen rivers
Foothill yellow-legged frog *Rana boylii*	–/SSC	Likely	Middle Eel River, Upper Eel River Van Duzen and Tributaries	CNDDB, CAFSD	Direct	Shallow tributaries and mainstems of perennial streams and rivers, typically associated with cobble or boulder substrate; occasionally found in isolated pools, vegetated backwaters, and deep, shaded, spring-fed pools; the frog is reliant on surface water that may be fed by groundwater; present along the lower Eel and Van Duzen rivers (CDFW 2020)
Northern red-legged frog *Rana aurora*	–/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River, Van Duzen and Tributaries	CNDDB, CAFSD	Direct	Breeds in still or slow-moving water with emergent and overhanging vegetation, including wetlands, wet meadows, ponds, lakes, and low-gradient, slow-moving stream reaches with permanent pools; uses adjacent uplands for dispersal and summer retreat. Relatively common in the groundwater basin (CDFW 2020).

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Pacific tailed frog *Ascaphus truei*	–/SSC	Possible	Middle Eel River	CNDDB	Direct	Cool perennial tributary streams; species observed in the hills east of Fortuna (CDFW 2020); habitat generally not present in the groundwater basin
Southern torrent salamander *Rhyacotriton variegatus*	–/SSC	Likely	Van Duzen and Tributaries	CNDDB, CAFSD	Direct	Cool perennial tributary streams with low amounts of fine sediment; observed along Highway 36 near the eastern boundary of the Van Duzen River portion of the basin (CDFW 2020)
Reptile						
Western pond turtle *Emys marmorata*	–/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River Van Duzen and Tributaries	CNDDB, CAFSD	Direct	Ponds, lakes, rivers, streams, creeks, marshes, and irrigation ditches with basking sites; feeds on aquatic plants, invertebrates, worms, frog and salamander eggs and larvae, crayfish, and occasionally frogs and fish; relies on surface water that may be supported by groundwater (Rohde et al. 2019); observed on the lower Van Duzen River (CDFW 2020)

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Bird						
American white pelican *Pelecanus erythrorhynchos*	–/SSC (nesting colonies)	Likely	Intertidal Zone and Tributaries	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; few observations in the vicinity of the Eel River Estuary; no nesting colonies (eBird 2021)
Bald eagle *Haliaeetus leucocephalus*	FD, BLMS, BGEPA/SE, SFP	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River, Van Duzen and Tributaries	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 (Rohde et al. 2019); observed foraging on the lower Eel River adjacent to Fortuna (eBird 2021)
Bank swallow *Riparia riparia*	BLMS/ST	Likely	Intertidal Zone and Tributaries, Middle Eel River, Van Duzen and Tributaries	CNDDB, 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); present on the lower Eel River, middle Eel River, and lower Van Duzen River (CDFW 2020, eBird 2021)

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Black tern *Chlidonias niger*	–/SSC	Likely	Intertidal Zone and Tributaries	CAFSD, eBird	Indirect	Nests semi-colonially in protected areas of marshes with floating nests; feeds on insects; few observations in the vicinity of the Eel River Estuary (eBird 2021)
Lucy's warbler *Leiothlypis luciae*	–/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River	CAFSD, eBird	Indirect	Breeds in riparian mesquite woodlands; preys on aquatic organisms, including insects, crustaceans, zooplankton, and invertebrates; infrequent sightings around Ferndale and floodplain (eBird 2021)
Marbled murrelet *Brachyramphus marmoratus*	FT/SE	Likely	Van Duzen and Tributaries	CNDDB, eBird	Indirect	Most time spent on the ocean; nests inland in old-growth conifers with suitable platforms, especially redwood or Douglas-fir forests near coastal areas; relies on old-growth coastal tree stands that may rely on groundwater to nest (Rohde et al. 2019); critical habitat located in the Van Duzen River and Tributaries GDE Unit (USFWS 2016); occupies old-growth redwood stands in the lower Grizzly Creek watershed on the Van Duzen River at the eastern edge of the basin (eBird 2021)
Redhead *Aythya americana*	–/SSC	Likely	Intertidal Zone and Tributaries	CAFSD, eBird	Indirect	Freshwater emergent wetlands with dense stands of cattails (*Typha* spp.) and bulrush (*Schoenoplectus* spp.) interspersed with areas of deep, open water; forages and rests on large, deep bodies of water; observed in lower Eel River downstream of Fernbridge (eBird 2021)

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Summer tanager *Piranga rubra*	–/SSC	Likely	Middle Eel River	CAFSD, eBird	Indirect	Open mixed lowland forests, nesting in mature riparian cottonwood forests; feeds on bees, wasps, and other insects; two sightings in Fortuna (eBird 2021)
Tricolored blackbird *Agelaius tricolor*	–/ST	Likely	Intertidal Zone and Tributaries, Middle Eel River	CAFSD, CNDDB, eBird	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 GDEs for breeding and roosting (Rohde et al 2019); observed on the floodplains downstream of the Van Duzen River (CDFW 2020, eBird 2021)
Western snowy plover *Charadrius alexandrinus nivosus*	FT/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River, and Van Duzen River and Tributaries	CNDDB, eBird	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; can nest near wetlands that may be supported by groundwater, including near freshwater wetlands (Rohde et al. 2019); critical habitat located all four (4) ERVB GDE units (USFWS 2012a); present along the lower Eel River between Fernbridge and the mouth of the Van Duzen River (eBird 2021)
Willow flycatcher *Empidonax traillii*	FE/SE	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River, Van Duzen and Tributaries	CAFSD, eBird	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; observed within all four (4) ERVB GDE units (eBird 2021)

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Yellow-billed cuckoo *Coccyzus americanus occidentalis*	FT, BLMS/ SE	Likely	Intertidal Zone and Tributaries, Middle Eel River	CAFSD, CNDDB, eBird	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 (Rohde et al. 2019); records showing presence on the lower Eel River downstream of Fernbridge (CDFW 2020, eBird 2021)
Yellow-breasted chat *Icteria virens*	–/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River, Van Duzen and Tributaries	CAFSD, eBird	Indirect	Early successional riparian habitats with a dense shrub layer and an open canopy; present throughout the Lower ERVB (eBird 2021)
Yellow-headed blackbird *Xanthocephalus xanthocephalus*	–/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River	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; forages within wetlands and surrounding grasslands and croplands; observed downstream of the Van Duzen River (eBird 2021)

Common name *Scientific name*	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Mammal						
Townsend's big-eared bat *Corynorhinus townsendii*	BLMS/SSC	Likely	Van Duzen and Tributaries	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 soft-bodied insects and drinks water; last recorded observation in 1924 from Carlotta area (CDFW 2020)

[1] Status codes

Federal
FD = Federally delisted
BGEPA = Federally protected under the Bald and Golden Eagle Protection Act
FE = Listed as endangered under the federal ESA
FT = Listed as threatened under the federal ESA
FSC = Federal species of concern
BLMS = Bureau of Land Management Sensitive Species

State
SE = Listed as Endangered under CESA
SSC = CDFW species of special concern
SFP = CDFW fully protected species
ST = Listed as Threatened under the CESA

[2] Potential to Occur:
Likely: the species has documented occurrences and the habitat is high quality or quantity
Possible: no documented occurrences and the species' required habitat is moderate to high quality or quantity
Unlikely: no documented occurrences and the species' required habitat is of low to moderate quality or quantity
None: no potential to occur due to lack of habitat and/or the population is assumed extirpated

[3] Query source:
CAFSD: California Freshwater Species Database (TNC 2020)
CNDDB: California Natural Diversity Database (CDFW 2020)
eBird: (eBird 2021)

[4] 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

4.3.3 Fish

Eight (8) special-status fish species occur within the ERVB (Table 4.3-4), though the their life history stages vary greatly, with some fish relatively stationary in their habitat areas (e.g., tidewater goby and coastal cutthroat trout), while others (anadromous salmonids and green sturgeon) migrate through the basin and only occupy it during certain periods. The general species descriptions below are intended to provide an understanding of the life history stages of special-status fish species that occupy the ERVB.

The mainstem Eel and Van Duzen rivers are generally used as passage corridors for adult and juvenile coho and Chinook salmon and steelhead (Figure 4.3-3). Water temperatures in the lower Eel and Van Duzen rivers generally exceed stressful conditions during the summer months, which limits juvenile salmonid rearing. The substrate in the mainstem Eel River is generally too fine and winter bedload movement too high for successful spawning. Winter flows and bedload movement are also generally too high in the Van Duzen River downstream of Carlotta for spawning. However, a low level of spawning does occur in these reaches during dry water years when access to upstream reaches is restricted by low flows (ERRP 2014). Adult coho, chinook, and winter-run steelhead passage in this reach typically begins in mid-September and runs through May, beginning with the Chinook salmon in the fall and ending with runback (kelts) steelhead in the late spring (Dennis Halligan, personal observations 1997-2020). Summer-run steelhead, which were recently listed as endangered by CDFW, enter the Eel River in the late spring/early summer to migrate to the Van Duzen River and Middle Fork Eel River (Kannry et al. 2020). Summer run steelhead have been observed holding near the mouth of the Van Duzen during the summer in some years (Dennis Halligan, personal observations). Spawning and rearing typically occur in the tributaries within the ERVB. The lone exception is that some steelhead rearing may occur near the Yager Creek confluence on the Van Duzen River, and some steelhead spawning may occur upstream of the Yager Creek confluence (Figure 4.3-3). Anadromous salmonid smolts move downstream to the estuary from their rearing areas in the spring and early summer. Critical riffles observed between 2006 and 2020 (Stillwater Sciences 2021), noted on Figure 4.3-3, block adult salmonid passage until the first high flows during the fall. Near the confluence with the Eel River, the Van Duzen River often goes dry from the late summer through the fall and does not connect to the Eel River until the first significant storm flows in the fall. The degree to which groundwater management affects fish passage will be explored using the groundwater-surface water model. Sediment deposition, particularly at the mouth of the Van Duzen River and downstream reaches of the Eel River, likely contributes to passage issues.

Coastal cutthroat trout occupy different areas of the ERVB than Chinook and coho salmon and steelhead. The Van Duzen River is considered the southernmost extent of the species. In the Eel River, this species occupies the Intertidal Zone and Tributaries and Middle Eel River GDE units (e.g., Strongs, Rohner, Barber, Francis, Reas, and Russ creeks) (Figure 4.3-3). Coastal cutthroat trout require cool, clean water with ample cover and deep pools for holding in summer, preferring small, low-gradient coastal streams (e.g, Strongs, Rohner, Barber, Francis, Reas, and Russ creeks) and estuarine habitats, including lagoons (Moyle et al. 2015). Optimal stream temperatures are less than 18°C, with preferred temperatures around 9°C to 12°C, which would limit their summer and early fall occupancy to the estuary and small cool tributaries.

The tidewater goby is a short-lived (about one year) fish that resides in lagoons and estuary areas with muted tidal flow and low to moderate salinities generally less than 12 parts per thousand (ppt), but they have been documented in salinities ranging from 0 to 44 ppt (USFWS 2013). Tidewater goby only occur in the Intertidal Zone and Tributaries GDE Unit (Figure 4.3-3). This species is known to be present in Salt River and on The Wildlands Conservancy property near the mouth of the Eel River.

Green sturgeon are known to inhabit the Eel River with a potentially persistent small spawning population using the Eel River. There are known historical and recent sightings of green sturgeon within the mainstem Eel River, with the majority of those sightings centered from the confluence of the North Fork (river kilometer [rkm] 155) to the confluence of the South Fork (rkm 65) as well as in the estuary (Stillwater Sciences and Wiyot Tribe 2017). The Eel River is proximate to the Klamath River, and it is even closer to Humboldt Bay, which is a documented feeding habitat for both the Southern and Northern Distinct Population Segments (DPS) (Lindley et al. 2011). Therefore, it is possible that any green sturgeon in the Eel River could be a mix of Northern and Southern DPS origin fish. However, the Southern DPS green sturgeon is only known to spawn in the Sacramento River and likely does not extend farther upstream in the Eel River than the mouth of the Van Duzen River. Adult green sturgeon generally return to spawn in rivers in late winter through early summer and spawn every two to six years. Post-spawn adults may choose to emigrate downstream soon after spawning or wait until the fall when water temperatures are low and early season runoff begins. Juveniles spend from one to four years in fresh and estuarine waters and disperse into salt water at lengths of 300 to 750 millimeters (mm) (USFWS 1995). Adults will return to spawn at about 13 years of age. Green sturgeon are not known to be present in the Van Duzen River and Tributaries GDE Unit.

Pacific lamprey are known to inhabit the Eel River (which was how it got its name). Pacific lampreys are anadromous, rearing in freshwater before outmigrating to the ocean, where they grow to full size prior to returning to their natal streams to spawn. Spawning typically takes place both in the mainstem of medium-sized rivers and smaller tributaries from March through July, depending on water temperature and local conditions such as seasonal flow regimes (Brumo et al. 2009, Gunckel et al. 2009). Spawning generally takes place in pool and run tailouts and low-gradient riffles. Both males and females build nests (redds) in gravel and cobble substrate. Adults die within a few weeks after spawning. Eggs hatch in about 15 days and larvae emerge from the gravel within a couple of weeks after that, then drift downstream with the current, settle out of the water column, and burrow into fine silt and sand substrate in low-velocity, depositional areas such as pools, alcoves, and side channels. They remain in this habitat for four (4) to 10 years, filter-feeding on algae and detrital matter prior to metamorphizing into smolt-like individuals known as macropthalmia (Stillwater Sciences 2010). They will then migrate downstream during high fall and winter flows to the ocean, where they mature for approximately 18 to 40 months, before returning to freshwater as sexually immature adults from late winter to early summer, beginning the cycle anew. Pacific lamprey are known to occur within all the GDEs units in the groundwater basin.

