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Elk River Planning Area 1: 10% Design Report

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1 INTRODUCTION

The Elk River watershed is currently the focus of intensive efforts to resolve complex watershed-wide water quality impairment issues. Collectively, these efforts include: (1) The Upper Elk River Sediment Total Maximum Daily Load (TMDL) and associated Waste Discharge Requirements (WDRs) for timber companies in the upper watershed under the authority of the North Coast Regional Water Quality Control Board and US EPA; (2) The Elk River Recovery Assessment (ERRA), a technical feasibility study of large-scale sediment remediation completed in 2018 by CalTrout and technical consultants (Project Team); and (3) The Elk River Watershed Stewardship Program (Recovery Program). The goal of the Elk River Recovery Program is to develop a landowner-supported, multi-objective approach to reduce nuisance flooding[1] and recover impaired beneficial uses that balances flood reduction, sediment remediation, and ecosystem recovery. Toward this end, the Recovery Program has engaged Elk River landowners, land managers, scientists, and resource agencies in a collaborative planning process with the following objectives:

1. Identify voluntary actions, strategies, and solutions to: (a) improve hydrologic and sediment processes, water quality conditions, and habitat functions; (b) reduce nuisance flooding[1], consequent risks to residents and properties, and improve access during high water conditions; and (c) improve domestic (drinking) and agricultural (irrigation) water supplies.
2. Design and implement voluntary actions in a coordinated, prioritized, and cost-effective manner.
3. Conduct a monitoring and adaptive management program to quantify project impacts and benefits, and track responses and outcomes of implemented actions.
4. Ensure that individual actions fit together and collectively yield the greatest benefit toward the recovery of beneficial uses[2].

The Elk River Recovery Program is a large and ambitious program that, to succeed, will require extensive support from the broader Elk River community (particularly river-adjacent landowners), leadership from the North Coast Regional Water Quality Control Board (NCRWQCB) and other resource agencies, and public funding (such as through grant programs).

The Recovery Program identified four Planning Areas. The work described in this report advances designs that meet the objectives of the Recovery Program in Planning Area 1 (PA-1). Planning Area A (PA-1) encompasses the lower-most reaches of the Elk River mainstem at the downstream (north-westerly) end of the Elk River valley (Figure 1-1). This Planning Area (Figure 1-2) includes 5.3 miles of channel length including Elk River and Swain Slough and spans

[1] California Water Code §13050 defines nuisance to mean anything which meets all of the following requirements:

1. Is injurious to the health, or is indecent or offensive to the senses, or an obstruction to the free use of property, so as to interfere with the comfortable enjoyment of life or property.
2. Affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted in individuals may be unequal.
3. Occurs during, or as a result of, the treatment or disposal of waste.

[2] Beneficial uses are the cornerstone of water quality protection under the RWQCB Basin Plan for the North Coast region. Designated beneficial uses, plus water quality objectives, form the basis of water quality standards. The federal Clean Water Act and California Water Code mandate the development of water quality standards for all waterbodies within the state, including wetlands.

approximately 867 acres (ac) of former tidal and brackish wetlands, riparian forest, and prairie grasslands, and was historically interspersed with mixed conifer forest stands. The western edge of this Planning Area is bordered by US Highway 101, although this is an artificial boundary; there are additional tidal wetlands on the west side of HWY 101 owned by the City of Eureka that were hydraulically interconnected with our PA-1 but are currently separated by HWY 101. City of Eureka tidal wetlands north of PA-1 are concurrently undergoing restoration planning and design by the City of Eureka and are not part of the Stewardship Program Area.

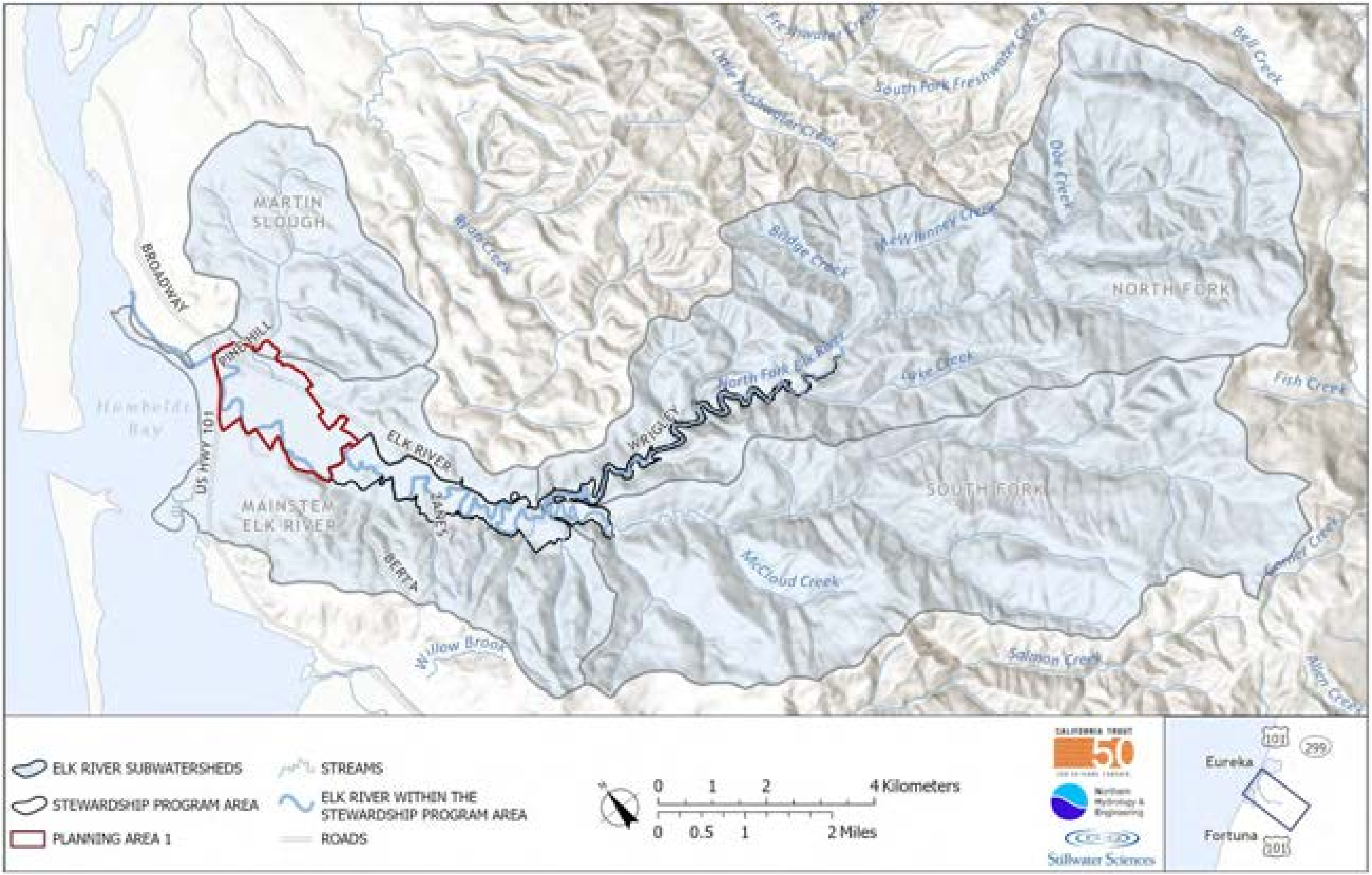


Figure 1-1. Vicinity map of Elk River Planning Area 1.

Figure 1-2. Map of Elk River Planning Area 1. River stationing represents the distance (ft) upstream from the Humboldt Bay confluence.

PA-1 is generally bounded to the south-west by the Elk River itself and to the north-east by Swain Slough and Elk River Road. The Elk River – Swain Slough confluence is at the very downstream end of PA-1, just upstream of HWY 101 at Sta. 7800; PA-1 extends up the sinuous Elk River to Showers Road. The total length of the channel, including Elk River and Swain Slough is 20,500 feet [ft] or 3.8 miles. Martin Slough branches off Swain Slough but is not considered part of our Stewardship Area or Recovery Plan.

This Planning Area is hydraulically and hydrologically inter-connected and is characterized by broad and flat low-elevation marsh plains that are variably protected from tidal inundation by unmaintained levees, ditches, tide gates and other drainage infrastructure. Exceptions to the otherwise typical agricultural land uses are the Elk River Wildlife Area (ERWA) (public lands), and several parcels at the northwesterly end of the valley in which breached levees and failed tide gates are allowing tidal inundation and land conversion to salt marsh. Numerous rural residential properties are scattered along Elk River Road, generally on upland areas above the 12–15 ft MSL elevation contour. There are 18 tide gates operate in this Area, several of which are dysfunctional. The abandoned Elk River railroad grade traverses the agricultural wetlands running up the valley parallel and to the west of Elk River Road.

The primary restoration actions proposed in this Planning Area include (a) maintaining and reconnecting the floodplain and marsh plains to Elk River and tidal slough channels, (b) enhancement of the tidal slough and creek drainage network, and off-channel ponds, to provide seasonally variable freshwater, brackish, and tidal aquatic habitat, (c) riparian expansion and enhancement, (d) minor recontouring of the floodplain, and (e) eradication of non-native vegetation and replacement/enhancement of wetland and riparian vegetation with native plant and tree species.

1.1 Objectives

Stewardship Program objectives that are continuing to advance in PA-1are listed below. Key objectives for PA-1 are summarized in Table 1-1.

- Coordinate and communicate directly with watershed residents, resource and permitting agency staff, and other stakeholders to solicit input and garner voluntary support for the Recovery Program and proposed Actions.
- Identify technical design and implementation approaches that are feasible, fundable, and broadly supported by landowners and permitting agencies; temporary impacts should be balanced to achieve long-term net benefits to public trust resources and ecosystem functions.
- Improve the living conditions of Elk River residents currently affected by frequent nuisance flooding (and the consequent risks and inconveniences) and impaired water quality.
- Protect and restore sensitive habitats and natural communities, special status fish species and critical habitat, sensitive and protected wetland and riparian plant species, and other statutorily protected areas.
- Increase Coastal Resiliency to buffer the threat of sea level rise to tidal marshes, aquatic habitat, and working agricultural lands in the lower reaches of Elk River.
- Restore a balance in ecological function so that eventually Elk River will function without ongoing maintenance and management.