Longfin smelt are found throughout coastal northern California. Most longfin smelt exhibit a two-year life cycle, spawning and dying during their second year. However, during good growth years, longfin smelt can spawn at the end of their first year, and three-year-old smelt have also been observed (Moyle 2002). Spawning occurs in fresh water during the winter to early spring (February through April) over sandy or gravel substrate. Most smelt die after spawning, but a few (mostly females) may live another year. The eggs are adhesive and hatch in 40 days when water temperatures are 7°C. Newly hatched larvae are 5-8 millimeters (mm) long. Larvae can be moved downstream to estuaries by high flows but may also spend considerable time in fresh water. It takes almost three (3) months for longfin smelt to reach the juvenile stage (USFWS 2012b). These fish have been observed in many areas throughout the Eel River Estuary and the mainstem portions of the coastal plain (Garwood 2017). Longfin smelt used a wide range of the lower river/estuary, with individuals sampled 5.7 km from the mainstem of the river in slough waters, and as far as 20 km upriver from the mouth in alluvial portions well outside the brackish zone (Garwood 2017). There are no observations of smelt within the Upper Eel River or Van Duzen River and Tributaries GDE units.

Additional information on these fish species in the Eel River, adapted from Rohde et al. (2019), is provided in Appendix C.

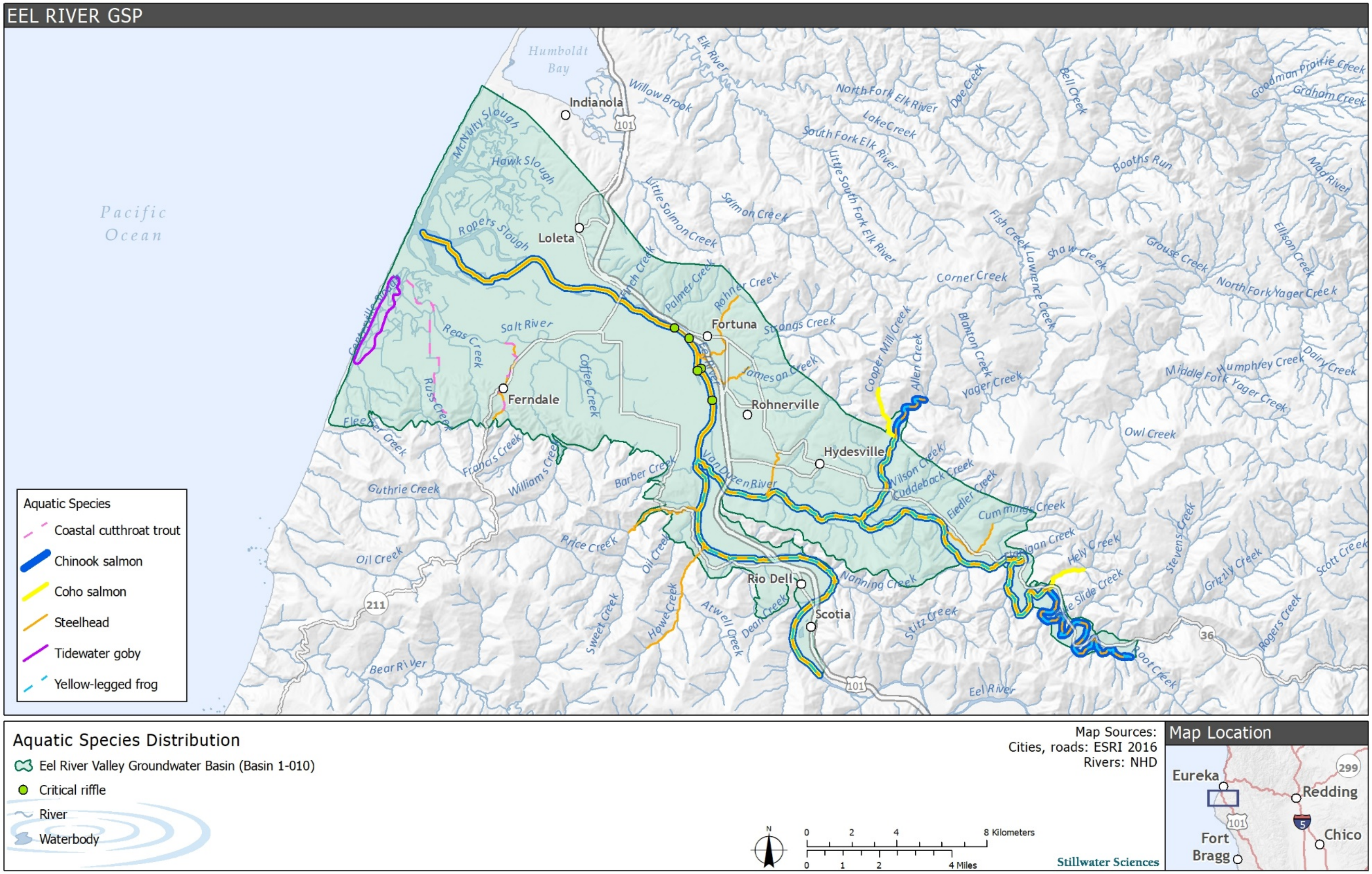


Figure 4.3-3. Aquatic species distribution in the ERVB; green circles indicate critical riffles observed from 2006 to 2020 (Stillwater Sciences 2021)

Table 4.3-4. Groundwater-dependent fish species with known occurrence or suitable habitat in the ERVB

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Chinook salmon *Oncorhynchus tshawytscha* (CC ESU)	FT/–	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River, Van Duzen and Tributaries	NMFS	Direct	Larger rivers and tributaries for migration, spawning, and rearing; estuaries and ocean for juvenile to adult growth; critical habitat located in all four (4) ERVB GDE units (NMFS 2005); present throughout watershed.
Coho salmon *Oncorhynchus kisutch* (SONCC ESU)	FT/ST	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River, Van Duzen and Tributaries	NMFS	Direct	Rivers for migration and tributaries for spawning and rearing; estuaries and ocean for juvenile to adult growth; critical habitat located in all four (4) ERVB GDE units (NMFS 2005); present throughout watershed
Steelhead *Oncorhynchus mykiss* (NC DPS)	FT/SE	Likely	Intertidal Zone and Tributaries, Middle Eel River, Van Duzen and Tributaries, Upper Eel River	NMFS	Direct	Rivers for migration and tributaries for spawning and rearing; estuaries and ocean for juvenile to adult growth; critical habitat located in all four (4) ERVB GDE units (NMFS 2005); present throughout watershed. Fall-run and summer-run steelhead are migrate through the ERVB, with summer-run steelhead listed as endangered by CDFW in 2021

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Coastal cutthroat trout *Oncorhynchus clarkii clarkii*	/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River	CNDDB	Direct	Small, low-gradient coastal streams and estuaries (CDFW 2020); occurs in the Intertidal Zone and Tributaries and Lower Eel River GDE units
Tidewater goby *Eucyclogobius newberryi*	FE/SSC	Likely	Intertidal Zone and Tributaries	CNDDB	Direct	Coastal lagoons and the uppermost zone of brackish large estuaries; prefer sandy substrate for spawning, but can be found on silt, mud, or rocky substrates; can occur in water up to 15 ft in lagoons and within a wide range of salinity (0–42 ppt); critical habitat located in the Intertidal Zone and Tributaries GDE Unit (USFWS 2013)
Green sturgeon *Acipenser medirostris* (Southern and northern DPS)	FT (southern DPS, FSC (Northern DPS/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River, Upper Eel River	NMFS	Direct	Spends most of its life at sea; returns to spawn in large rivers; juveniles rear in freshwater for up to two years then migrate to estuary and ocean; observed in estuary, Fortuna area, and upper Eel River (Halligan, pers. Comm 2021)
Pacific lamprey *Entosphenus tridentatus*	–/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River, Van Duzen and Tributaries, Upper Eel River	CNDDB	Direct	Migration in rivers and tributaries; spawning in medium-sized rivers and tributaries; rearing in low-velocity depositional areas for four to 10 years prior to outmigration to estuary and ocean; present throughout the watershed (Stillwater Sciences 2010)

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Longfin smelt *Spirinchus thaleichthys*	– /ST	Likely	Intertidal Zone and Tributaries, Middle Eel River	CNDDB	Direct	Offshore areas, coastal lagoons, bays, estuaries, sloughs, and freshwater rivers and streams; spawns in freshwater; observed in the estuary in 1995 and near mouth of Van Duzen River in 1956 Garwood 2017), also captured during monitoring operations in Salt River in 2014/2015 (HCRCD 2014)

Notes: CC = California Coast; ESU = evolutionarily significant unit; SONCC = Southern Oregon/Northern California Coast

[1] Status codes

Federal
- FE = Listed as endangered under the federal ESA
- FT = Listed as threatened under the federal ESA
- FSC = Federal species of concern

State
- SSC = CDFW species of special concern
- ST = Listed as Threatened under the California Endangered Species Act
- SE == Listed as Endangered under CESA

[2] Potential to Occur:

Likely: the species has documented occurrences and the habitat is high quality or quantity
Possible: no documented occurrences and the species' required habitat is moderate to high quality or quantity
Unlikely: no documented occurrences and the species' required habitat is of low to moderate quality or quantity
None: no potential to occur due to lack of habitat and/or the population is assumed extirpated

[3] Query source:

CAFSD: California Freshwater Species Database (TNC 2020)
CNDDB: California Natural Diversity Database (CDFW 2020)
eBird: (eBird 2021)

[4] 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

4.4 Invasive Species

Non-native and invasive species are distributed throughout the Eel River watershed, including the Lower ERVB. Invasive species have a negative impact on the riparian corridor and threaten native species populations.

Reed canary grass (*Phalaris arundinacea*) was noted in the Intertidal Zone and Tributaries GDE Unit, where it was prevalent within the wet grassland and high marsh community types near the Salt River confluence with the Eel River (H.T. Harvey & Associates 2015). This non-native perennial rhizomatous grass invades moist wetland habitat and spreads and establishes quickly, forming dense monotypic stands that displace native herbaceous stands and are difficult to eradicate once established. Other woody non-native invasive species (listed by California Invasive Plant Council with a high rating [i.e., species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure]) included Himalayan blackberry (*Rubus armeniacus*), Scotch broom (*Cytisus scoparius*), and pampas grass (*Cortaderia jubata*), all of which establish within the riparian forest and shrubland communities as well as some grassland communities near development and roads.

American bullfrog (*Lithobates catesbeianus*), an invasive amphibian species, is documented throughout the lower Eel and Van Duzen river floodplains within isolated ponds. The bullfrog preys on practically whatever can fit in its mouth, including native amphibian species (e.g., foothill yellow-legged frogs and northern red-legged frogs).

Many non-native fish species have been introduced into the Eel River by direct stocking or releases of live bait used to catch other species. Various sunfish species (*Lepomis* spp.) (e.g., green sunfish [*Lepomis cyanellus*] and bluegill [*Lepomis macrochirus*]), and bass species (*Micropterus* spp.) (e.g., largemouth bass [*Micropterus salmoides*]), have been documented in Lake Pillsbury, which is in Lake County and outside of the Lower ERVB. The Sacramento pikeminnow (*Ptychocheilus grandis*), which is believed to have been introduced into the Eel River through release of unused live bait in Lake Pillsbury, has spread throughout the watershed. Non-native predatory fish may have a large impact on native fish populations (e.g., salmonids), reducing the size of already diminished populations and limiting their ability to recover in response to habitat restoration efforts.

5 POTENTIAL EFFECTS ON GROUNDWATER-DEPENDENT ECOSYSTEMS

5.1 Approach

SGMA describes six (6) groundwater conditions that could cause undesirable results, including adverse impacts on GDEs: 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 ERVB, reduction of groundwater storage and land subsidence have been removed from consideration as conditions leading to undesirable results because they are not relevant to GDE units in the ERVB. Seawater intrusion could occur due to decreased groundwater levels or rising sea level in the Intertidal Zone and Tributaries GDE Unit.

The potential for chronic lowering of groundwater levels, degraded groundwater quality, depletion of interconnected surface waters, and seawater intrusion to cause direct effects on GDE units were evaluated compared to baseline conditions. First, baseline hydrologic conditions for the GDE units were identified using available information (Section 3), then each GDE unit's susceptibility to changing groundwater conditions was determined using available hydrologic data and the GDE susceptibility classifications (Rohde et al. 2018) summarized in Table 5.1-1. Once the groundwater and interconnected surface water models are available, the potential for groundwater management to affect interconnected surface water and seawater intrusion will be evaluated. Other than algal blooms due to high nutrient concentrations in surface water and elevated nutrient levels in groundwater due to high nutrient input (State Water Resources Control Board [SWRCB] 2020), there have not been declines in water quality.

Table 5.1-1. Susceptibility classifications developed for evaluation of a GDE unit'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.[1]
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.

[1] For purposes of this analysis, the baseline range is defined as the range of variability of the shallow groundwater depth for the period of record through 2015, with a minimum of 10 years (2005–2015).

Susceptibility classifications were used to trigger further evaluation of potential effects on GDE units. If a GDE unit was determined to have moderate or high susceptibility to changing groundwater conditions, biological information was used to assess whether evidence exists of a biological response to changing groundwater levels or degraded groundwater quality. The biological response analysis was based on changes in Normalized Difference Vegetation Index (NDVI) data for individual vegetation polygons within the GDE units (Klausmeyer et al. 2019). The51olygonns correspond to different GDE mapping units (i.e., different species compositions) and the size of the GDE polygons varied. The Normalized Difference Moisture Index (NDMI) was also evaluated, but the results were very similar to NDVI and are not included here.

NDVI, which estimates vegetation greenness, was generated from surface reflectance corrected multispectral Landsat imagery corresponding to the period from July 9 to September 7 of each year, which represents the summer period when GDE species are most likely to use groundwater (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 vigorous, growing vegetation. NDVI is a commonly used proxy for vegetation health in analyses of temporal trends in the health of groundwater-dependent vegetation (Rouse et al. 1974 and Jiang et al. 2006 as cited in Klausmeyer et al. 2019).

Critical riffle depth data collected within the GDE units were used to assess the potential effects late summer and fall groundwater use may have on passage during the upstream anadromous salmonid migration.

Based on the NDVI data, groundwater quality data from wells in or near GDE units in the ERVB, and the likely susceptibility of the terrestrial and aquatic species and natural communities in each GDE unit to reported groundwater quality constituents, no evidence was found of a biological response associated with groundwater quality in any of the GDE units. Groundwater quality is therefore not addressed further in the analysis of potential effects.

The extent and magnitude of interconnected surface waters is a key component supporting aquatic ecosystem health. Because surface water flows depend on surface water inflows and interconnected surface water, the numerical modeling conducted as part of this GSP will be used to evaluate changes to interconnected surface water due to groundwater management and the potential effect on aquatic GDE units. The extent of interconnected surface water and the effect of groundwater management on interconnected surface water and aquatic habitat will be evaluated in the GSP. The assessment of interconnected surface water is dependent upon the groundwater model. The comparisons will therefore be included in the final GSP.

5.2 Biological Data

Tracking the health of key components of groundwater dependent ecosystems through time would involve systematic tracking of populations and key ecosystem functions through that same duration and accounting for changes in driving variables such as floods, climate, and other stressors on populations. Accordingly, this section focuses on changes in vegetation through time using remote sensing data.

While increases or decreases in vegetation health do not provide a definitive indication that other components of the ecosystem are thriving or under stress, they do provide a reasonable first-order check on the clear linkage between groundwater and the other communities that compose the ecosystem. NDVI is not useful for tracking changes to aquatic GDE units that rely on interconnected surface water. Previous work has shown that decreases in vegetation vigor correlate to decreases in remote sensing metrics such as NDVI (e.g., Huntington et al. 2015), and that decreases in vegetation health often correspond with decreases in overall ecosystem health. Tracking the change in NDVI for individual polygons shows how the greenness of those polygons change through time. It is crucial to remember that the rivers in the ERVB, particularly the Eel and Van Duzen rivers, have very high sediment loads and are quite dynamic. This shifting uproots vegetation and creates new surfaces upon which seedlings can germinate. Following floods, the proximity to the river channel (and often depth to groundwater), the relative elevation of a given vegetation polygon, or location of riffles that may hinder upstream salmonid migration may change. It is therefore useful to average these changes across the different GDE polygons to account for and address them.

To assess potential groundwater thresholds for vegetation health, average NDVI from July 9 to September 7 for each year in each GDE unit is compared to DTW at corresponding monitoring wells. For each year, the DTW measurement taken at the closest date within three months of August 8, the median summer NDVI date, is used, where available. Long-term well data (since

1985) is only available for a limited number of wells in the coastal plain of the Intertidal Zone and Tributaries and Middle Eel GDE units.

5.2.1 Intertidal Zone and Tributaries

The median NDVI in the Intertidal Zone and Tributaries GDE Unit ranges from 0.48 to 0.74 and has generally been increasing through time (Figure 5.2-1), which occurs across the entire range of GDE units. Short-term changes in NDVI are not systematically tied to water-year type. The reasons for the increase in NDVI are not known but appear to reflect establishment and maturation of riparian vegetation in the past few decades on some bars and islands along the mainstem Eel River.

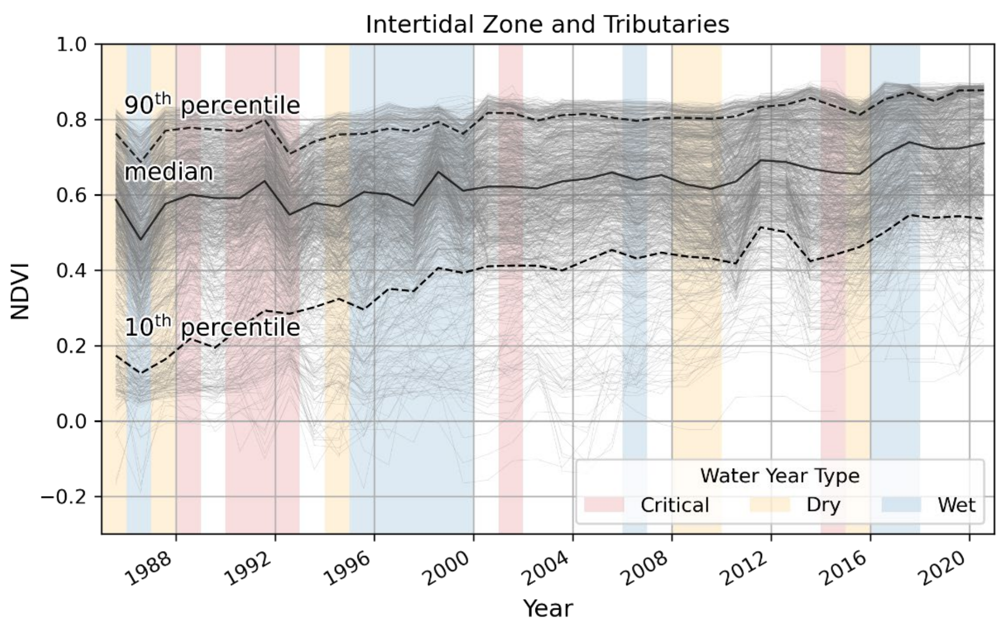


Figure 5.2-1. NDVI changes through time for the Intertidal Zone and Tributaries GDE Unit; the solid black line is the median value, and the dashed lines represent the 10th and 90th percentiles

There is no apparent correlation between median summer NDVI and DTW (within three [3] months of August 8; see Section 5.2) at either of the associated monitoring wells in the Intertidal Zone and Tributaries GDE Unit (Figure 5.2-2).

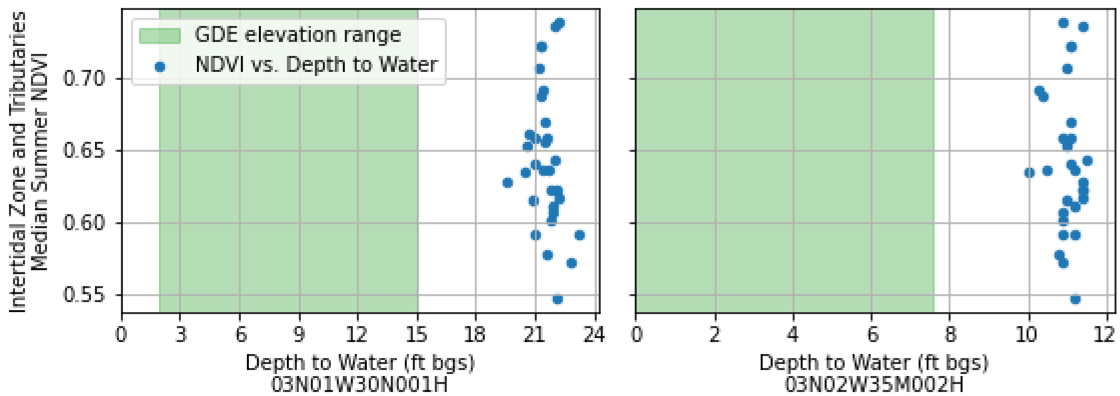


Figure 5.2-2. Median summer NDVI in the Intertidal Zone and Tributaries GDE Unit versus DTW at the two associated monitoring wells (DTW data selection method is outlined in Section 5.2.)

Willow shrub and willow are the dominant vegetation types in the Intertidal Zone and Tributaries GDE Unit. The dominant willow species in these vegetation types have reported maximum rooting depths of 6.9 ft (Appendix A). Groundwater is typically within the rooting depth of the dominant vegetation types at the lowest-elevation GDEs when adjusted for the difference in elevation between GDEs and monitoring well sites (Figure 5.2-3, see methods in Section 3.1.1).

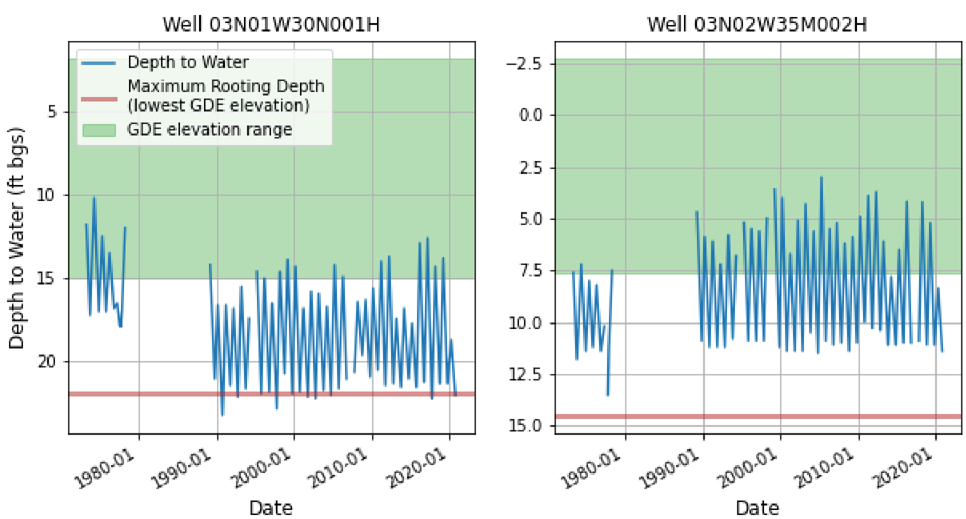


Figure 5.2-3. Depth to groundwater and maximum rooting depth of dominant vegetation type in the Intertidal Zone and Tributaries GDE Unit. Maximum rooting depth is plotted relative to the lowest-elevation GDEs.

Depths of riffles and anadromous salmonid fish passage in the Intertidal Zone and Tributaries GDE Unit are not fully dependent on surface flow inputs from upstream due to the intertidal nature of the GDE.

5.2.2 Middle Eel River

The median NDVI for the Middle Eel River GDE Unit was relatively steady through time, with slight increases in the mid-1990s and from 2010 through 2011. The median NDVI over the period of record was 0.57-0.80 (Figure 5.2-3). Between these increases NDVI was relatively steady, with slight drops in 1992 (critically dry) and in 2002 (a normal year following critically dry 2001). Similar to at the Intertidal Zone GDE Unit, the reasons for the generally increasing trend are not known but appear to reflect establishment and maturation of riparian vegetation in the past few decades on some bars and islands along the mainstem Eel River.

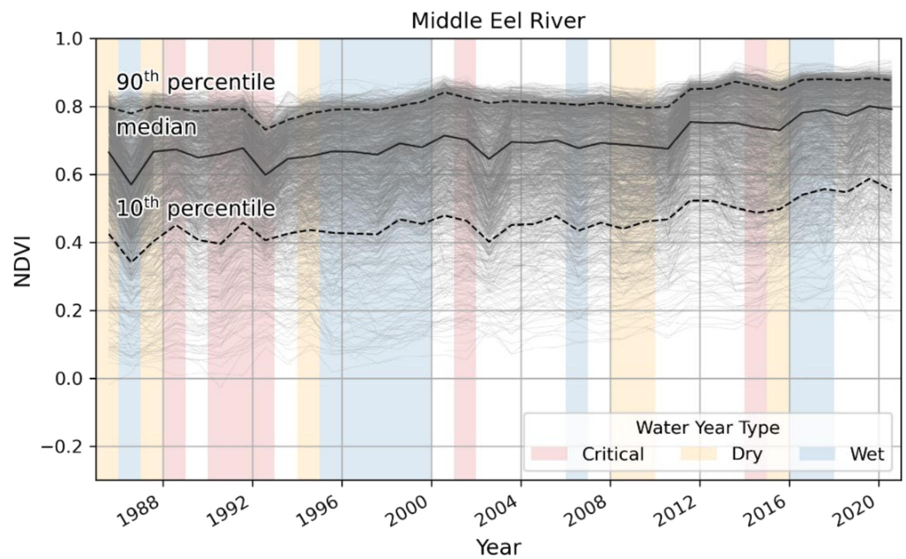


Figure 5.2-4. NDVI changes through time for the Middle Eel River GDE Unit; the solid black line is the median value and the dashed lines represent the 10th and 90th percentiles

There is no apparent correlation between median summer NDVI and DTW at either of the associated monitoring wells in the Middle Eel River GDE Unit (Figure 5.2-4).

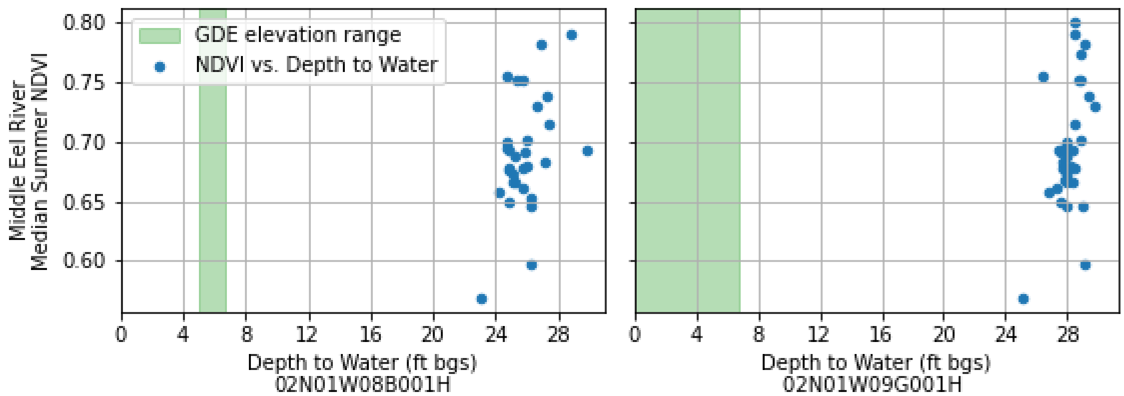


Figure 5.2-5. Median summer NDVI in the Middle Eel River GDE Unit versus DTW at the two (2) associated monitoring wells (DTW data selection method is outlined in Section 5.2.)