- Reduce, and where feasible eliminate, invasive, non-native vegetation as well as native vegetation encroaching unnaturally into the river channel.
- Demonstrate that the Project does not raise the 100-year flood level above existing conditions.
- Increase awareness of resident’s vulnerability to extreme flood events.

Table 1-1. Summary of Stewardship Program objectives in Planning Area 1.

Focus	Objective
Ecological	Maintain existing tidal inundation and expand tidal prism where feasible, to restore natural tidal marsh and estuarine functions; and restore seasonal freshwater wetlands, ponds, and aquatic habitats, to increase resiliency of native fish and wildlife species dependent on these habitats.
Ecological	Restore and maintain a natural riverine and riparian corridor along Elk River, with natural flood-flow and sediment regimes, seasonal freshwater wetlands, ponds, and aquatic habitats, and buffered protection from agricultural land uses, to increase resiliency of native fish and wildlife species dependent on these habitats.
Land Use	Protect the productivity and long-term sustainability of existing forestry and agricultural operations; protect existing rural residential land uses; and provide access to potable domestic and agricultural water supplies.
Water Quality	Protect and restore water quality from impairment by suspended sediment and turbidity, water temperature, dissolved oxygen, and coliform bacteria (impairment = anthropogenic alteration from natural water quality regimes).
Floodplain	Improve channel/floodplain connectivity during winter flooding, promote natural sedimentation processes, and minimize/avoid stranding of juvenile salmon and steelhead.
Habitat	Restore high quality winter and summer rearing habitat for juvenile salmon and steelhead, within tidal creeks and slough channels, in off-channel freshwater ponds, and in the mainstem Elk River.
Nuisance Flooding	Reduce nuisance flooding (e.g., of roadways, residential and agricultural infrastructure) by restoring channel conveyance capacity, maintaining and improving floodplain flow pathways, and upgrading drainage infrastructure (culverts, tide gates, bridges, etc.).
Vegetation	Restore and maintain healthy and mature vegetation assemblages, including a mosaic of native riparian hardwood and conifer species; manage and prevent/suppress vegetation growth within the channel bed.

2 EXISTING CONDITIONS

Existing conditions within Planning Area 1 were characterized through field surveys and desktop analyses of key attributes including channel and floodplain geomorphology, hydrology and hydraulics, aquatic habitat, vegetation community classification and mapping, floristic surveys, and infrastructure. This baseline information will be used to inform reach-specific goals and objectives, identify opportunities and constraints, and develop habitat enhancement design concepts.

2.1 Geomorphology

An understanding of geomorphology (e.g., valley bottom landforms and channel longitudinal profile, gradient, width, entrenchment, morphology, sediment composition, and bank conditions) is critical to effectively plan and design for recovery of beneficial uses and ecosystem functions in the planning area.

The Elk River valley occupies a deep, structural trough formed within the coastal plain formed by regional tectonic uplift and subsidence, faulting, and folding. The valley is a naturally occurring depocenter filled with thick, unconsolidated Late Pleistocene and younger alluvium deposited during marine transgression related to eustatic sea level changes. Geology in the Elk River basin is predominantly composed of the Wildcat Group, a thick overlap assemblage of poorly indurated marine siltstone and fine-grained sandstone; the Yager terrane, highly folded and sheared argillite and sandstone turbidites with minor pebbly conglomerate; and the Franciscan Complex Central Belt, an accretionary mélange enclosing blocks of more coherent sandstone, greenstone, and chert (Ogle 1953, McLaughlin et al. 2000, Marshall and Mendes 2005). Undifferentiated shallow marine and fluvial deposits of middle to late Pleistocene age cap ridges across the western portion of the watershed. The valley bottom is occupied by Quaternary and Holocene alluvium, river and marine terraces, fan deposits, dune deposits, and existing and relict slough channels within the former tidal estuary.

Widespread channel aggradation has occurred throughout the Project reach from upstream sediment sources (Tetra Tech, Inc. 2015). Trends in historical and contemporary sediment loading in Elk River from the mid-1950s to present describe two cycles of elevated then diminishing sediment loads corresponding to decadal changes in timber harvest rates and associated road construction. The period of accelerated timber harvest between approximately 1988 to 1997 corresponded with a series of large storm events that significantly increased management-related sediment loading to and increased aggradation in the South Fork Elk River. Despite a decline in the rate of sediment production from the upper watershed since 1998, the Elk River continues to aggrade. Tributary watersheds draining from Humboldt Hill to Planning Area 1 and adjacent upstream reaches of mainstem Elk River (e.g., Shaw, Clapp, and Railroad gulches) have historically had high unit-area sediment loads comprised dominantly of small gravel, sand, and silt size classes derived from ridge capping shallow marine and fluvial deposits and the underlying Wildcat Group.

2.1.1 Valley bottom landforms

To characterize existing geomorphology (including relict channels) within the lateral extent of the valley bottom in the Project area, we analyzed the relative height of landforms above and below a reference surface defined by near-channel floodplain elevations. Near-channel floodplain elevations were used to create a digital slope model (i.e., the reference datum) for the area encompassing the valley bottom. The slope model was then subtracted from the original Project area digital terrain model (DTM). The resulting differences between the two surfaces indicate the height of geomorphic features relative to the reference datum (Figure 2-1, Appendix G). The process is equivalent to removing the overall trend in down valley slope from the topography (commonly referred to as surface detrending). The relative elevation model was used to describe current landforms and their relative elevations; inform placement of breaklines in the computational mesh used in hydraulic modeling; and assess potential fisheries habitat restoration and enhancement opportunities based on flow paths, relative inundation potential, and depth to groundwater.

The following sections briefly describe the main geomorphic features that comprise the mainstem Elk River Valley within Planning Area 1 as it transitions from a predominantly fluvial system in the upstream reaches (MSR3) to a predominantly estuarine setting in the lower reaches (MSR1).

Mainstem Elk River Reach 3. Mainstem Elk River Reach 3 (MSR3) is characterized by longitudinally extensive natural levees (Figure 2-1, Feature A) that separate the channel from low-lying adjacent floodplains (i.e., flood basins) (Figure 2-1, Feature B). The deepest parts of the flood basins are typically about the same elevations as the nearby channel thalweg. The channel planform is less stable than in upstream and downstream reaches, with a tendency for channel avulsion indicated by natural levee breaches that concentrate out-of-bank flow and create crevasse splays onto the floodplain. A much larger percentage of runoff during high flow events is conveyed down extensive floodplains than in the main channel. Return flows from the floodplain to the main channel are concentrated just downstream of Showers Road (i.e., Sta 25,400–23,700). The combination of floodplain return flows, high topography, and other confining features (e.g., constructed levees) in this area creates a large-scale hydraulic control that leads to backwater effects in the upstream reach during high flows.

Mainstem Elk River Reach 2. Mainstem Elk River Reach 2 (MSR2) defines the fluvial-tidal estuarine transition zone. Valley toe slopes are typically more gradual, Late Pleistocene fluvial and marine terraces are better preserved, and tributary alluvial fans (most notably the Orton Creek fan; Figure 2-1, Feature C) are more extensively developed along the northeastern margin of the valley compared to the southwestern margin in this area. These landforms reflect the shallow northeastern dip of the regional landscape north of the Little Salmon fault zone, as well as the higher elevations and greater topographic relief associated with increasing uplift rates progressing up the hanging wall of the fault zone to the southwest.

Topography is generally higher across the valley floor in the transition between MSR3 and MSR2 (i.e., the vicinity of Showers Road). The Elk River channel makes a conspicuous meander from the north side to the south side of the valley in this area (Figure 2-1, Feature D), one of the few places where the flow direction in the mainstem channel is perpendicular to the general trend of the valley axis. This channel segment and associated high surrounding topography occurs just upslope of the historical extent of tidal inundation, approximated by the 9.5-ft contour associated with the highest tide on record at the North Spit tide gage. The coincidence of the approximate extent of historical tidal inundation with relatively high valley floor topography and the major change in the mainstem Elk River planform suggests that the backwater effects of tidal inundation and associating sedimentation may be responsible for generating these geomorphic features.

Two main secondary flow paths (Figure 2-1, Features E and F) convey overbank flow through the relatively high floodplain topography in MSR2 near the end of Showers Road. These channels coalesce down-valley floodplain flow moving across the Elk River channel and convey it through the MSR2 floodplain into the former estuary (MSR1). These secondary flow paths, as well as Orton Creek, form the historical headwaters for Swain Slough.