Red alder is the dominant species in the Middle Eel River GDE Unit and has a maximum rooting depth of approximately 13 ft (Appendix A). Spring groundwater elevations are typically within the rooting depth of the dominant vegetation types at the lowest-elevation GDE units when adjusted for the difference in elevation between GDEs and monitoring well sites (Figure 5.2-6, see methods in Section 3.1.1). The GDEs within 0.5 miles of the long-term wells in this reach are former channels and oxbow lakes (see Figure 2.3-1).

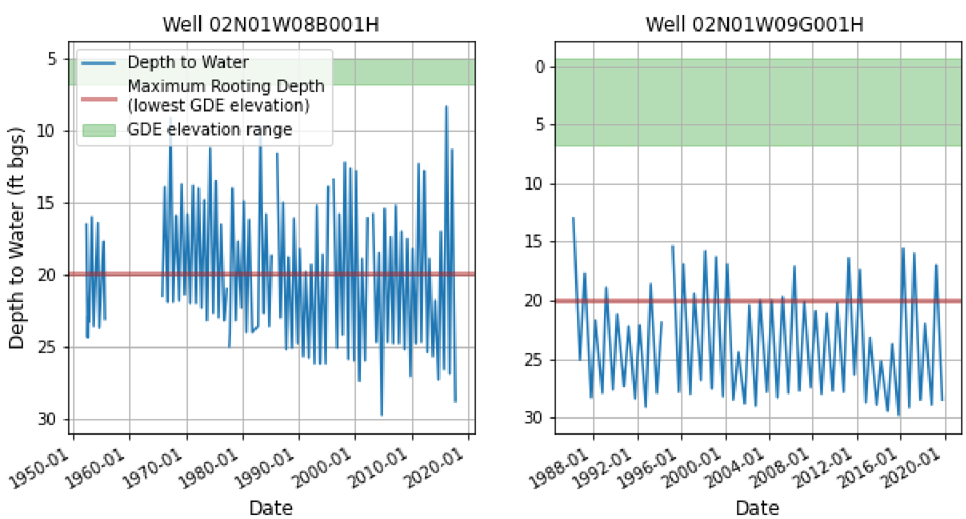


Figure 5.2-6. Depth to groundwater and maximum rooting depth of dominant vegetation type in the Middle Eel River GDE Unit; maximum rooting depth is plotted relative to the lowest-elevation GDE units

Critical riffle depths in the Middle Eel River GDE have been recorded between 2005 and 2020 (Stillwater Sciences 2021). The shallowest riffles appeared only to be loosely correlated with river flow as measured at the USGS Scotia gauge (Figure 5.2-7). It is possible that riffle depth is more a function of geomorphic processes than total inflow into the GDE. The role of interconnected surface water will be explored once the model results are available.

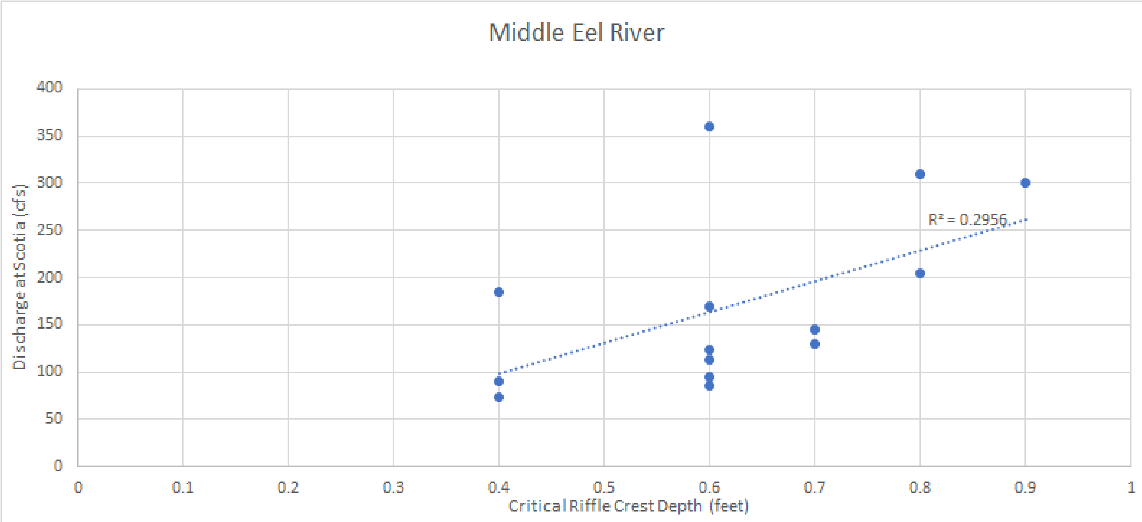


Figure 5.2-7. Shallowest riffle depths vs. discharge at Scotia within the Middle Eel River GDE Unit

5.2.3 Upper Eel River

The NDVI in the Upper Eel River shows similar trends to the other GDE units, with median values that gradually increased over time from 0.46 to 0.76 (Figure 5.2-8). The declines in 1993 and 2003 lasted one (1) year and were less than those for the Middle Eel River GDE Unit.

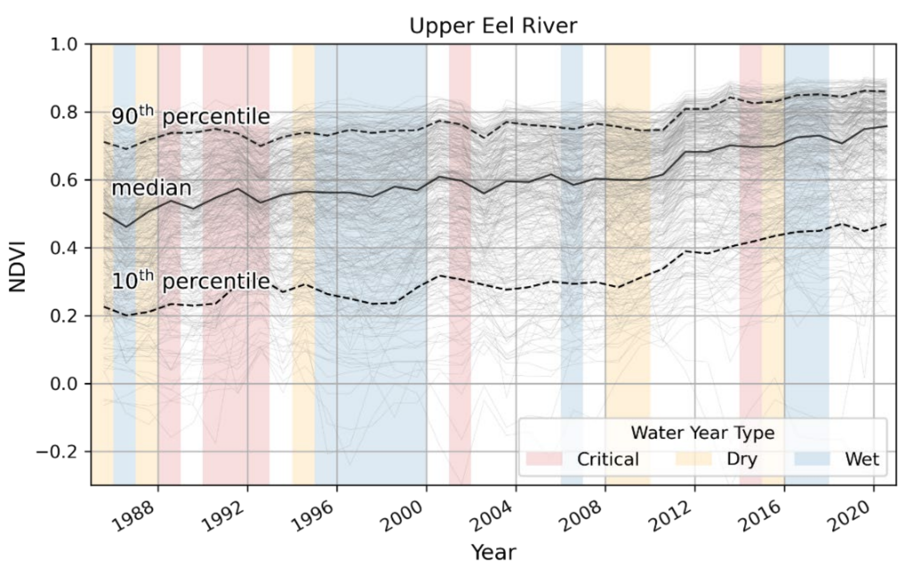


Figure 5.2-8. NDVI changes through time for the Upper Eel River GDE Unit; the solid black line is the median value and the dashed lines represent the 10th and 90th percentiles

Red alder is the dominant species in the Upper Eel River GDE Unit and has a reported maximum rooting depth of 13.12 ft (Appendix A). There are no shallow well data in this unit.

Critical riffle depths are not available for the Upper Eel River GDE Unit.

5.2.4 Van Duzen River and Tributaries

NDVI was relatively constant in the Van Duzen River and Tributaries GDE Unit from 1985 to 2011, increasing in 2012 and remaining relatively steady through 2020 (Figure 5.2-9). The median NDVI ranged from 0.56 to 0.75.

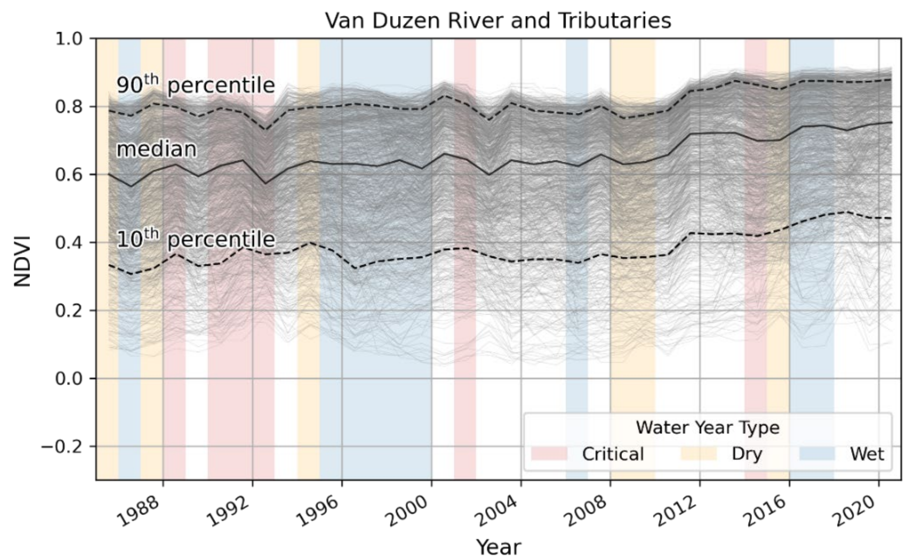


Figure 5.2-9. NDVI changes through time for the Van Duzen River and Tributaries GDE Unit; the solid black line is the median value, and the dashed lines represent the 10th and 90th percentiles

No DTW data within three months of August 8 (the midpoint of the NDVI data) are available for the Van Duzen River and Tributaries GDE Unit.

Redwood and annual/perennial grassland are the dominant species in the Van Duzen River and Tributaries GDE Unit, with likely maximum rooting depths ranging from 8.5 to 16.4 (redwood) and 2.3 to 4.6 ft (grassland) (Appendix A). Recent shallow groundwater elevations (Section 3.1.3) are typically within the rooting depth of the dominant vegetation types at the lowest-elevation GDE units when adjusted for the difference in elevation between GDEs and monitoring well sites (Figure 5.2-10, see methods in Section 3.1.1).

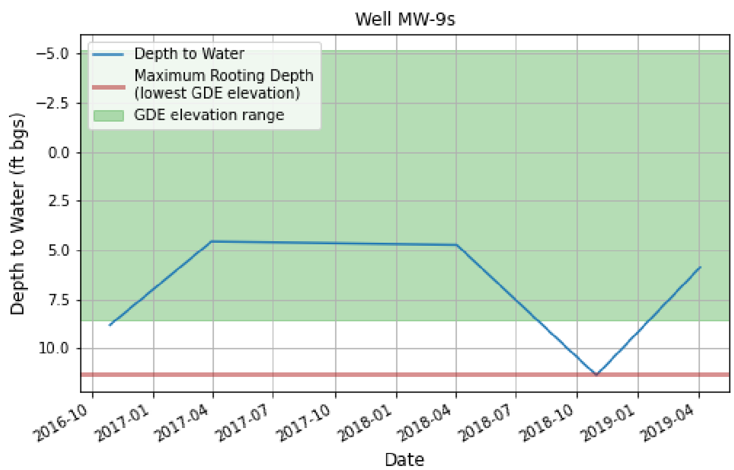


Figure 5.2-10. Depth to groundwater and maximum rooting depth of dominant vegetation type in the Van Duzen River and Tributaries GDE Unit; maximum rooting depth is plotted relative to the lowest-elevation GDE units

The delta at the mouth of the Van Duzen River goes subsurface during all but the wettest water years (Dennis Halligan, Stillwater Sciences, pers. Comm. 2021) and creates a complete barrier to upstream anadromous salmonid migration. In addition, other reaches within the Van Duzen River and Tributaries GDE Unit (e.g., Carlotta area) experience intermittent flow characteristics during below-normal water years. Riffle crest depth data for the years 2006-2021 were collected by Stillwater Sciences (2021). The average riffle crest data show correlation (R^2=0.6978) with the USGS Bridgeville gauge data at the time of collection (Figure 5.2-11) suggesting that passage is related to surface water inflows to the basin.

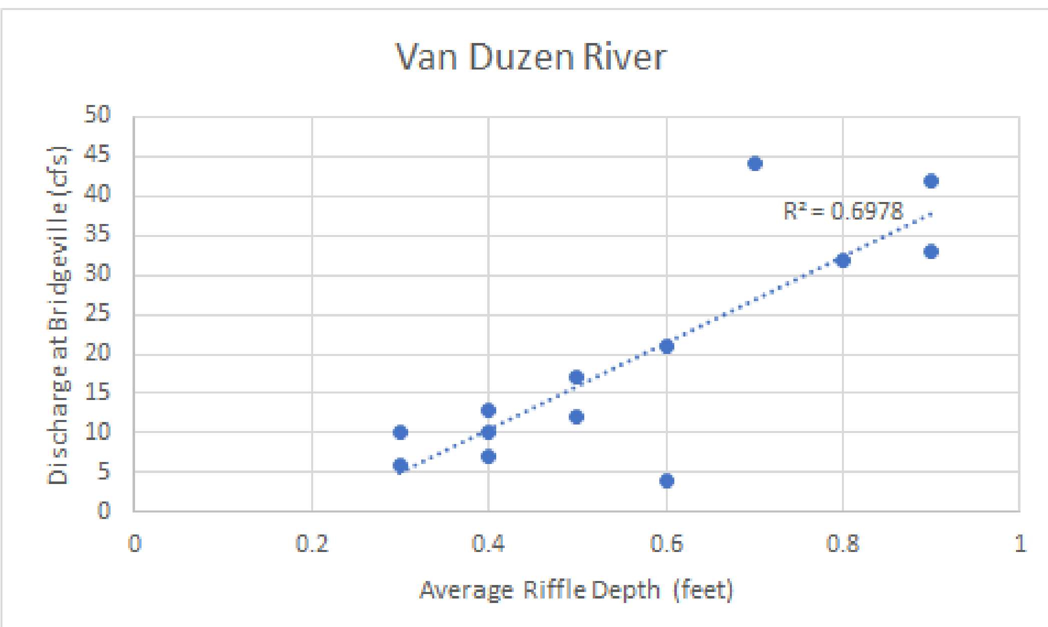


Figure 5.2-11. Average riffle depth vs. discharge at Bridgeville within the Van Duzen River and Tributaries GDE Unit

5.3 Climate Change Effects

In general, climate change can affect GDEs by altering the water budget, causing groundwater levels to decline, and causing interconnected surface flows to decrease (Dwire et al. 2018). Moreover, climate change could increase the risk of wildfire and promote establishment of non-native species, which could impact GDE health (Dwire et al. 2018).