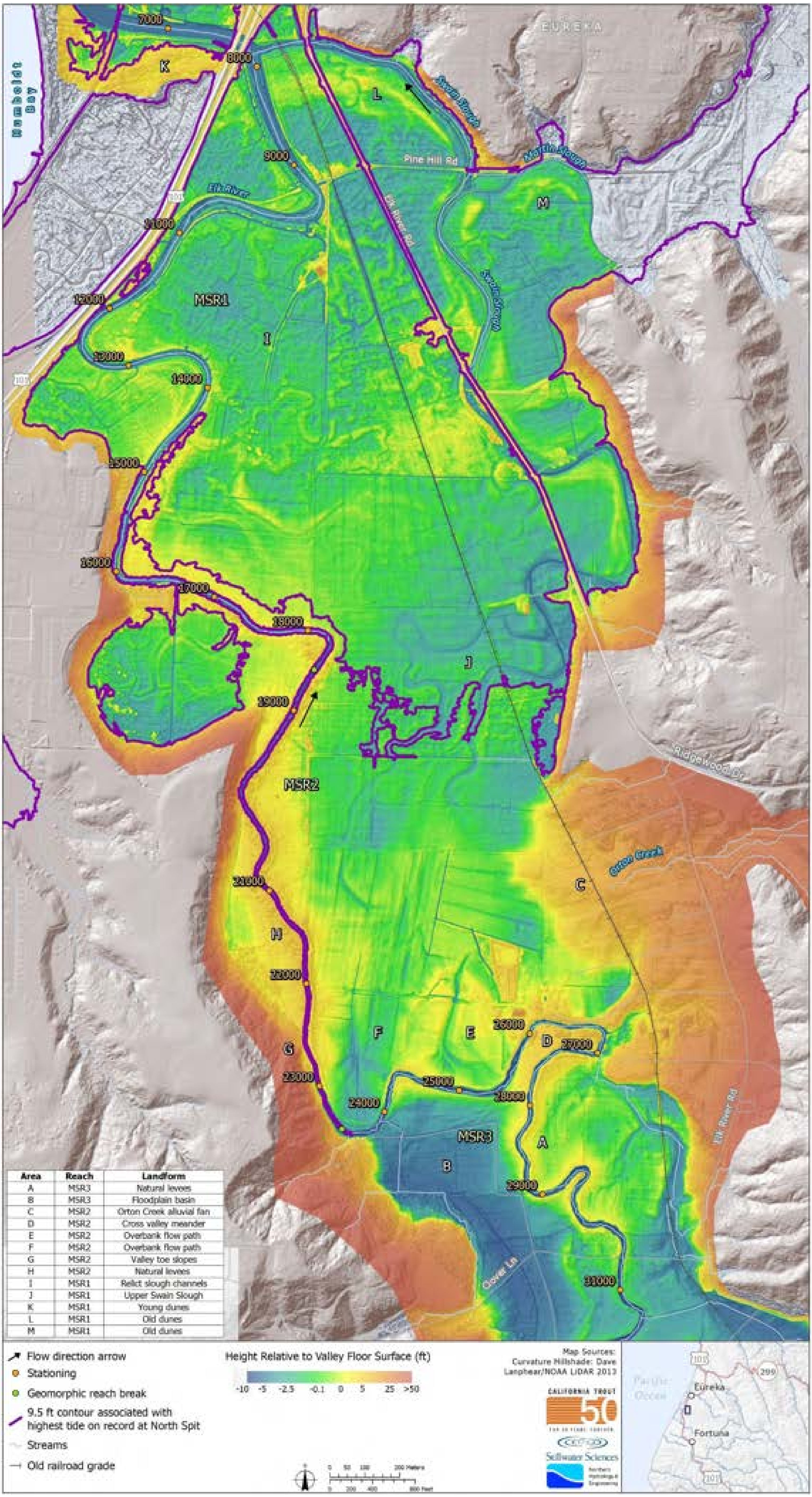


Figure 2-1. Valley bottom landforms.

The channel through MSR2 is located against the southwest valley toe slopes (Figure 2-1, Feature G) rather than occurring in a meandering pattern within the middle of the valley, as is common in upstream reaches. Natural and constructed levees are built to their highest elevations (Figure 2-1, Feature H) and the adjacent floodplains maintain a relatively consistent elevation across the valley floor. Channel widths begin to expand after remaining consistent through MSR3. Flow is typically contained within the channel through the reach, in part, because out-of-bank flow in the upstream reach conveys a large fraction of the total runoff during floods to the broad adjacent floodplain. The mainstem channel within the reach is inundated by high tides.

Mainstem Elk River Reach 1. Mainstem Elk River Reach 1 (MSR1) encompasses the existing and former tidal estuary. The mainstem Elk River channel morphology through this reach is typical of a tidally influenced channel, with a large width-to-depth ratio, near vertical banks, and fine-grained bed and bank material. The channel is confined by constructed levees in places and adjoined by historical and existing intertidal mudflats and tidal wetlands. Hydrodynamics and sediment transport within the channel are predominantly controlled by tidal action.

A network of relict, highly sinuous slough channels occur throughout the valley bottom in MSR1 (Figure 2-1, Feature I), indicating a once extensive tidal estuary prior to agricultural conversion. Swain Slough and Martin Slough are the largest of the remaining historical tidal slough channels within the area, with the headwater portions of the Swain Slough channel network (Figure 2-1, Feature J) historically draining much of the valley floor within the project area downstream of Showers Road.

Extensive dunes occur near the Elk River confluence with Humboldt Bay downstream of Highway 101 (Figure 2-1, Feature K). Relict older dunes are preserved along the river left bank of Swain Slough between Highway 101 and Pine Hill Road (Figure 2-1, Feature L), and along the left bank of Martin Slough upstream of the Swain Slough confluence (Figure 2-1, Feature M).

2.1.2 Historical channel conditions

Historical maps and aerial photos were used in combination with the relative elevation model and other terrain analyses to assess the location and extent of former fluvial and estuarine channels within Planning Area 1. The earliest sources of map information depicting channels within the planning area include the US Surveyor General Township Plat Map of 1854 and a series of US Coast and Geodetic Survey maps (commonly referred to as “T-sheets”) showing topography and bathymetry of the Humboldt Bay shoreline and Pacific Coast margin dating back to 1916.

2.1.2.1 Mainstem Elk River

We used the 1854 Township Plat Map and information from the original surveyors notes to compare the historical mainstem Elk River channel planform to current conditions (Figure 2-2). The primary purpose of the 1854 plat map surveys was to document property information rather than information about the terrain, and as such, the standard surveying procedures involved traversing the Township and Range lines, typically recording observations about the topography and vegetation only at the intersections of major channels. The channels represented on the 1854 plat map therefore are qualitatively interpreted between the points of intersection and are often depicted in much simplified form relative to the actual channel planform. The points of intersection from the 1854 surveys were digitized, rubber-sheeted, and overlayed onto existing LiDAR-derived hydrography to assess the degree of correspondence between historical and current mainstem Elk River channel planform (Figure 2-2). The results indicate that although the

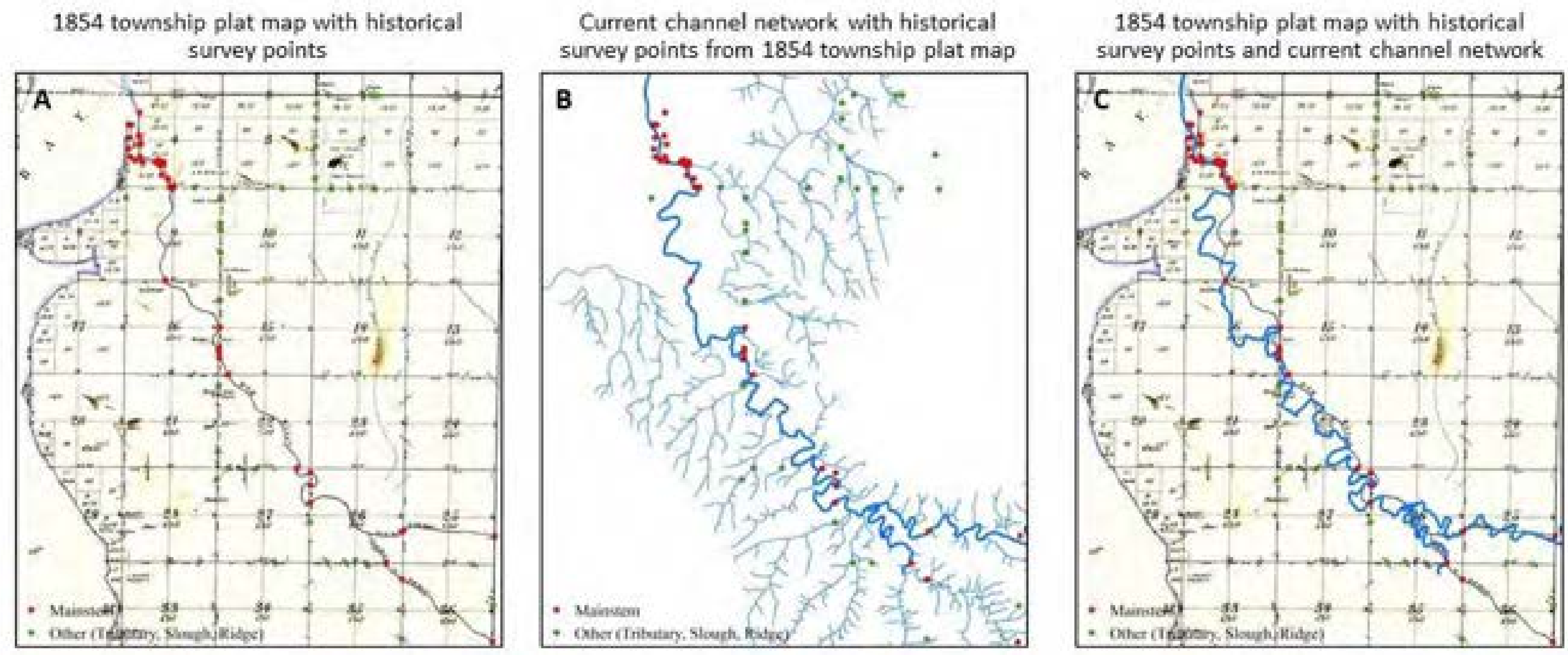


Figure 2-2. Comparison of historical 1854 mainstem Elk River channel planform to current channel conditions.

mainstem channel depicted on the 1854 plat map appears substantially more simplified than current channel conditions, the points of intersection nearly all correspond with current channel planform locations. Although the US Coast and Geodetic Survey maps focus almost exclusively on the Humboldt Bay shoreline and Pacific Coast margin, the earliest map from 1916 also depicts the lower approximately 4.5 miles of the mainstem Elk River channel in nearly the same channel planform as current conditions. We strongly infer from these results that the mainstem Elk River channel has maintained a stable planform throughout Planning Area 1 with little change since at least 1854. The degree of mainstem channel modification prior to 1854 is unknown, however, it is unlikely that large scale, mechanized channel modification (e.g., relocation of mainstem channel to the southern edge of the valley) occurred during the period of early Anglo-American settlement prior to 1884.

2.1.2.2 Tidal slough channels and tributaries

We used historical aerial photographs and terrain analyses of LiDAR data to assess the presence of relict tidal slough channels and tributaries within Planning Area 1. The earliest aerial photographs of the area are black and white images from 1939 and 1941. The 1939 photo has better tonal quality and contrast, with the larger relict slough channels typically appearing wetted. However, the 1939 photo covers only a portion of the Planning Area. The 1941 photo covers the entire planning area, but relict channels are less apparent due to overexposure and perhaps drier conditions. Most of the Planning Area 1, including the former estuary, had been entirely converted to agricultural land uses by the time the 1939 and 1941 aerial photographs were taken. The exact time period during which the estuary and adjoining riverine and floodplain ecosystem were converted to agricultural land uses is unknown.

The historical aerial photographs were rubber-sheeted and used to digitize the planform of relict channel features. To better understand the relative size and importance of relict channel features and how the channel network defines small watershed areas; we classified primary, secondary, and tertiary channel segments based on the clarity of the air photo signature, channel size, and continuity of the feature across the landscape. The network of channel features was then adapted and refined by overlaying it onto the relative elevation map with a curvature-enhanced hillshade as background (Figure 2-1) that allowed for detailed identification of subtle topographic features indicative of relict channel features. The resulting map of historical tidal slough channels and tributaries (Figure 2-3) reveals an extensive tidal slough channel network in the lower portion of the planning area comprised of several discrete watershed areas located downstream of Pine Hill Road, in the general vicinity of the ERWA, branching from the right bank of Elk River upstream of the ERWA, and along the left bank of Elk River between about station 19,000 and station 16,500. The historical mapping also reveals the large aerial extent of the Swain Slough channel network, the largest of the remaining historical tidal slough channels within the area and with headwater portions historically draining much of the valley floor within the project area downstream of Showers Road. The historical mapping was used to inform field data collection, hydraulic modeling, and conceptual design.

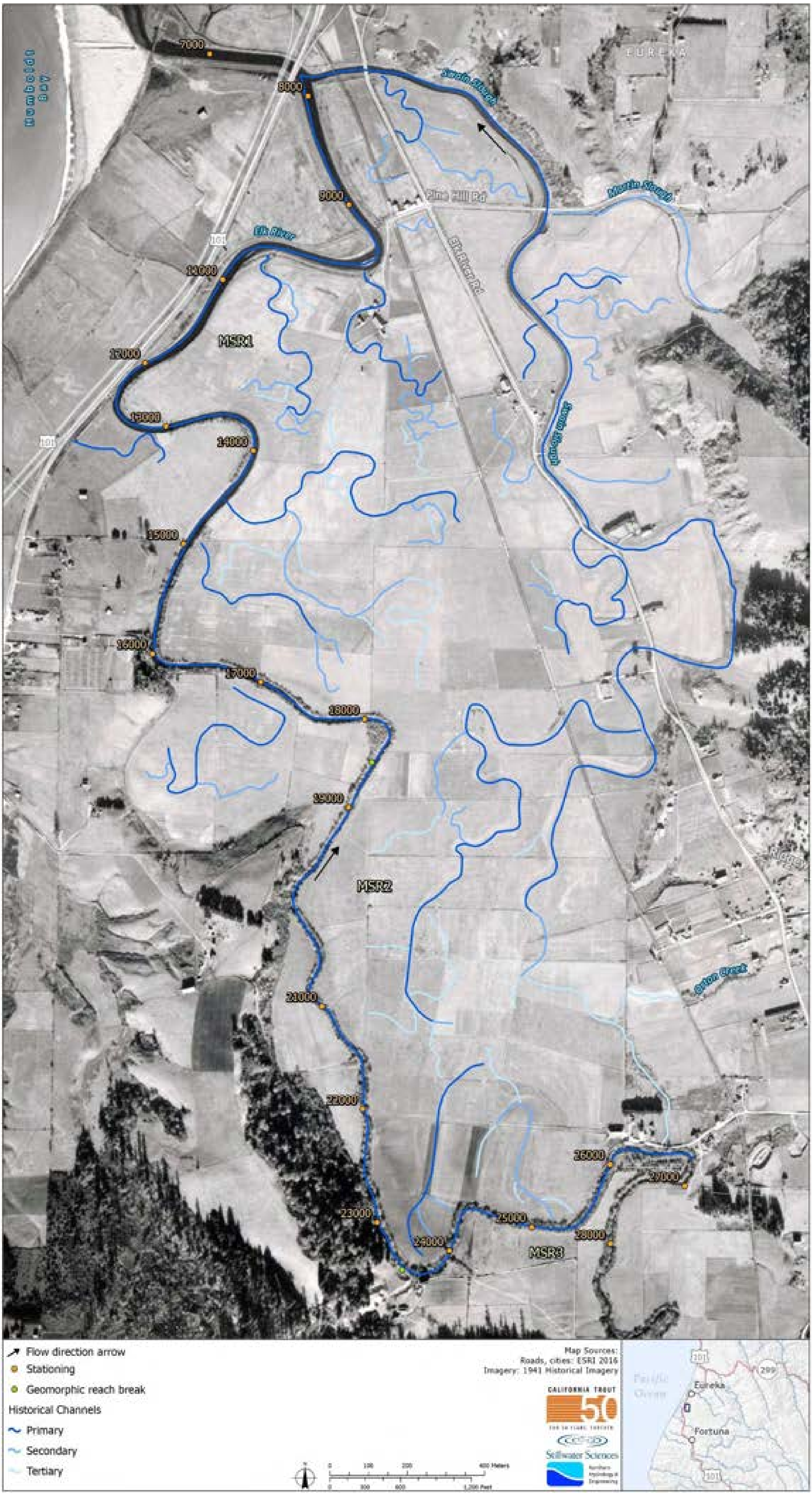


Figure 2-3. Historical tidal slough and tributary channel network shown on aerial imagery from 1941.

Orton Creek, one of the larger freshwater tributaries in the planning area, enters a culvert near the old railroad grade and is routed subsurface for approximately 1,400 ft to Elk River near the historical location of the Eureka municipal water intake at the end of Showers Road. This major modification to Orton Creek likely occurred during construction of the railroad. Based on historical aerial photographs and terrain analyses, Figure 2-3 depicts the probable historical (i.e., predisturbance) alignment of Orton Creek prior to being culverted. The overall conical form of the Orton Creek alluvial fan (Figure 2-1, Feature C) and the crenulations developed within it suggest that this lower reach of Orton Creek likely migrated laterally across the fan, and as a result, may have connected to Swain Slough at different locations over time prior to Anglo-American settlement.

2.2 Hydrology and Water Quality

2.2.1 Freshwater hydrology

Freshwater flows in PA-1 is derived from runoff from the upstream watershed (47.9 square miles), two perennial tributaries within the Planning Area, Martin Slough (5.2 square miles) and Orton Creek (0.6 square miles), several small intermittent tributaries and springs that flow from the adjacent valley wall, and four artesian wells (Figure 2-4).

Peak flows with specific recurrence intervals relevant for the site designs are estimated for PA-1. The hydrologic computations include: (1) a flood-frequency analysis of annual peak flows; (2) extension of the peak flow analysis to estimate the magnitude of smaller, more frequent storms via a Log-Pearson III curve fitting procedure; and (3) a flow-duration analysis of mean daily flows.

Select regional flood frequency equation parameters and revised regional skew estimates, and peak flows above the 2-year flood were determined from the USGS StreamStats program (http://water.usgs.gov/osw/streamstats/) for four sites. Elk River Court is the upstream boundary condition of the existing condition hydraulic model, PA-1 boundary at Showers Road, Orton Creek, and Martin Slough (Table 2-1). These estimates use the regional flood-frequency equation for California (regional-equation; Gotvald et al. 2012).

Figure 2-4. Sources of water and drainage infrastructure in Planning Area 1.

Table 2-1. Select regional flood-frequency equation parameters and revised regional skew estimates for the Elk River at various locations.

Site	Basin area (mi²)	Annual precipitation (in)	Mean basin elevation (ft)	% Forest	Revised USGS regional skew
Elk River Ct	45.0	55.9	875	78.8	-0.597
PA-1 Boundary	47.9	55.3	836	77.2	-0.599
Orton Creek	0.6	44.6	250	63.1	-0.618
Martin Slough	5.2	43.1	145	46.1	-0.619
Shaw Gulch	0.5	46.3	350	71.6	-0.616
Unnamed Trib. 1	0.7	45.6	376	64.3	-0.616

Peak flows less than the 2-year event were developed by extending the regional equation flood-frequency estimates by fitting a Log Pearson Type III (LP3) curve using LP3 frequency factors (Chow et al. 1988), and the regional skew value for the site. The LP3 fitting technique uses Excel Solver to determine the mean and standard deviation of hypothetical flood values (assuming the regional skew value) that minimizes the difference between the regional equation and LP3 peak flood estimates. Figure 2-5 shows an example of the regional equation peak flood estimates and the fitted LP3 curve determined for the Elk River at the upstream extent of PA-1. Table 2-2 and summarizes the peak flow estimates conducted for the hydraulic analysis.

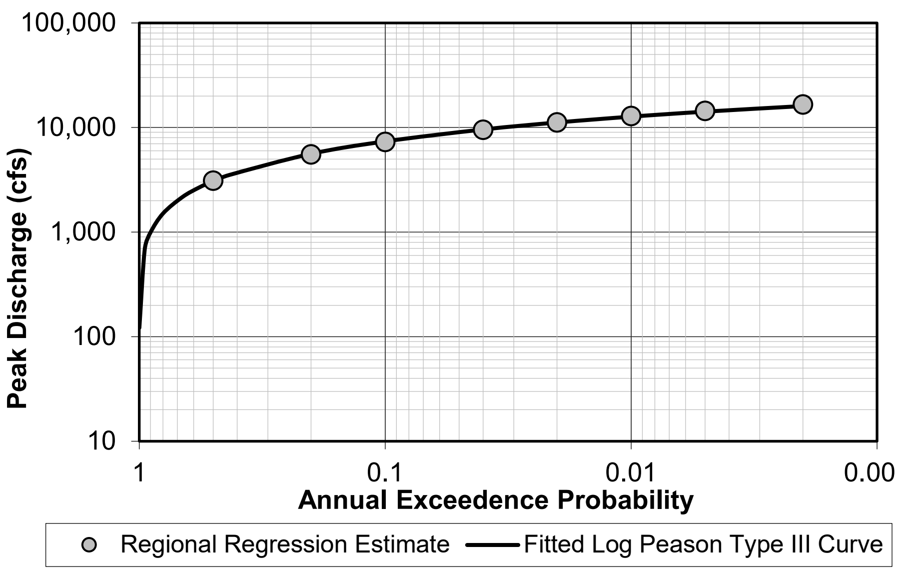


Figure 2-5. Example of flood-frequency results for the Elk River at the upstream extent of Planning Area 1; regional regression equation and fitted Log-Pearson III curve.