Though climate change may alter the water demands of groundwater-dependent vegetation, the response is complex. Decreased transpiration associated with increased carbon dioxide in the atmosphere may counter increased evaporation due to temperature increases (e.g., Kløve et al. 2014). In addition, sea level rise may extend the existing tidal influence farther inland and increase salinity levels in inundated soils and waterways, thus impacting existing groundwater-dependent vegetation communities and possibly shifting vegetation towards more salt-tolerant species assemblages.

5.4 Summary of Potential Effects

The potential effects of groundwater management on GDEs can be used to assess the likely future susceptibility to groundwater management and climate change. This is based on an analysis of the data presented in previous sections, plus the ecological value of the GDE units (following Rohde et al. 2018). The potential effects can be used to prioritize monitoring and to develop sustainable management criteria.

The potential effects on each GDE Unit are summarized here based on three primary criteria:

1. Ecological value (high, moderate, low), 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). In addition, the presence of natural or near-natural conditions and ecosystem function was also considered.
2. Ecological condition of the GDEs within each unit (good, fair, poor), based on the information summarized in Section 4 and the NDVI/NDMI data presented in Section 5.2.
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 5.1-1. Susceptibility determinations may be changed following the completion of the groundwater model.

The groundwater-dependence of each GDE unit, including any interconnected surface water, is also summarized to provide context for the effects assessment. Groundwater-dependence was determined based on the reported or assumed rooting depths relative to the depth to groundwater and the presence of interconnected surface water based on field observations and the groundwater model.

5.4.1 Intertidal Zone and Tributaries

The Intertidal Zone and Tributaries GDE Unit contains 43% of the total GDE acreage in the ERVB (Table 3.3-1). The reach of the lower Eel River in the Intertidal Zone and Tributaries GDE Unit is considered perennial and intertidal and is typically connected to groundwater. The degree to which interconnected surface waters affect the salinity in this reach varies by season and flow. Salinity is generally reduced during periods of high runoff and groundwater accretion, increasing during the low flow season.

Groundwater-dependence

Both terrestrial and aquatic species and habitat in the Intertidal Zone and Tributaries GDE Unit are likely dependent on groundwater. Additionally:

- Shallow groundwater elevations in the limited long-term well data have remained stable since 1990. Groundwater levels in wells installed in 2016 show no systematic changes over a limited period of record. Groundwater elevations are within the rooting depth of dominant species within the GDE.
- Terrestrial components of this GDE unit are mostly composed of riparian forested vegetation communities formed by a mixture of willows, red alder, and black cottonwood that are likely connected to groundwater.
- Perennial surface water flows are likely connected to groundwater in the Eel and Salt rivers.

Ecological value

Aquatic

The Intertidal Zone and Tributaries GDE Unit was determined to have high ecological value for aquatic species and habitat because: 1) It supports many aquatic special-status species, including two (2) amphibian, one (1) aquatic reptile, and eight (8) fish species (Tables 4.3-3 and 4.3-4); 2) it contains designated critical habitat for listed anadromous salmonids (Chinook salmon, coho salmon, and steelhead) and tidewater goby (Table 4.3-1, Figures 4.3-1 and 4.3-2); 3) it supports native special-status species with a known or high likelihood of direct groundwater-dependence (six [6] ESA- and/or CESA-listed fish [Chinook and coho salmon, steelhead, Southern and Northern DPS green sturgeon, longfin smelt, and tidewater goby]) (Tables 4.3-3 and 4.3-4); and 4) it includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could alter their distribution, species composition, and/or health (Rohde et al. 2018, 2019). The Intertidal Zone area also provides important habitat for other special-status semi-aquatic species, including, but not limited to, western snowy plover, black tern, and bald eagle.

Terrestrial

The Intertidal Zone and Tributaries GDE Unit was determined to have high ecological value for terrestrial groundwater-dependent species and habitat because: 1) It supports four (4) special-status plant species in marsh and riparian groundwater-dependent habitats, multiple sensitive natural riparian communities, and 12 special-status bird species (Tables 4.3-2 and 4.3-3); 2) it contains designated critical habitat for one (1) listed bird species (western snowy plover) (Table 4.3-1, Figure 4.3-1); 3) it supports native special-status wildlife species with a known or high likelihood of groundwater dependence (six [6] ESA- and/or CESA-listed bird species [bald eagle, bank swallow, tricolored blackbird, western snowy plover, willow flycatcher, and western yellow-billed cuckoo]) (Table 4.3-3); and 4) it includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could alter their distribution, species composition, and/or health (Rohde et al. 2018, 2019).

Ecological condition

The ecological condition for the Intertidal Zone and Tributaries GDE Unit is good. Additionally:

- NDVI suggests that vegetation in mapped GDEs is relatively robust, and the GDE unit's general health (as indicated by NDVI) has been increasing over the past few decades.

- Habitat suitability for special-status species (e.g., yellow-headed blackbird) and the habitat condition of sensitive natural communities in floodplain grassland areas of the unit may be compromised by the presence of reed canary grass, which forms dense monotypic stands that reduces botanical and biological diversity.
- Suitable habitat is present for those special-status species with likelihood to occur in the unit.
- Groundwater contributes to the ecological function and habitat value of the Intertidal Zone and Tributaries GDE Unit, which supports native aquatic and terrestrial species and beneficial uses in and adjacent to the unit.

Susceptibility to changing groundwater conditions

The Intertidal Zone and Tributaries GDE Unit's susceptibility to changing groundwater conditions is uncertain. Additionally:

- Shallow groundwater conditions have remained stable since 1990.
- The rooting depth of dominant species in this unit included willows that ranged from a minimum of 1 ft to a maximum of 6.9 ft, black cottonwood from 2.5 ft to 16 ft, and red alder from 2.5 ft to 13.1 ft, whereas shallow groundwater depth varied in this unit from 2 to 7 ft bgs, 14-22 ft bgs, and 4-11 ft bgs, respectively, for each of the three vegetation types. Future changes will be explored once the model results are available.
- Tidal influence may extend further inland due to sea level rise, causing a shift in dominant vegetation stands with lower salinity tolerances toward species assemblages with greater salt tolerance.
- Future changes in groundwater conditions in the unit related to increased groundwater pumping, reduced inflows to the basin, or climate change could cause groundwater levels to fall below the baseline range and result in mortality of the trees that comprise the GDE. Projections of climate change and groundwater pumping suggest that changes in groundwater elevation are unlikely.
- Due to daily tidally influenced water surface elevation changes, aquatic habitat within the mainstem Eel River in this unit may be minimally affected by groundwater management. The assessment of interconnected surface water is dependent upon the groundwater model. The effect of groundwater management on surface water in this unit will be included in the final GSP.

Potential for effects

Given the relative stability of the vegetation health as indicated by NDVI, current pumping levels are unlikely to impact terrestrial GDEs. The major potential for effects in this unit is saltwater intrusion associated with sea level rise. The degree to which intrusion could be exacerbated by pumping is unknown, but will be assessed using the groundwater model. The effect of pumping on aquatic GDEs is unknown, although passage issues for anadromous salmonids occur upstream of this unit. Saltwater intrusion could potentially increase salinity in freshwater waterbodies, which could reduce available habitat and reproductive success for amphibian species. Habitat for snowy plover on the bars of the Intertidal Zone and Tributaries GDE Unit may also be impacted by sea level rise, but the degree to which sedimentation will compensate is unknown.

5.4.2 Middle Eel River

The Middle Eel River GDE Unit contains 28% of the total GDE acreage in the ERVB (Table 3.3-1). The mainstem Middle Eel River is interconnected with groundwater for most of this reach. Groundwater is relatively shallow and is within 15 ft of the ground surface. The Middle Eel River GDE Unit contains barriers to anadromous fish passage prior to the first storm flows in the fall.

Groundwater-dependence

Both the terrestrial and aquatic species and habitats in the Middle Eel River GDE Unit are likely connected to groundwater. Additionally:

- Shallow groundwater elevations in the limited long-term well data have remained stable since 1990. Groundwater levels in wells installed in 2016 show no systematic changes over a limited period of record. Groundwater elevations are within the rooting depth of dominant species within the GDE unit.
- This GDE unit is mostly composed of red alder stands. Other riparian stands dominated by willow and black cottonwood are also notable components of this unit. All are likely connected to groundwater.
- Perennial surface water flows are connected to groundwater. Losing conditions may occur in some reaches of the river during summer and fall. The degree to which losing conditions are due to groundwater pumping or sedimentation will be explored using the groundwater model.

Ecological value

Aquatic
The Middle Eel River GDE Unit was determined to have high ecological value for aquatic species and habitat because: 1) It supports many aquatic special-status species, including four (4) amphibian, one (1) aquatic reptile, and seven (7) fish species (Tables 4.3-3 and 4.3-4); 2) it contains designated critical habitat for listed anadromous salmonids (Chinook salmon, coho salmon, and steelhead) (Table 4.3-1 and Figure 4.3-2); 3) it supports native special-status species with a known or high likelihood of direct groundwater-dependence (five [5] ESA- and/or CESA-listed fish [Chinook and coho salmon, steelhead, Northern and possibly Southern DPS green sturgeon, and longfin smelt]) (Table 4.3-4); and 4) it includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could alter their distribution, species composition, and/or health (Rohde et al. 2018, 2019).

Terrestrial
The Middle Eel River GDE Unit was determined to have high ecological value for terrestrial groundwater-dependent species and habitat because: 1) It supports six (6) special-status plant species in wetland, grassland, and riparian potentially groundwater-dependent habitat, multiple sensitive natural riparian communities, and 10 special-status bird species (Tables 4.3-2 and 4.3-3); 2) it contains designated critical habitat for two (2) listed bird species (western snowy plover and western yellow-billed cuckoo) (Table 4.3-1, Figure 4.3-1); 3) it supports native special-status wildlife species with a known or high likelihood of groundwater-dependence (six [6] ESA- and/or CESA-listed bird species [bald eagle, bank swallow, tricolored blackbird, western snowy plover, western yellow-billed cuckoo, and willow flycatcher]) (Table 4.3-1); and 4) it includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could alter their distribution, species composition, and/or health (Rohde et al. 2018, 2019).

Ecological condition

The Middle Eel River GDE Unit has a good ecological condition. Additionally:

- NDVI is relatively stable and increased slightly through time.
- Suitable habitat is present for those special-status species with likelihood to occur in the unit.
- Fish passage through the reach typically begins during the first storm flows.
- Groundwater contributes to the ecological function and habitat value of the Middle Eel River, which supports native aquatic terrestrial species and beneficial uses in and adjacent to the unit.

Susceptibility to changing groundwater conditions

The Middle Eel River GDE Unit has an undetermined susceptibility to changing groundwater conditions. Additionally:

- Shallow groundwater conditions have remained stable since 1990 at long-term wells on the coastal plain.
- The rooting depth of red alder depends on soil characteristics and tree size. It has a spreading fibrous root system and remains shallow in poorly drained soils but can also root deeply if soil aeration is not limiting and in soils with good drainage (ranging from 2 to 13.1 ft deep [the reported maximum for the *Alnus* genus]) (Harrington 2006, TNC 2018). Other dominant species in this unit included willows (6.9 ft maximum rooting depth) and black cottonwood (16 ft maximum rooting depth). Shallow groundwater depth in long-term wells in this unit is between 10 and 30 ft bgs, which is within the rooting zone of some of the vegetation.
- The susceptibility of interconnected surface water in the reach to groundwater pumping is uncertain and will be explored with the groundwater model.
- Future changes in groundwater conditions in the unit related to increased groundwater pumping or climate change could cause groundwater levels to fall below the baseline range and result in mortality of the trees that comprise the GDE. Projections of climate change and groundwater pumping suggest that changes in groundwater elevation are unlikely.

Potential for effects

Given the relative stability of the vegetation health as indicated by NDVI, current pumping levels are unlikely to impact terrestrial GDEs. The effect of pumping on aquatic GDEs and critical riffle conditions is unknown and will be investigated in using the groundwater model. Tidal influence may move upstream into this reach as sea levels rise. The degree to which sedimentation will compensate for sea level rise is unknown. Saltwater intrusion could potentially increase salinity in freshwater waterbodies, which could reduce available habitat and reproductive success for amphibian species and potentially cause a shift in adjacent vegetation towards more salt-tolerant species.

5.4.3 Upper Eel River

The Upper Eel River GDE Unit contains 8% of the total GDE acreage in the ERVB (Table 3.3-1). The reach of the Upper Eel River is considered perennial and is typically connected to groundwater.

Groundwater-dependence

The Upper Eel River GDE Unit is likely dependent on groundwater. Additionally:

- There is no shallow groundwater data available in the Upper Eel GDE Unit to verify groundwater levels.
- This GDE unit is mostly composed of red alder stands. Other dominant vegetation includes stands of naturalized grassland, redwood, willow, and black cottonwood. These stands are all likely connected to groundwater.

Perennial surface water flows are connected to groundwater in places within the mainstem Eel River and Price, Howe, Barber, and Oil creeks. However, surface flow connection at the mouths of these creeks with the Eel River varies depending on location of gravel bars, secondary channels, and other geomorphic features. The extent of the interconnection with groundwater and the effect of groundwater management on interconnected surface water will be evaluated using the groundwater model. The effect of groundwater management on surface water in this unit will be included in the final GSP.

Ecological value

Aquatic
The Upper Eel River GDE Unit was determined to have high ecological value for aquatic species and habitat because: 1) It supports many aquatic special-status species, including one (1) mollusk, three (3) amphibian, one (1) aquatic reptile, and five (5) fish species (Tables 4.3-3 and 4.3-4); 2) it contains designated critical habitat for listed anadromous salmonids (Chinook salmon, coho salmon, and steelhead) (Table 4.3-1 and Figure 4.3-2); 3) it supports native special-status species with a known or high likelihood of direct groundwater-dependence (four [4] ESA- and/or CESA-listed fish [Chinook and coho salmon, steelhead, and Northern DPS green sturgeon]) (Table. 4.3-4); and 4) it includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could alter their distribution, species composition, and/or health (Rohde et al. 2018, 2019).

Terrestrial
The Upper Eel River GDE Unit was determined to have high ecological value for terrestrial groundwater-dependent species and habitat because: 1) It supports five (5) special-status plant species in wetland, grassland, and riparian potentially groundwater-dependent habitat, multiple sensitive natural riparian communities, and four (4) special-status bird species (Tables 4.3-2 and 4.3-3); 2) it contains designated critical habitat for one (1) listed bird species (western snowy plover) (Table 4.3-1, Figure 4.3-1); 3) it supports native special-status wildlife species with a known or high likelihood of groundwater-dependence (three [3] ESA- and/or CESA-listed bird species [bald eagle, western snowy plover, and willow flycatcher]) (Table 4.3-3); and 4) it includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could alter their distribution, species composition, and/or health (Rohde et al. 2018, 2019).

Ecological condition

The ecological condition for the Upper Eel River GDE Unit is good. Additionally:

- NDVI values have remained stable through time.

- Suitable habitat is present for those special-status species with likelihood to occur in the unit.
- Groundwater contributes to the ecological function and habitat value of the Upper Eel River, which supports native aquatic and terrestrial species and beneficial uses in and adjacent to the unit.

Susceptibility to changing groundwater conditions

The susceptibility of the Upper Eel River GDE Unit to changing groundwater conditions is uncertain. Additionally:

- Shallow groundwater conditions have remained stable since 1990.
- The rooting depth of red alder ranges from 2.5 ft to 13.1 ft. Other dominant species in this unit have the following reported maximum rooting depths (Appendix A): naturalized grasses (2 to 5 ft), redwood (8.5 to 16.4 ft), willows (6.9 ft), and black cottonwood (16 ft). No shallow groundwater depth was available for this unit. The groundwater model will be used to evaluate the DTW relative to rooting depth beneath the mapped GDEs.
- Future changes in groundwater conditions in the unit related to increased groundwater pumping or climate change could cause groundwater levels to fall below the baseline range and result in mortality of the trees that comprise the GDE. Projections of climate change and groundwater pumping suggest that changes in groundwater elevation are unlikely.

Potential for effects

Given the relative stability of the vegetation health as indicated by NDVI, current pumping levels are unlikely to impact mapped terrestrial GDEs. The effect of pumping on aquatic GDEs is unknown and will be investigated with the groundwater model.

5.4.4 Van Duzen River and Tributaries

The Van Duzen River and Tributaries GDE Unit contains 21% of the total GDE acreage in the ERVB (Table 3.3-1). The Van Duzen River in this unit is generally connected to groundwater, but has losing reaches, particularly at its downstream end.

Groundwater-dependence

The Van Duzen River and Tributaries GDE Unit is likely dependent on groundwater, but the groundwater-dependence is somewhat uncertain due to a paucity of groundwater wells. Additionally:

- Groundwater levels in wells installed in 2016 show no systematic changes over a limited period of record. Groundwater elevations are within the rooting depth of dominant species within the GDE.
- This GDE unit is composed of stands of redwood, naturalized grassland, red alder, and willow that are associated with channel floodplain and floodplain steps. These stands are all likely connected to groundwater.
- Perennial surface water flows in the Van Duzen River and Yager Creek are connected to groundwater, at least in some reaches. The assessment of interconnected surface water is dependent upon the groundwater model. The effect of groundwater management on surface water in this unit will be included in the final GSP.

- The dry reach at the mouth of the Van Duzen River that is present during the late summer and early fall may be caused more by sediment deposition in the delta than to groundwater use.

Ecological value

Aquatic

The Van Duzen River and Tributaries GDE Unit was determined to have *high ecological value* for aquatic species and habitat because: 1) It supports many aquatic special-status species, including four (4) amphibian, one (1) aquatic reptile, and four (4) fish species (Tables 4.3-3 and 4.3-4); 2) it contains designated critical habitat for listed anadromous salmonids (Chinook salmon, coho salmon, and steelhead) (Table 4.3-1 and Figure 4.3-3); 3) it supports native special-status species with a known or high likelihood of direct groundwater-dependence (three ESA- and/or CESA-listed fish [Chinook and coho salmon and steelhead]) (Table 4.3-4); and 4) it includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could alter their distribution, species composition, and/or health (Rohde et al. 2018, 2019).

Terrestrial

The Van Duzen River and Tributaries GDE Unit was determined to have *high ecological value* for terrestrial groundwater-dependent species and habitat because: 1) It supports 12 special-status plant species in wetland, grassland, and riparian potentially groundwater dependent habitat, multiple sensitive natural riparian communities, seven (7) special-status bird species, and one (1) special-status mammal species (Tables 4.3-2 and 4.3-3); 2) it contains designated critical habitat for two (2) listed bird species (western snowy plover and marbled murrelet) (Table 4.3-1, Figure 4.3-1); 3) it supports native special-status wildlife species with a known or high likelihood of groundwater-dependence (five [5] ESA- and/or CESA-listed bird species [bald eagle, bank swallow, marbled murrelet, western snowy plover, and willow flycatcher]) (Table 4.3-3); and 4) it includes species and ecological communities that are highly or moderately vulnerable to changes in groundwater discharge or groundwater levels that could alter their distribution, species composition, and/or health (Rohde et al. 2018, 2019).

Ecological condition

The Van Duzen River and Tributaries GDE Unit is in a good ecological condition. Additionally:

- The NDVI values were relatively stable and increased slightly with time.
- Suitable habitat is present for those special-status species with likelihood to occur in the unit.
- Groundwater contributes to the ecological function and habitat value of the Van Duzen River and Tributaries GDE Unit, which supports aquatic and terrestrial species and beneficial uses in and adjacent to the unit.

Susceptibility to changing groundwater conditions

The Van Duzen River and Tributaries GDE Unit's susceptibility to changing groundwater conditions is unknown. Additionally:

- There are no long-term groundwater wells in this unit. One (1) well installed in 2016 has very shallow groundwater, but the variation in groundwater depth in this unit is unknown.
- The reported maximum rooting depth of redwood ranges from 8.5 to 16.4 ft, while that of local grassland species ranges from 2 to 5 ft. Maximum rooting depths for other dominant

species in this unit include 7.9 ft for Douglas-fir, 6.9 ft for willows, and 13.1 ft for red alder. The modeled depth to groundwater under the GDEs will be explored when the model is available.

- Future changes in groundwater conditions in the unit related to increased groundwater pumping or climate change could cause groundwater levels to fall below the baseline range and result in mortality of the trees that comprise the GDE. However, projections of climate change and groundwater pumping suggest that changes in groundwater elevation are unlikely.

Potential for effects

Given the relative stability of the vegetation health as indicated by NDVI, current pumping levels are unlikely to impact terrestrial GDEs. The effect of pumping on aquatic GDEs, particularly the dry reach near the confluence with the Eel River, is unknown and will be investigated using the groundwater model. The model results will help to determine the relative importance of sedimentation and groundwater pumping on this dry reach at the mouth of the Van Duzen River. In the event of a change in the water balance in the reach due to increased upstream water withdrawals or climate change, the extent of the dry reach could change, impacting aquatic GDEs.

6 SUSTAINABLE MANAGEMENT CRITERIA AND PROJECTS AND MANAGEMENT ACTIONS

Sustainable management criteria (SMCs), projects and management actions, and monitoring will be addressed in the final GSP. GDEs will be considered as part of the development of SMCs and Projects and Management Actions.

7 LITERATURE CITED

Azevedo, J. and Morgan, D.L., 1974. Fog precipitation in coastal California forests. Ecology, 55(5), pp.1135-1141.

Braudrick, C.A., A.G. Merrill, and B.K. Orr. 2018. Groundwater dependent ecosystems. Fremontia, 46 (2). P 54-55.

Brumo, A. F., L. Grandmontagne, S. N. Namitz, and D. F. Markle. 2009. Evaluation of approaches used to monitor Pacific lamprey spawning populations in a coastal Oregon stream. Pages 204–222 in L. R. Brown, S. D. Chase, M. G. Mesa, R. J. Beamish, and P. B. Moyle, editors. Biology, management, and conservation of lampreys in North America. American Fisheries Society, Symposium 72, Bethesda, Maryland.

CDFW (California Department of Fish and Wildlife) Coastal Watershed Planning and Assessment Program. 2014. SF Eel River Basin Assessment Report. Available online at ftp://ftp.streamnet.org/pub/coastalwatersheds/SFERBasinOverview_07-29-2014.pdf .

CDFW. 2020. California Natural Diversity Database. RareFind 5 [Internet], Version 5.1.1.

Consortium of California Herbaria. 2021. Consortium of California Herbaria Portal 1 (CCH1). Data provided by the participants of the Consortium of California Herbaria https://ucjeps.berkeley.edu/consortium/ .

Dwire, K. A., S. Mellmann-Brown, and J. T. Gurrieri. 2018. Potential effects of climate change on riparian areas, wetlands, and groundwater-dependent ecosystems in the Blue Mountains, Oregon, USA. Climate Services, 10, pp.44-52.

DWR (California Department of Water Resources). 2016. Bulletin 118 Interim Update– Groundwater Basins and Subbasins, California.

DWR. 2020. Natural Communities Commonly Associated with Groundwater Dataset Viewer. https://gis.water.ca.gov/app/NCDatasetViewer/# [Accessed November 2020].

eBird. 2021. eBird: An online database of bird distribution and abundance. Website [accessed November 2020]. eBird, Cornell Lab of Ornithology, Ithaca, New York.

Eel River Forum. 2016. Eel River Action Plan A Compilation of Information and Recommended Actions. Prepared for the Eel River Forum by Eel River Forum Members.

ERRP (Eel River Recovery Project). 2014. Final Report Eel River Recovery Project Eel River Basin 2013-2014 Fall Chinook Salmon Monitoring. Arcata, California. http://eelriverlibrary.org/ERRP%20Reports/Chinook/ERRP_2013_14_Fall_Chinook_Monitoring_Poject_04_25_14_Final.pdf

Garwood, R. 2017. Historic and contemporary distribution of longfin smelt (*Spirinchus thaleichthys)* along the California coast. California Fish and Game 103(3): 96-117; 2017.

Golec, C., and L. Miller. 2017. Ocean Ranch unit vegetation and rare plant assessment. Prepared by California Department of Fish and Wildlife, Northern Region.

GHD. 2021a. Hydrogeological Conceptual Model for the Eel River Valley Groundwater Basin – Draft. Prepared for Humboldt County Department of Public Works – Environmental Services. Ref. No. 11217388 2.3.1.

GHD. 2021b. Eel River Valley Basin Water Budget Technical Memorandum Draft.

GHD. 2021c. Water Levels Technical Memorandum Draft. Prepared for Humboldt County Department of Public Works – Environmental Services. Ref. No. 11217388 2.3.1.

Gunckel, S. L., K. K. Jones, and S. E. Jacobs. 2009. Spawning distribution and habitat use of adult Pacific and western brook lampreys in Smith River, Oregon. Pages 173–189 *in* L. R. Brown, S. D. Chase, M. G. Mesa, R. J. Beamish, and P. B. Moyle, editors. Biology, management, and conservation of lampreys in North America. American Fisheries Society, Symposium 72, Bethesda, Maryland.

Harrington, C.A., 2006. Biology and ecology of red alder. United States Department of Agriculture Forest Service General Technical Report PNW, 669, p.21.

H.T. Harvey & Associates. 2015. 2015 Quantitative habitat monitoring for the Salt River Ecosystem Restoration Project. Final Report. Prepared for Humboldt County Resource Conservation District, Eureka, California.

HCRCD (Humboldt County Resource Conservation District). 2015. Fish sampling on the Salt River, Phase 1. Eureka, California.

HCRCD (Humboldt County Resource Conservation District). 2021. Salt River Ecosystem Restoration Project Habitat Mitigation and Monitoring Plan Monitoring Report 2020.

Huntington, J., McGwire, K., Morton, C., Snyder, K., Peterson, S., Erickson, T., Niswonger, R., Carroll, R., Smith, G. and Allen, R., 2016. Assessing the role of climate and resource management on groundwater dependent ecosystem changes in arid environments with the Landsat archive. Remote sensing of Environment, 185, pp.186-197.

Jepson Flora Project. 2020. Jepson eFlora. Website. http://ucjeps.berkeley.edu/eflora [Accessed October 2020].

Kannry, S.H., O'Rourke, S.M., Kelson, S.J. and Miller, M.R., 2020. On the ecology and distribution of steelhead (Oncorhynchus mykiss) in California's Eel River. Journal of Heredity, 111(6), pp.548-563.

Klausmeyer K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. Natural Communities Commonly Associated with Groundwater (NCCAG) Dataset Viewer. The Nature Conservancy and California Department of Water Resources. https://gis.water.ca.gov/app/NCDatasetViewer/.

Klausmeyer, K.R.,. B. Tanushree, M.M. Rohde, F. Schuetzenmeister, N. Rindlaub, I. Housman, and J. K. Howard. 2019. GDE Pulse: Taking the Pulse of Groundwater Dependent Ecosystems with Satellite Data. San Francisco, California. Available at https://gde.codefornature.org.