Table 2-2. Flood-frequency estimates at four locations along the Elk River computed via the regional regression equation and the LP3 fitted curve.

T (yr)	P (%)	Discharge (cfs)					
		Elk River Ct	PA-1	Orton Creek	Martin Slough	Unnamed Trib 1	Shaw Gulch
500	0.2	15,800	16,600	345	2,170	399.00	301.00
200	0.5	13,800	14,500	295	1,870	341.00	257.00
100	1.0	12,300	12,900	257	1,640	298.00	224.00
50	2.0	10,700	11,200	218	1,400	253.00	190.00
25	4.0	9,060	9,510	181	1,170	210.00	158.00
10	10.0	6,940	7,280	133	867	154.00	116.00
5	20.0	5,300	5,560	97	640	113.00	84.70
2.33*	42.9	3,363	3,524	56	379	65.60	49.20
2	50.0	2,970	3,110	48	327	56.30	42.20
1.75*	57.1	2,547	2,668	40	276	47.30	35.42
1.5*	66.7	2,071	2,169	31	217	37.00	27.72
1.25*	80.0	1,443	1,510	20	144	24.10	18.05
1.11*	90.0	949	992	12	89	14.70	10.96
1.053*	95.0	655	684	8	58	9.40	7.04

* Estimated via fitted LP3 curve.

2.2.2 Tidal hydrology and water quality

Elk River and Swain Slough are tidally influenced in PA-1. Water level, salinity and temperature were monitored in PA-1 to support interpretations of current habitat conditions and assist in the identification of opportunities for enhancement. All dates and times are reported in Coordinated Universal Time (UTC) and elevations are referenced to the NAVD88 vertical datum.

Water level, salinity and temperature data were collected for 12 months at several locations within PA-1 to document the site specific and seasonal conditions (Figure 2-6). Data were collected with a Solinst Levelogger 5 LTC. Continuous measurements (6-min measurement interval) were collected in Swain Slough (2 sites) and in Elk River (3 sites). Spot measurements were collected in the ERWA within the tidal channels (DFW-1), ditches (Y-Ditch & T-Ditch) and ponds (DFW-2).

Data loggers at the continuous sites were located roughly 4 inches (in) above the channel bed to minimize sedimentation around the logger and minimize the frequency of drying out the logger. The location of the logger affects the salinity and temperature results when there is variation in the salinity and temperature with depth. Generally, salinity is higher at depth dure to density differences between salt water and fresh water. Periodic spot measurements of salinity and temperature were collected at 1-ft increments in the water column to document stratified conditions at all measurement sites.

The closest long-term tidal water level station is located within Humboldt Bay North Spit, CA (Station ID: 9418767). The North Spit station was established August 16, 1977 (NOAA website). The maximum observed water level occurred on December 31, 2005 (9.54 ft, NAVD88). During the Project monitoring period, the highest measured water level at North Spit was just 0.1 ft lower than the maximum, 9.44 ft, NAVD88 on January 3, 2022. The minimum water level at North Spit occurred on January 20, 1988 at -3.24 ft, NAVD88. During the Project monitoring period, the lowest measured water level was -2.54 ft, NAVD88 occurred on two days 12/5/2021 and 2/1/2022. Mean Higher High Water (MHHW) reported for the 1983–2001 Epoch is 6.51 ft, NAVD88.

Tidal levels and annual extreme high water level probability estimates were estimated for each site for present day conditions (2022) (Table 2-3). These datum estimates use a rate of 2.28 mm/year of regional sea level rise (NHE 2015), and vertical land motion rate of -1.82 mm/year (Patton et al. 2017). The estimates for the stations in PA-1 demonstrate that tidal datums for 2022 are about half foot higher in PA-1 compared to the tidal datums reported at North Spit for the Epoch (1983–2001) as a combined result of regional sea level rise, vertical land motion and tidal amplification in the Elk River. There is just under a tenth of a foot of tidal amplification between ER-1 and ER-2 and a very minor amount of tidal amplification between SS-1 and SS-2 (a couple of hundredths of a foot).

Figure 2-6. Water level, salinity, and temperature monitoring sites in Planning Area 1.

Table 2-3. Tidal levels and annual extreme high water level probability estimates for present day conditions, adjusted for vertical land motion and regional sea level rise (2022).

Tidal value and % probability of exceedance	Return interval (years)	PA-1 at ER-1 (ft)
MHHW		7.05
MMMW		8.33
MAMW		9.35
99.0	1.01-year	8.55
90.9	1.1-year	8.82
66.7	1.5-year	9.13
50.0	2-year	9.30
20.0	5-year	9.69
10.0	10-year	9.93
4.0	25-year	10.20
2.0	50-year	10.40
1.0	100-year	10.57
0.2	500-year	10.93

MHHW = mean higher high water
MMMW = mean monthly maximum water
MAMW = mean annual maximum water

2.2.2.1 Water level

Water levels were continuously monitored (6-minute interval) at 3 sites on the Elk River and 2 sites on Swain Slough (Figure 2-6). These sites were selected to capture the expected variation in salinity and temperature along the Elk River which is a critical mixing zone of fresh and salt water. Water levels are influenced by both tides and stream flows in the Elk River. Swain Slough has a major tributary (Martin Slough) near Pine Hill Road and significant sources of freshwater from Elk River during larger storms that result in significant flooding of the valley bottom.

Spot measurements of water levels within the ERWA were collected between July 2021 and May 2022. Spot measurements were collected near mean higher high water on September 10, 2021, and above mean higher high water on October 7, 2021 and December 5, 2021 to estimate muting within ERWA.

Elk River

Three sites were monitored on the Elk River (Figure 2-6 and Figure 2-7). The downstream most site, ER-1, is located near Pine Hill Road at STA 9,920. ER-1 is 1,350 ft upstream of the confluence with Swain Slough and 430 ft downstream of the primary tide gate controlling water levels in the southern portion of the ERWA. ER-2 is located at STA 14,920, at the southern boundary of the ERWA. ER-3 is located at STA 19,800. The tidal influence extends to about STA 25,000 where the bed elevation of the channel is equal to the highest tide on record.

Figure 2-7. Elk River monitoring sites, ER-1 (A), ER-2 (B), ER-3 (C).

Swain Slough currents extends 4,480 ft from the Elk River at STA 7,870 to a tide gate at Elk River Road (TG-100) (Figure 2-6). Martin Slough, a major slough channel and tributary, enters Swain Slough 2,700 ft upstream of the Elk River. Two sites were monitored on Swain Slough (Figure 2-6 and Figure 2-8). The downstream most site, SS-1 is located at the abandoned railroad crossing (STA 250). The upstream site is located at STA 4,360 which is 1,660 ft upstream of Martin Slough, and 480 ft downstream of the tide gate (TG-100) at Elk River Road.

Figure 2-8. Swain Slough monitoring sites, SS-1 (left) and SS-2 (right).

ER-1 water levels during the monitoring period are primarily controlled by the tides. High flows from Elk River did not significantly affect high water levels but did elevate the minimum water levels during the winter period (Figure 2-9 and Figure 2-10). The channel bed elevation downstream of ER-1 creates a sill that fluctuates by about a foot with a minimum level of 0.9 ft during the monitoring period. This sill limits the minimum water level in the Elk River. The minimum observed water level at ER-1 was 0.9 ft on February 24, 2022. The maximum observed water level was 9.3 ft on January 3, 2022 and corresponded with the high tide observed at North Spit, CA of 9.4 ft. The data indicates <0.1 ft of tidal amplification between North Spit, CA and ER-1. The lag time between tidal peaks at North Spit, CA and ER-1 varies, and was 21 minutes on January 3, 2022 and the difference in the low water minima was 96 minutes. This extended period of draining occurs as the tides in Humboldt Bay continue to drop below the sill elevation and the Elk River continues to drain as the tide rises.

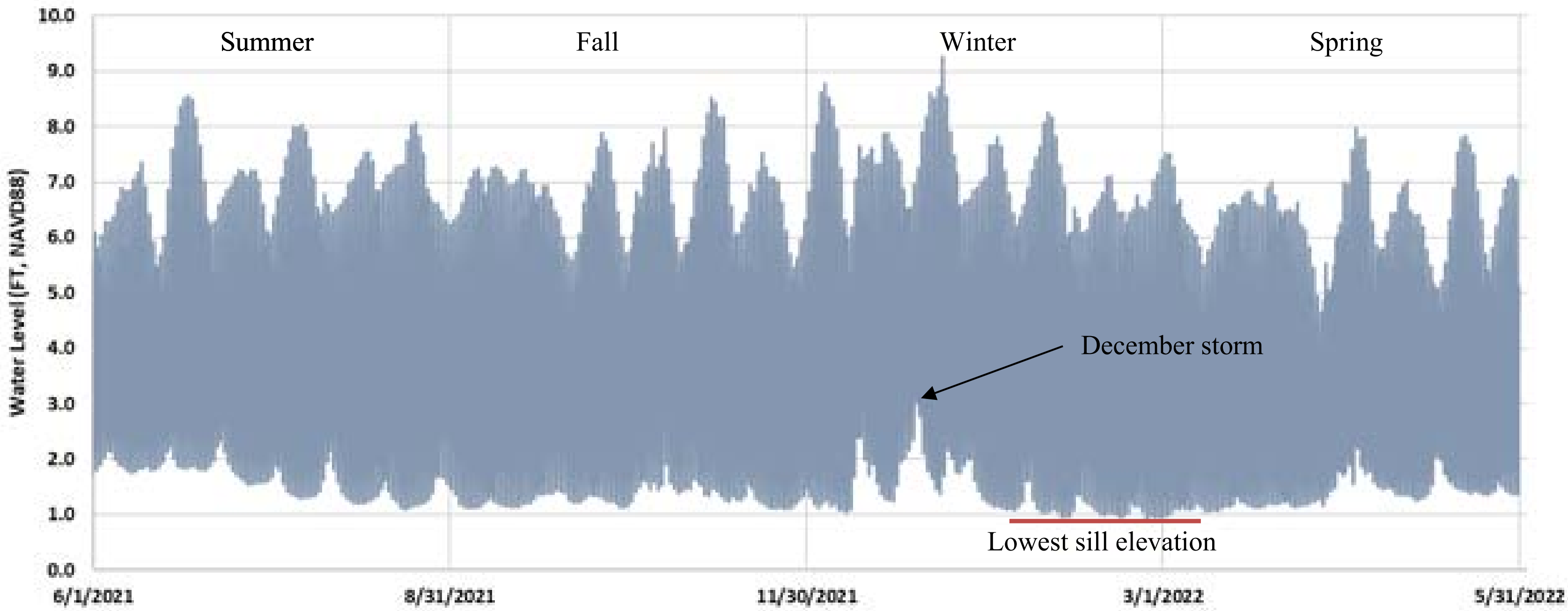


Figure 2-9. Example water level during monitoring period at ER-1. The sill elevation controls the minimum water level at ER-1, ER-2, SS-1 and SS-2.

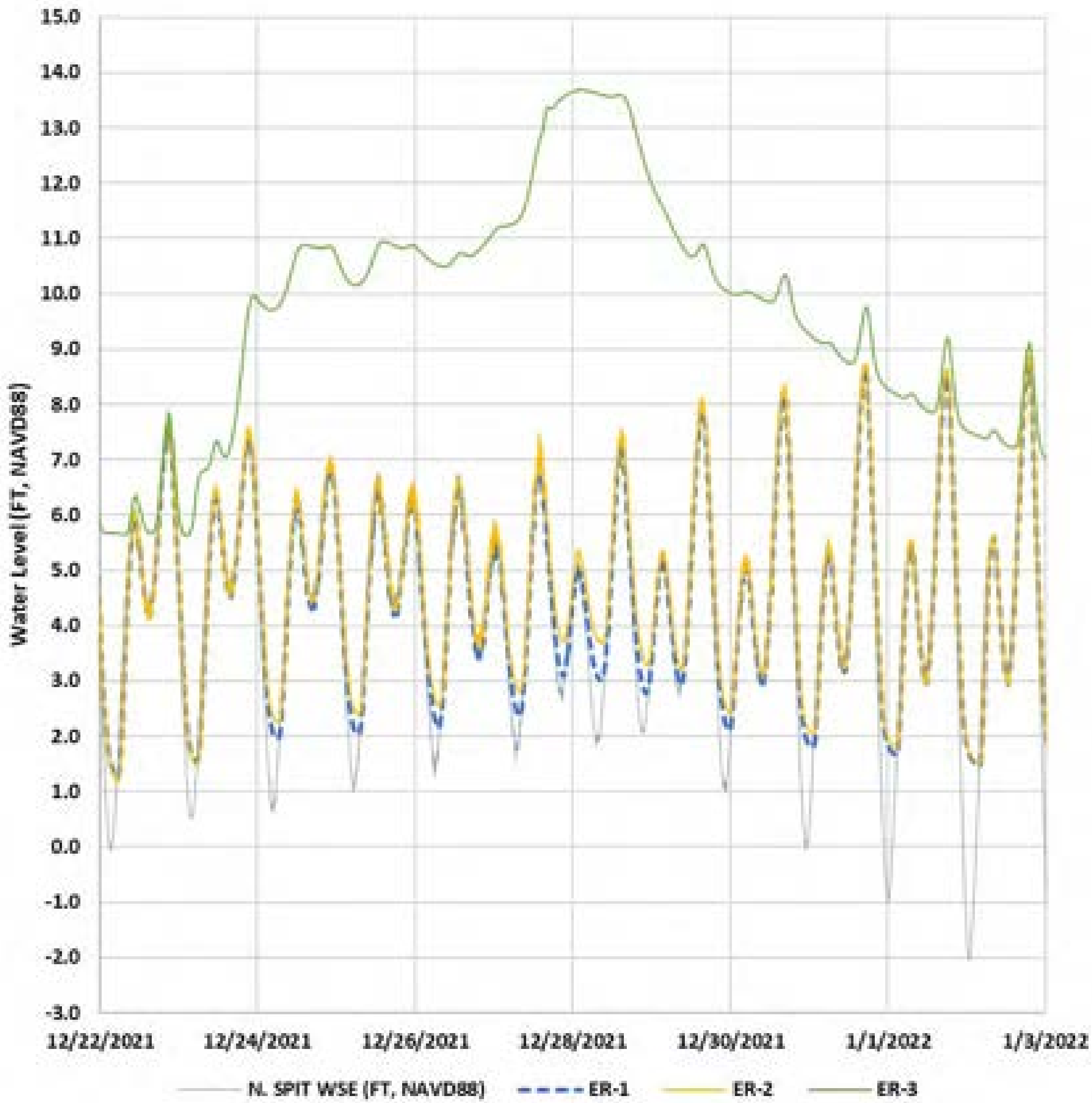


Figure 2-10. Water level at Elk River sites (ER-1, ER-2, ER-3) and North Spit during the December storm.

ER-2 water levels are very similar to ER-1, with minor differences occurring during storm periods (Figure 2-11). During low water conditions, ER-2 appears to have the same sill elevation control as ER-1. The minimum observed water level at ER-2 was 0.9 ft on February 27, 2022. The highest water level at ER-2 (9.4 ft) occurred a day earlier than ER-1 (January 3, 2022) There is less than 0.1 ft of tidal amplification between North Spit, CA and ER-2. The lag time between tidal peaks at North Spit, CA and ER-2 is less than 12 minutes. During the December storm, the peak water level at ER-2 did not coincide with the peak in the storm hydrograph, rather the peak was driven by high tide which was elevated by less than 0.5 ft compared to ER-1 and North Spit, CA as a result of elevated stream flows. Similarly minimum water levels were elevated compared to ER-1 by about 0.5 ft.

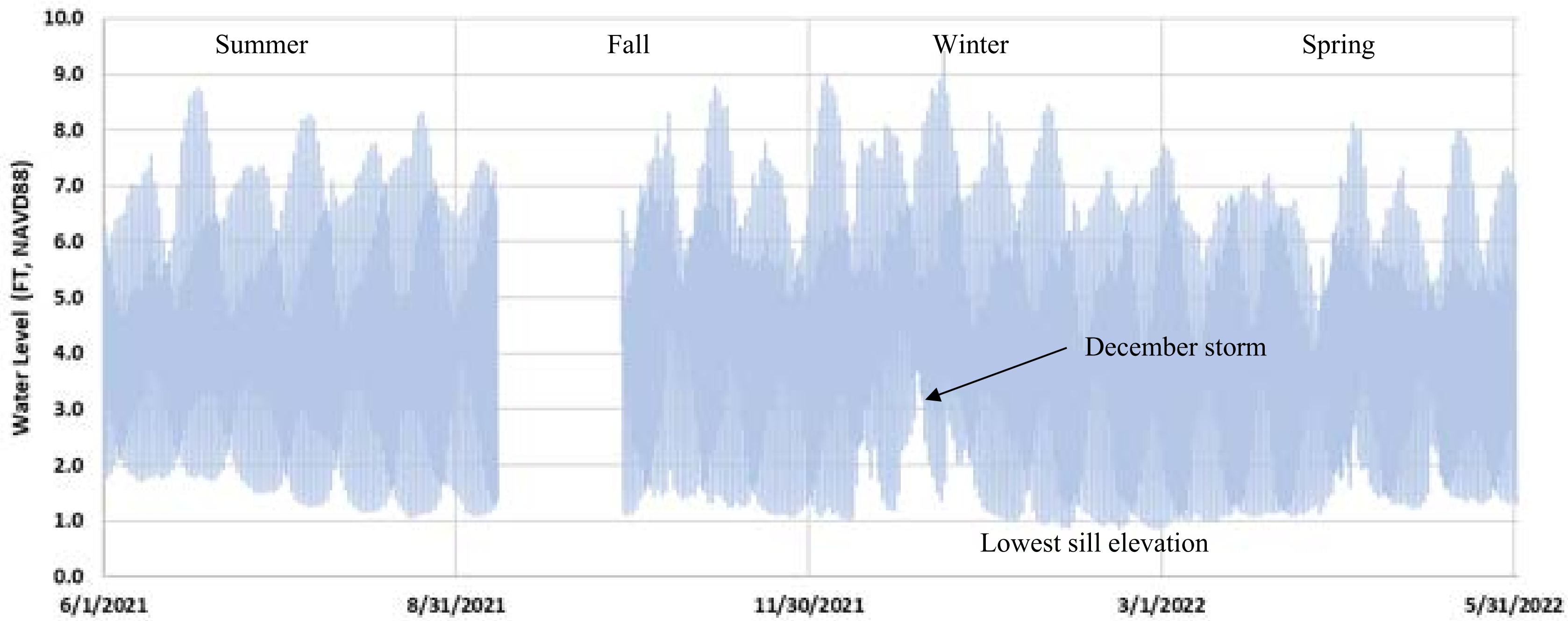


Figure 2-11. Water level during monitoring period at ER-2.