Kløve, B., P. Ala-Aho, G. Bertrand, J. J. Gurdak, H. Kupfersberger, J. Kværner, T. Muotka, H. Mykrä, E. Preda, P. Rossi, C. Bertacchi Uvo, E. Velasco, and M. Pulido-Velazquez. 2014. Climate change impacts on groundwater and dependent ecosystems. J. Hydrology 518 : 250–266.

Lindley, S. T., D. L. Erickson, M. L. Moser, G. Williams, O. P. Langness, B. W. McCovey Jr., M. Belchik, D. Vogel, W. Pinnix, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movements among estuaries. Transactions of the American Fisheries Society 140: 108–122.

McLaughlin, R. J., S. D. Ellen, M. C. Blake, Jr., A. S. Jayko, W. P. Irwin, K. R. Aalto, G. A. Carver, and S. H. Clarke Jr.. 2000. Geology of the Cape Mendocino, Eureka, Garberville, and Southwestern Part of the Hayfork 30 x 60 Minute Quadrangles and Adjacent Offshore Area, Northern California. US Geological Survey Miscellaneous Field Studies MF-2336.

Moyle, P. B. 2002. Inland fish of California. University of California Press, Berkeley, California.Moyle, P.B., R. M. Quiñones, J. V. Katz and J. Weaver. 2015. Fish Species of Special Concern in California. Sacramento: California Department of Fish and Wildlife. www.wildlife.ca.gov

Moyle, P.B., R. M. Quiñones, J. V. Katz and J. Weaver. 2015. Fish Species of Special Concern in California. Sacramento: California Department of Fish and Wildlife. www.wildlife.ca.gov

Natural Resources Conservation Service (NRCS) United States Department of Agriculture. 2016. Web Soil Survey. Available online at https://soilseries.sc.egov.usda.gov/OSD_Docs/F/FERNDALE.html/ [accessed November 4, 2020].

NMFS (National Marine Fisheries Service). 2005. Endangered and Threatened Species; Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule. Federal Register 70 (170): 52,488–52,627.

NMFS. 2014. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA.

NMFS. 2016. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2021. California Species List Tools. http://www.westcoast.fisheries.noaa.gov/maps_data/california_species_list_tools.html [Accessed May 2021]

NCRWQCB (North Coast Regional Water Quality Control Board. 2018. Water Quality Control Plan for the North Coast Region. June 2018.

OCM Partners. 2021. 2018 - 2019 USGS Lidar: Northern California Wildfire - QL2, https://www.fisheries.noaa.gov/inport/item/58957.

Robinson, T.W. 1958. Phreatophytes. Geologic Survey Water Supply Paper 1423. US Government Printing Office. https://pubs.usgs.gov/wsp/1423/report.pdf

Rohde, M. M., S. Matsumoto, J. Howard, S. Liu, L. Riege, and E. J. Remson. 2018. Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans. The Nature Conservancy, San Francisco, California.

Rohde, M. M., B. Seapy, R. Rogers, X. Castañeda, editors. 2019. Critical Species LookBook: A compendium of California's threatened and endangered species for sustainable groundwater management. The Nature Conservancy, San Francisco, California.

Sawyer, J. O. 2007. Forests of Northwestern California. Pages 253–284 in Barbour, M. G., T. Keeler-Wolf, and A. A. Schoenherr, editors. Terrestrial vegetation of California, third edition. University of California Press, Berkeley and Los Angeles, California.

SHN Consulting Engineers and Geologists. (SHN) 2016. Eel River Valley Groundwater Basin, Humboldt County, California. Groundwater Sustainability Plan Alternative. Humboldt County Public Works. Eureka, California.

SHN. 2019. Technical Memorandum: Preliminary Analysis of Surface Water/Groundwater Interaction Monitoring. Eel River Valley Groundwater Basin.

SHN. 2020. Groundwater Sustainability Plan Alternative Annual Report 2019 Water Year. Prepared for County of Humboldt Public Works Department. Eureka, California.

SHN. 2021a. Saltwater Intrusion Technical Memorandum for the Eel River GSP.

SHN. 2021b. Water Quality Technical Memorandum for the Eel River GSP.

State Water Resources Control Board. 2020. Staff Report for North Coast Hydrologic Region salt and nutrient management planning, groundwater basin evaluation and prioritization. Public Review Draft. Dec. 31 2020

State Water Resources Control Board. 2021. California Code of Regulations, Title 23. CCR (California Code of Regulations). January 2021. https://www.waterboards.ca.gov/laws_regulations/docs/wrregs.pdf [accessed July 2021]

Steinwand, A.L., Harrington, R.F. and Or, D. 2006. Water balance for Great Basin phreatophytes derived from eddy covariance, soil water, and water table measurements. Journal of Hydrology, 329(3-4), pp.595-605.

Stillwater Sciences. 2010. Pacific lamprey in the Eel River basin: a summary of current information and identification of research needs. Prepared by Stillwater Sciences, Arcata, California for Wiyot Tribe, Loleta, California.

Stillwater Sciences. 2020. Freshwater mussels. Survey in the Eel River. Prepared for the City of Rio Dell, California.

Stillwater Sciences. 2021. 2020 Fisheries monitoring program report for gravel extraction operations on the Lower Eel, South Fork Eel, Van Duzen, and Trinity Rivers, California. Prepared by Stillwater Sciences, Arcata, California.

Stillwater Sciences and Wiyot Tribe Natural Resources Department. 2017. Status, distribution, and population of origin of green sturgeon in the Eel River: results of 2014–2016 studies. Prepared by Stillwater Sciences, Arcata, California and Wiyot Tribe, Natural Resources Department, Loleta, California, for National Oceanic and Atmospheric Administration, Fisheries Species Recovery Grants to Tribes, Silver Springs, Maryland.

TNC (The Nature Conservancy) 2021. Freshwater species list for Eel River Valley Groundwater Basins. https://groundwaterresourcehub.org/sgma-tools/environmental-surface-water-beneficiaries. [Accessed March 2021]

USDA (U.S. Department of Agriculture) 2014. Classification and Assessment with Landsat of Visible Ecological Groupings (CalVeg). Region 1: North Coast: Imagery date: 2000–2007. https://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192 [Accessed March 2021].

USDA (U.S. Department of Agriculture) FSA Aerial Photography Field Office. 2020. National Agriculture Imagery Program. Mosaicked County Image for Humboldt, CA.

USDA (U.S. Department of Agriculture) Soil Survey Staff. Natural Resources Conservation Service. Available online at https://websoilsurvey.nrcs.usda.gov/. Accessed May 2021.

US Geological Survey. 1978. Ground-water Conditions in the Eureka Area, Humboldt County, California. 1975. US Geological Survey Water Resources Investigations 78-127.

US Geological Survey. 2019. National Water Information System data available online (USGS Water Data for the Nation), at https://waterdata.usgs.gov/usa/nwis/uv?11477000, accessed December 1, 2020.

USFWS (U.S. Fish and Wildlife Service). 1995. Age and Growth of Klamath River Green Sturgeon (*Acipenser medirostris*). Klamath River Fishery Resource Office, Yreka, California. 20 p.

USFWS. 2005. Recovery Plan for the Tidewater Goby (Eucyclogobius newberryi). U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS. 2009. Lilium occidentale (Western lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Arcata, CA.

USFWS. 2012a. Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for the Pacific Coast Population of the Western Snowy Plover; Final rule. Federal Register 77(118): 36,728–36,869.

USFWS. 2012b. Endangered and threatened wildlife and plants; 12-month finding on a petition to list the San Francisco Bay- Delta population of the longfin smelt as endangered or threatened. Federal Register 77: 19,756–19,797.

USFWS. 2013. Endangered and Threatened Wildlife and Plants; Determination of Critical Habitat for Tidewater Goby; Final rule. Federal Register 78(25): 8,746–8,819.

USFWS. 2016. Endangered and Threatened Wildlife and Plants; Determination of Critical Habitat for the Marbled Murrelet; Final determination. Federal Register 81(150): 51,348–51,370.

USFWS. 2020. Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for the Western Distinct Population Segment of the Yellow-Billed Cuckoo; Proposed rule. Federal Register 85(39): 11,458–11,594.

Watson, E. B., S. W. Cosby, and A. Smith. 1925. Soil Survey of the Eureka Area California. US Department of Agriculture, Bureau of Soils, In Cooperation with the University of California Agricultural Experiment Station.

Appendices

Appendix A

Special-status Terrestrial and Aquatic Wildlife Species Identified in Database Queries but Determined to Have No Reliance on Groundwater Dependent Ecosystem Units

Table. A-1. Special-status terrestrial and aquatic wildlife species identified in database queries that are not groundwater-dependent and/or unlikely to occur in the ERVB GDE units

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Insect						
Western bumble bee *Bombus occidentalis*	–/SCE	Likely	Middle Eel River	CNDDB	No known reliance on groundwater	Uses flowering plants in meadows and forested openings; abandoned rodent burrows are used for nest and hibernation sites for queens; present in groundwater basin. Observed in Rio Dell along the Eel River (CDFW 2020)
Birds						
Black swift *Cypseloides niger*	–/SSC	Likely	Intertidal Zone and Tributaries	CAFSD, eBird	No known reliance on groundwater	Nests in moist crevices behind or beside permanent or semipermanent waterfalls in deep canyons, on perpendicular sea cliffs above surf, and in sea caves; forages widely for insects over many habitats; observed sporadically in the Lower Eel River groundwater basin (eBird 2021)
Grasshopper sparrow *Ammodramus savannarum*	–/SSC	Likely	Middle Eel River	CNDDB	No known reliance on groundwater	Typically found in moderately open grasslands with scattered shrubs; observed in the pastures south of Fernbridge (CDFW 2020)
Mountain plover *Charadrius montanus*	FPT, BLMS/SSC	None	Intertidal Zone and Tributaries	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; isolated record in Eel River. Winter resident (eBird 2021); does not breed in California

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Yellow rail *Coturnicops noveboracensis*	–/SSC	None	None	CNDDB	Indirect	Marshes, often next to sedges; feeds on invertebrates in wetlands (e.g., aquatic insects and mollusks) (CDFW 2020)
Mammal						
Humboldt marten *Martes caurina humboldtensis*	–/SE	None	Van Duzen and Tributaries	CNDDB	No known reliance on groundwater	Mid- to advanced-successional stands of conifers with complex structure near the ground and dense canopy closure; observed in 1913 in forestland adjacent to Carlotta (CDFW 2020); no habitat present in the ERVB
Pallid bat *Antrozous pallidus*	BLMS/SSC	Possible	Middle Eel River	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; Last recorded observation in 1924 in Ferndale (CDFW 2020)

Common name ***Scientific name***	**Status[1] federal/State**	**Potential to occur in ERVB[2]**	**Documented occurrences in GDE units**	**Query source[3]**	**GDE association[4]**	**Habitat and documented occurrences in ERVB**
Sonoma tree vole *Arborimus pomo*	–/SSC	Likely	Intertidal Zone and Tributaries, Middle Eel River, Van Duzen and Tributaries, Upper Eel River	CNDDB	No known reliance on groundwater	Occupies primarily mid- to late-successional conifer stands with a high component of Douglas-fir; present in conifer forests in the hillslopes surrounding the Lower ERVB (CDFW 2020)

[1] Status codes
Federal
FPT = Proposed as threatened under the federal ESA
BLMS = Bureau of Land Management Sensitive Species

State
SE = Listed as Endangered under CESA
SSC = CDFW species of special concern

[2] Potential to Occur:
Likely: the species has documented occurrences and the habitat is high quality or quantity
Possible: no documented occurrences and the species' required habitat is moderate to high quality or quantity
Unlikely: no documented occurrences and the species' required habitat is of low to moderate quality or quantity
None: no potential to occur due to lack of habitat and/or the population is assumed extirpated

[3] Query source:
CAFSD: California Freshwater Species Database (TNC 2020)
CNDDB: California Natural Diversity Database (CDFW 2020)
eBird: (eBird 2021)

[4] 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 B

Vegetation Communities, Associated Alliances and Characteristics

Table B-1. Maximum rooting depth of dominant species.