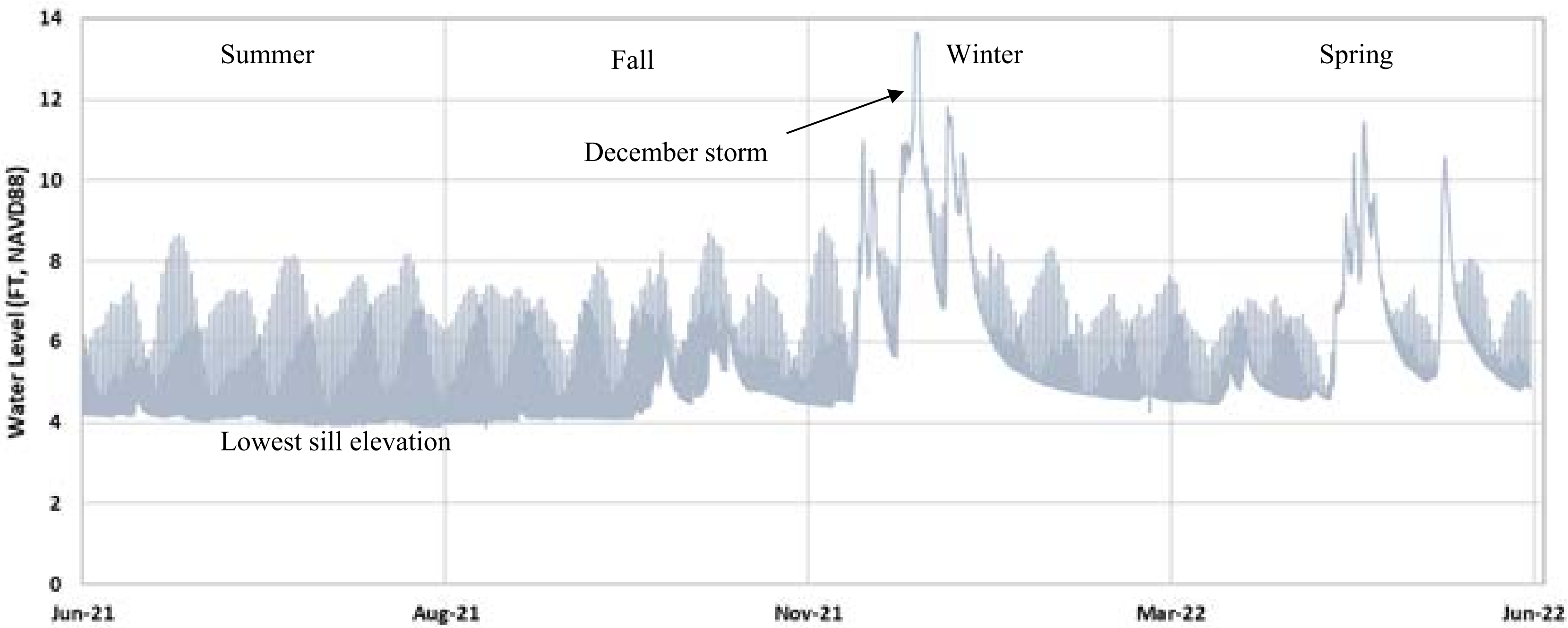


Figure 2-12. Water level during monitoring period at ER-3. A sill elevation of ~4 ft controls the minimum water level during low stream flows.

The controls on water levels at ER-3 are significantly different than downstream stations ER-1 and ER-2. The minimum observed water level at ER-3 was 3.86 ft on September 10, 2021, which occurred during the low flow fall period and low tide of 3.02 ft at North Spit. The lowest water levels at ER-3 are limited by the local bed elevation downstream of the data logger. High water levels are controlled by tides during low stream flows and are controlled by stream flow during storm periods. As stream flows drop, the tides punctuate the recessional limb of the hydrograph. The maximum observed water level was 13.69 ft on December 28, 2021 due to high flows in the Elk River and a 4.02 ft tide at North Spit, CA. The data indicates tidal amplification between North Spit, CA and ER-3. The lag time between tidal peaks at North Spit, CA and ER-3 is about 12 minutes (Figure 2-12).

Elk River Wildlife Area

A system of levees and tide gates limits tidal inundation in the southern portion of the ERWA, referred to as a "muted tide". The degree of tidal muting was estimated using spot measurements of water surface elevation during high tide. Measurements were collected on Oct 7, 2021 at a 7.57 ft, tide and on December 5, 2021 during an 8.56 ft tide measured at North Spit, CA. Measurements adjacent to the failed tide gate that allows water into the southern portion of the ERWA (DFW-1) were a few tenths of a foot lower than Elk River outside the tide gate. However, the tide gate acts as a constriction, limiting the amount of water that can enter the ERWA. At the 7.57 ft tide, peak water levels were ~1.3 ft lower that the Elk River in the central portion of the ERWA (DFW-2) (Figure 2-13) and ~0.8 ft lower in the main ditch (T-ditch). Water levels in the ERWA were ~1.6 ft lower at the 8.56 ft tide (Figure 2-14). These lower water levels in ERWA affect the existing distributions of vegetation and aquatic habitats compared to tidal wetlands with unrestricted tides.

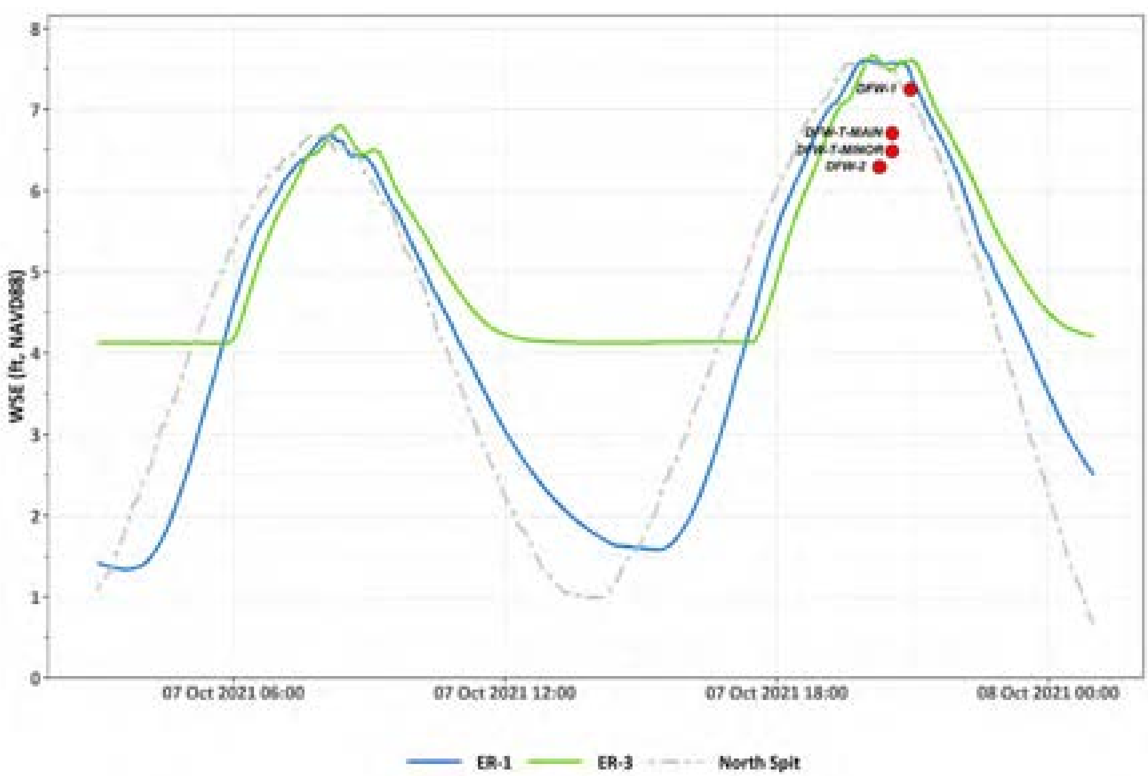


Figure 2-13. Water level at ER-1 and ER-3 and Elk River Wildlife Area monitoring sites compared to North Spit on October 7, 2021.

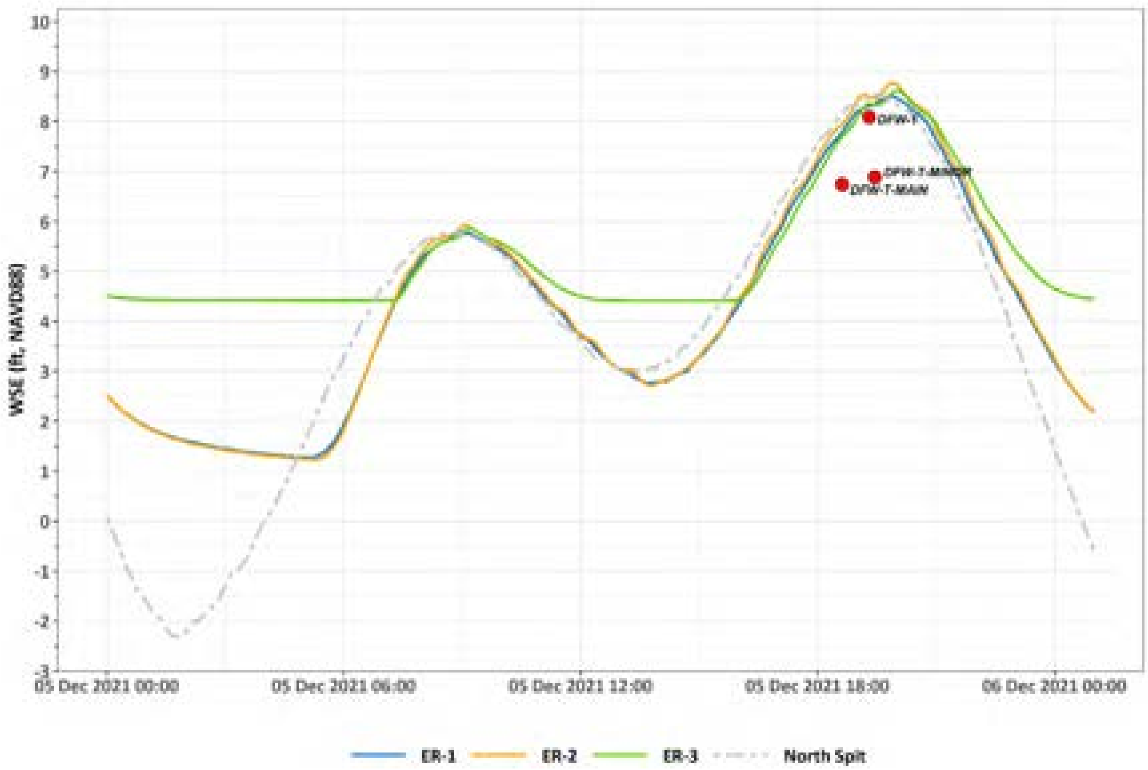


Figure 2-14. Water level within the Elk River Wildlife Area on December 5, 2021.