Cover Type[1]	Associated Alliance[2]	Dominant species	Minimum rooting depth (in)[3]	Maximum rooting depth (ft)[4]	Season with water needs[5]	Salt Tolerance[6]
Annual/Perennial Grasses and Forbs	Phalaris aquatica - Phalaris arundinacea Herbaceous Semi-Natural Alliance Holcus lanatus - Anthoxanthum odoratum Herbaceous Semi-Natural Alliance Poa pratensis - Agrostis gigantea - Agrostis stolonifera Herbaceous Semi-Natural Alliance Lolium perenne Herbaceous Semi-Natural Alliance	Phalaris arundinacea Holcus lanatus Agrostis stolonifera Poa pratensis Festuca perennis	14 4 12 10 10	4.6 - 2.3 4.2 3.8	Spring–Fall Spring Spring–Summer Spring–Fall Spring and Fall	Mild (<4 dS m-1) High (8-12 dS m-1)
Black Cottonwood	Populus trichocarpa Forest & Woodland Alliance	Populus trichocarpa	30	10–16.0	Spring–Summer	Mild (<4 dS m-1)
California Bay	Umbellularia californica Forest & Woodland Alliance	Umbellularia californica	16	3	Spring–Fall	Mild (<4 dS m-1)
Coastal Mixed Hardwood	Umbellularia californica Forest & Woodland Alliance	Umbellularia californica	16	3	Spring–Fall	Mild (<4 dS m-1)
	Acer macrophyllum Forest & Woodland Alliance	Acer macrophyllum	24	5.7	Spring and Summer (April)	Mild (<4 dS m-1)
	Quercus garryana (tree) Forest & Woodland Alliance	Quercus garryana	42	6.7	Spring and Summer	Mild (<4 dS m-1)

Cover Type[1]	**Associated Alliance**[2]	**Dominant species**	**Minimum rooting depth (in)**[3]	**Maximum rooting depth (ft)**[4]	**Season with water needs**[5]	**Salt Tolerance**[6]
Red Alder	Alnus rubra Forest Alliance	Alnus rubra	25	13.12[7]	Spring-Fall	Mild (<4 dS m-1)
Redwood	Sequoia sempervirens Forest & Woodland Alliance	Sequoia sempervirens	40	8.5–16.4	Spring and Summer	Mild (<4 dS m-1)
Redwood - Douglas-Fir	Sequoia sempervirens Forest & Woodland Alliance	Sequoia sempervirens	40	8.5–16.4	Spring and Summer	Mild (<4 dS m-1)
		Pseudotsuga menziesii	26	7.87	Spring and Summer	Mild (<4 dS m-1)
Riparian Mixed Hardwood	Alnus rubra Forest Alliance	Alnus rubra	24	13.12	Spring–Fall	Mild (<4 dS m-1)
	Acer macrophyllum Forest & Woodland Alliance	Acer macrophyllum	24	5.7	Spring and Summer	Mild (<4 dS m-1)
River/Stream/Canal	N/A	Typha latifolia Eleocharis macrostachya Bolboschoenus maritimus Distichlis spicata	14 14 12	No data available	Spring and Summer Spring Summer	Very High (> 12 dS m-1) Very High (> 12 dS m-1) Very High (> 12 dS m-1) Very High (> 12 dS m-1)
Sitka Spruce	Picea sitchensis Forest & Woodland Alliance	Picea sitchensis	30	6.5	Spring and Summer	Mild (<4 dS m-1)

Cover Type[1]	Associated Alliance[2]	Dominant species	Minimum rooting depth (in)[3]	Maximum rooting depth (ft)[4]	Season with water needs[5]	Salt Tolerance[6]
Willow	**Salix lucida ssp. lasiandra Forest & Woodland Alliance**	**Salix lasiandra (lucida)**	36	6.9[7]	Spring and Summer	Mild (<4 dS m-1)
	Salix sitchensis Provisional Shrubland Alliance	Salix sitchensis	24	6.9[7]	Spring and Summer	Mild (<4 dS m-1)
	Salix lasiolepis Shrubland Alliance	Salix lasiolepis	26	6.9[7]	Spring and Summer	Mild (<4 dS m-1)
	Salix hookeriana Shrubland Alliance	Salix hookeriana	20	6.9[7]	Spring and Summer	Mild (<4 dS m-1)
Willow (Shrub)	**Salix exigua Shrubland Alliance**	Salix exigua	20	6.9[7]	Spring and Summer	Mild (<4 dS m-1)
	Salix lasiolepis Shrubland Alliance	*Salix melanopsis*	see *S. exigua*	*6.9*[7]		
	Salix hookeriana Shrubland Alliance	Salix scouleriana	12	6.9[7]	Spring and Summer	Mild (<4 dS m-1)
	Salix sitchensis Provisional Shrubland Alliance	Other willows	20–26	6.9[7]	Spring and Summer	Mild (<4 dS m-1)
Intermittent Lake or Pond	N/A No vegetation associated with this cover type					
Perennial Lake or Pond	N/A No vegetation associated with this cover type					
Pickleweed - Cordgrass	Sarcocornia pacifica (Salicornia depressa) Herbaceous Alliance Spartina (alterniflora, densiflora) Herbaceous Semi-Natural Alliance	N/A not determined to be a GDE Habitat				

1 Based on cover types describe in the CalVeg regional data set (USDA 2014)
2 *Manual of California Vegetation*, online edition (CNPS 2021)
3 Minimum rooting depth as noted in the USDA Plants Database (2021)
4 Maximum rooting depth sources: Fann et al. 2017, Burns and Honkala 1990, TNC 2018, *Fire Effects Information System* (online database)
5 Months with water needs is based on the reported active growth period provided in USDA Plants Database (2021)
6 Salinity tolerance based on NRCS eVegGuide reported salt tolerances.
7 Rooting depth assigned by genus or close species association.

Appendix C

Special-status Fish

The text below adapts the Critical Species Lookbook (Rohde et al. 2019) for fish species found the ERVB. Note: The *italicized text* presented below in the reliance on groundwater and groundwater-related threats sections for each species are direct quotes from Rohde et al. (2019).

California Coast EST Chinook salmon (*Oncorhynchus tshawytscha*)
Status: Federally threatened
Reliance on groundwater: *Direct. Chinook salmon are reliant on groundwater-fed rivers to provide adequate water quality, temperature, and volume for upstream migration in the fall before rainfall elevates river flows, as well as for spawning and freshwater residency.*
Habitat: Chinook salmon in the Eel River spend a relatively short time in fresh water as juveniles before heading to estuaries or marine environments for the bulk of this phase of their lives. Adult Chinook spawn in larger rivers and streams, where they require sufficient flows for migration and largely sediment-free gravel for spawning. Juveniles need areas of refuge from high water velocities during the wet season (e.g., floodplains, backwaters, etc.). Water quality, including temperature and dissolved oxygen, is important for juveniles living in estuaries.
Groundwater-Related Threats: *Groundwater pumping can have an adverse impact on the survival of this species by depleting surface water flows for upstream migration, impeding migration by disconnecting groundwater and surface water, destabilizing water temperatures by decreasing baseflow at spawning sites, and reducing riparian habitat.*
Presence in the Eel River Valley groundwater basin: Chinook salmon in the Eel River are primarily fall-run, although a small number of spring-run fish do spawn and rear in the Middle Fork Eel River. They can be found in the Eel River Valley during the fall adult upstream migration, early juvenile rearing, and spring downstream smolt migration periods. Fall-run juvenile Chinook salmon generally do not rear in freshwater during the summer and fall. Spring-run juveniles will rear for a year prior to migrating downstream to the estuary and the ocean.

SONCC ESU Coho salmon (*Oncorhynchus kisutch*)
Status: Federally threatened
Reliance on groundwater: *Direct. Coho salmon are reliant on groundwater-fed rivers to provide adequate water quality, temperature, and volume for upstream migration in the fall before rainfall elevates river flows, as well as for spawning and freshwater residency. Juveniles can rear in mainstem rivers but are dependent on locations that contain cold water tributary inflow, bank seeps, or subsurface flow upwelling. Backwater alcoves with stratified water temperatures also provide habitat during the warm summer months.*
Habitat: Juveniles spend one year in freshwater prior to migrating to the estuary and ocean during the spring. Juveniles require deep pools with cool water temperatures, slow water velocities, and abundant instream cover during their rearing phase. Juveniles are associated with native riparian vegetation that provides instream cover and food resources from insect drop. Adult coho salmon return to freshwater to spawn in the fall of their third year. They primarily spawn in tributaries to rivers but would spawn in larger rivers during drought years when tributary flows are low. However, mainstem rivers typically do not provide suitable habitat for rearing juveniles.
Groundwater-Related Threats: *Groundwater conditions that alter groundwater baseflow into rivers can negatively affect coho salmon habitat. Juvenile salmonids generally require cold, clear, well-oxygenated water and adequate streamflow volume during their time in fresh water. Adult salmon similarly require adequate water quality and volume during their upstream migration. Groundwater pumping can have a negative impact on instream habitat by depleting streamflow volume and interrupting the influx of cold groundwater into the stream environment.*
Presence in the Eel River Valley groundwater basin: Mainstem Eel and Van Duzen rivers are primarily used for migration only. Juveniles have been found in Price Creek, Williams Creek, Francis Creek, Howe Creek, and Yager Creek tributaries.

Northern California Coast Steelhead (*Oncorhynchus mykiss*)
Status: Federally threatened
Reliance on groundwater: *Direct. Steelhead are reliant on rivers and streams that are likely supported by groundwater.*
Habitat: While steelhead are generally more adaptable to habitat extremes than either coho or Chinook salmon, they nevertheless require cold water and complex instream habitat during their freshwater juvenile residency, which generally lasts at least one year, including at least one dry season. Estuaries can provide important rearing habitat for steelhead, with opportunities for rapid growth prior to entering the marine environment. For spawning, all adult salmonids require sufficient flow and suitably cool water temperature for upstream migration to spawning grounds and streambeds with clean gravel, free of excessive fine sediment deposition, to spawn in. Some adult steelhead will survive to spawn a second or third time; thus, adequate streamflows are required for post-spawn adult steelhead to migrate downstream during spring.
Groundwater-Related Threats: *Groundwater conditions that alter instream flow and water quality can have an adverse impact on steelhead habitat conditions. Juvenile steelhead generally require cold, clear, well oxygenated water and adequate streamflow volume while residing in freshwater. Adult steelhead also require adequate water quality and instream flows during their upstream and downstream migration, which can be limited by streamflow depletion. However, adult steelhead typically conduct upstream migrations in the winter and spring when streamflow are usually adequate. Cold groundwater inputs can provide local areas of water temperature refugia in which rearing juvenile steelhead are less susceptible to stress or mortality that can otherwise result from elevated water temperatures during warm, dry months when streamflows are typically lowest. Groundwater pumping can affect instream habitat particularly in the summer by depleting streamflow volume and interrupting the influx of cold groundwater into the stream.*
Presence in the Eel River Valley groundwater basin: mainstem Eel and Van Duzen rivers and tributaries

Longfin smelt (*Spirinchus thaleichthys*)
Status: State threatened
Reliance on groundwater: *Direct. These fish rely directly on groundwater discharge that supports estuarine wetlands and sloughs used by the species for spawning, feeding and rearing.*
Habitat: These smelt depend on a diverse range of habitats, including offshore areas, coastal lagoons, bays, estuaries, sloughs, and freshwater rivers and streams. Longfin smelt are euryhaline and able to tolerate a variety of salinity in their habitats, from completely freshwater to marine. Spawning occurs preferentially in freshwater and areas of low salinity.
Groundwater-related threats: *Longfin smelt have a low tolerance for warm waters. Water diversion and drought may lead to increased water temperatures. Groundwater management that decreases groundwater discharge to estuaries can negatively impact temperature and salinity conditions important to this species' spawning, rearing, and survival.*
Presence in the Eel River Valley groundwater basin: Longfin smelt have not been recorded in the Eel River basin since 1995. The last recorded sighting was in the estuary downstream of Fernbridge in 1995. Prior to that a sighting was recorded near the mouth of the Van Duzen River in 1956.

Tidewater goby (*Eucyclogobius newberryi*)
Status: Federal endangered
Reliance on groundwater: *Direct. Tidewater gobies rely on surface waters in coastal areas that are likely to be supported by groundwater discharge.*
Habitat: These fish live in lagoons and estuaries with submerged and emergent aquatic vegetation that can provide protection from predators and flooding. They also occupy locations characterized by muted tidal flow in areas subject to tides. They can also be found in backwater marshes and freshwater tributaries to estuarine environments. Their food sources include macroinvertebrates (e.g., amphipods, aquatic insects).
Groundwater-related threats: *Groundwater conditions that alter surface water flows in coastal lagoons and estuaries can have a negative impact on the species' breeding and foraging activities.*

Presence in the Eel River Valley groundwater basin: Gobies are present in the sloughs of the Eel River delta. They are not present upstream of Fernbridge.

Pacific lamprey (*Entosphenus tridentatus*)
Status: California species of special concern
Reliance on groundwater: *Direct. This species relies on surface water flows that may be supported by groundwater.*
Habitat: Spawning typically takes place from March through July depending on water temperature and local conditions such as seasonal flow regimes. Spawning occurs both in the mainstem of medium-sized rivers and smaller tributaries and generally takes place in pool and run tailouts and low-gradient riffles. Both males and females build nests (redds), which are approximately 40 x 40 cm in area and constructed in gravel and cobble substrate. After about 30 days, the larvae emerge from the gravel and begin drifting downstream. The eyeless larvae, known as ammocoetes, settle out of the water column and burrow into fine silt and sand substrate in low-velocity, depositional areas such as pools, alcoves, and side channels where they may spend between 4 and 10 years prior to migrating to the ocean. They reside in the ocean for approximately 18–40 months before returning to freshwater.
Groundwater-related threats: *Groundwater conditions that either temporarily or permanently alter surface water flows can have a negative impact on the spawning and rearing capabilities of this fish and decrease its population.*
Presence in the Eel River Valley groundwater basin: The Eel River Valley groundwater basin is primarily used by adult lamprey as an upstream migration corridor. However, lamprey ammocoetes may be found within the basin rearing in backwater areas containing organic silty deposits or in the fine substrate between cobbles in the mainstem river.

Green sturgeon (*Acipenser medirostris*)
Status: Southern DPS — Federal threatened; Northern DPS — Federal species of concern; State species of special concern; Designated critical habitat
Reliance on groundwater: *Direct. This species relies on surface water flows that may be supported by groundwater.*
Habitat: This anadromous species spends most of its life at sea but returns to freshwater to spawn. Young fish may remain in these freshwater environments for up to two years. Adults spawn in fast, deep water during the first half of the year. Post-spawn adults then move back down the river during the fall and re-enter the ocean.
Groundwater-related threats: *Groundwater conditions that either temporarily or permanently alter surface water flows can have a negative impact on the spawning capabilities of this fish and decrease its population. However, spawning does not occur in the Lower Eel River Groundwater Basin.*
Presence in the Eel River Valley groundwater basin:
Green sturgeon are known to inhabit the lower Eel River and have been frequently observed upstream of Fernbridge in the 12^{th} Street pool adjacent to Riverwalk during fall salmon surveys. Sturgeon have also been observed holding in the intertidal area downstream of Fernbridge. Finally, Northern DPS sturgeon are presumed to spawn in the upper mainstem Eel River, based on observations at Fort Seward, approximately 80 miles upstream of the Lower Eel River Groundwater Basin. The Southern DPS spawn in the Sacramento River.