Swain Slough
Water levels in Swain Slough were monitored upstream and downstream of the main tributary, Martin Slough. Water levels at both sites tracked ER-1 nearly identically. The only exceptions occurred during winter storms. SS-2 (upstream of Martin Slough) had an extended period of higher water levels at low tide, due to freshwater inflows from Martin Slough and upstream tributaries upstream increased water depth and a narrower channel geometry. There is no apparent tidal amplification or time lag in Swain Slough at peak tides compared to ER-1.

2.2.2.2 Salinity

Salinity affects the spatial distribution of aquatic organisms and vegetation species and distribution. These data are used to inform and understand existing habitat and vegetation distributions (Section 2.3 and 2.4) and identify opportunities and constraints for ecological enhancement. Ocean water is typically 35 PSU, brackish water is 1-35 PSU and freshwater is <1 PSU. The difference between PSU (practical salinity unit) and PPT (parts per thousand) are small and are used interchangeable in this section.

PA-1 has a significant seasonal, longitudinal, and daily variation in salinity (Figure 2-15). Monitoring sites ER-1, ER-2, SS-1 and SS-2 are generally brackish range year-round (Table 2-4 and Table 2-5) with short periods of freshwater conditions when stream flows are elevated in the winter and spring when tides are low (Figure 2-16). During the summer months, when stream flows are low, there is less variability in salinity and freshwater conditions typically do not occur. ER-2 has longer periods of freshwater conditions (Figure 2-17) than ER-1 due to a greater influence of stream flows at the site. ER-2 also shows more extended periods of high salinities compared to ER-1 in the spring. These differences may be due, in part, to salinity stratification of the water column.

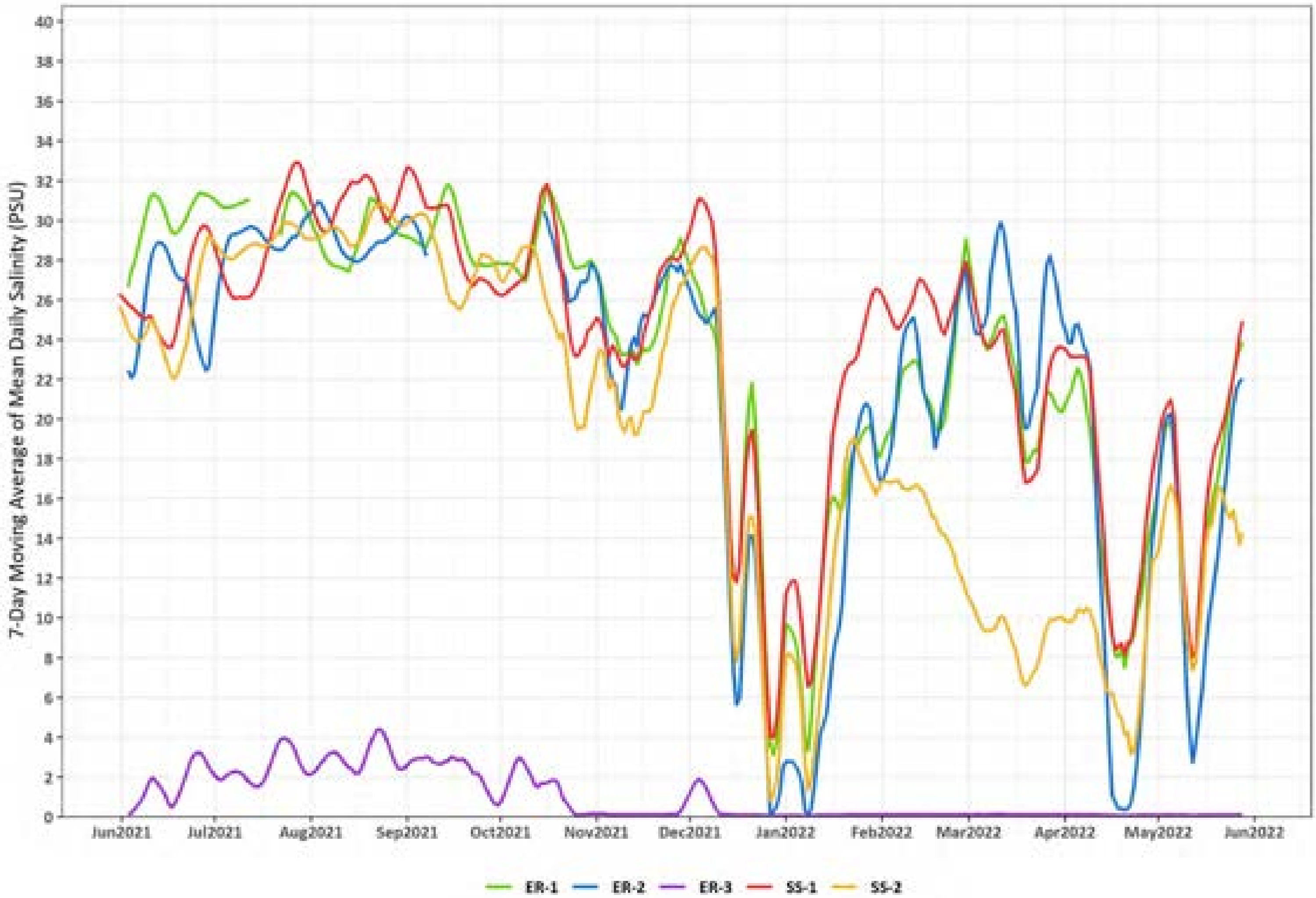


Figure 2-15. Seven-day moving average of the mean daily salinity at continuous monitoring sites on Elk River (ER-1, 2, and 3) and Swain Slough (SS-1 and 2).

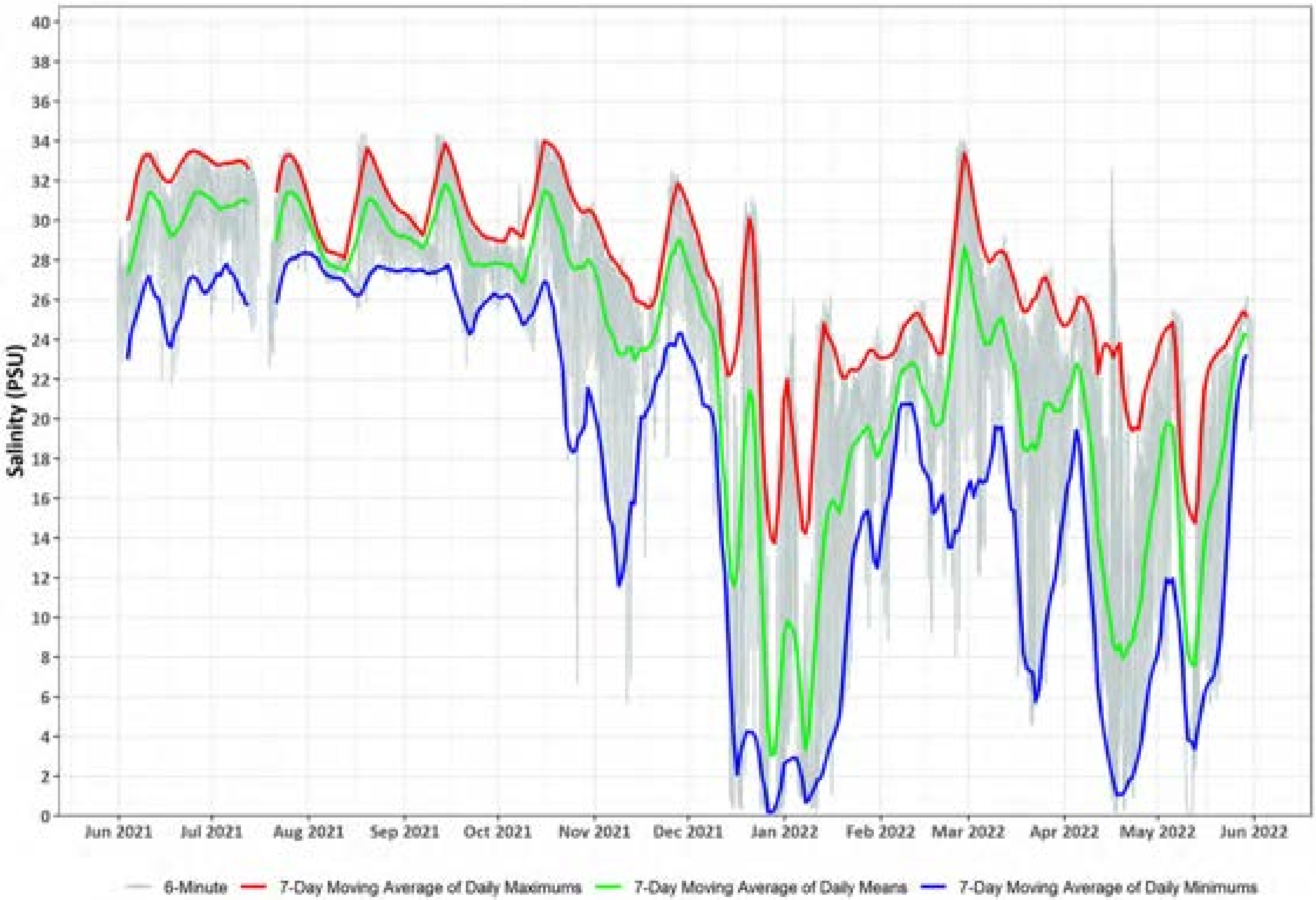


Figure 2-16. Seven-day average of daily maximum, mean and minimum salinity values at ER-1 during the monitoring period June 2021–June 2022.

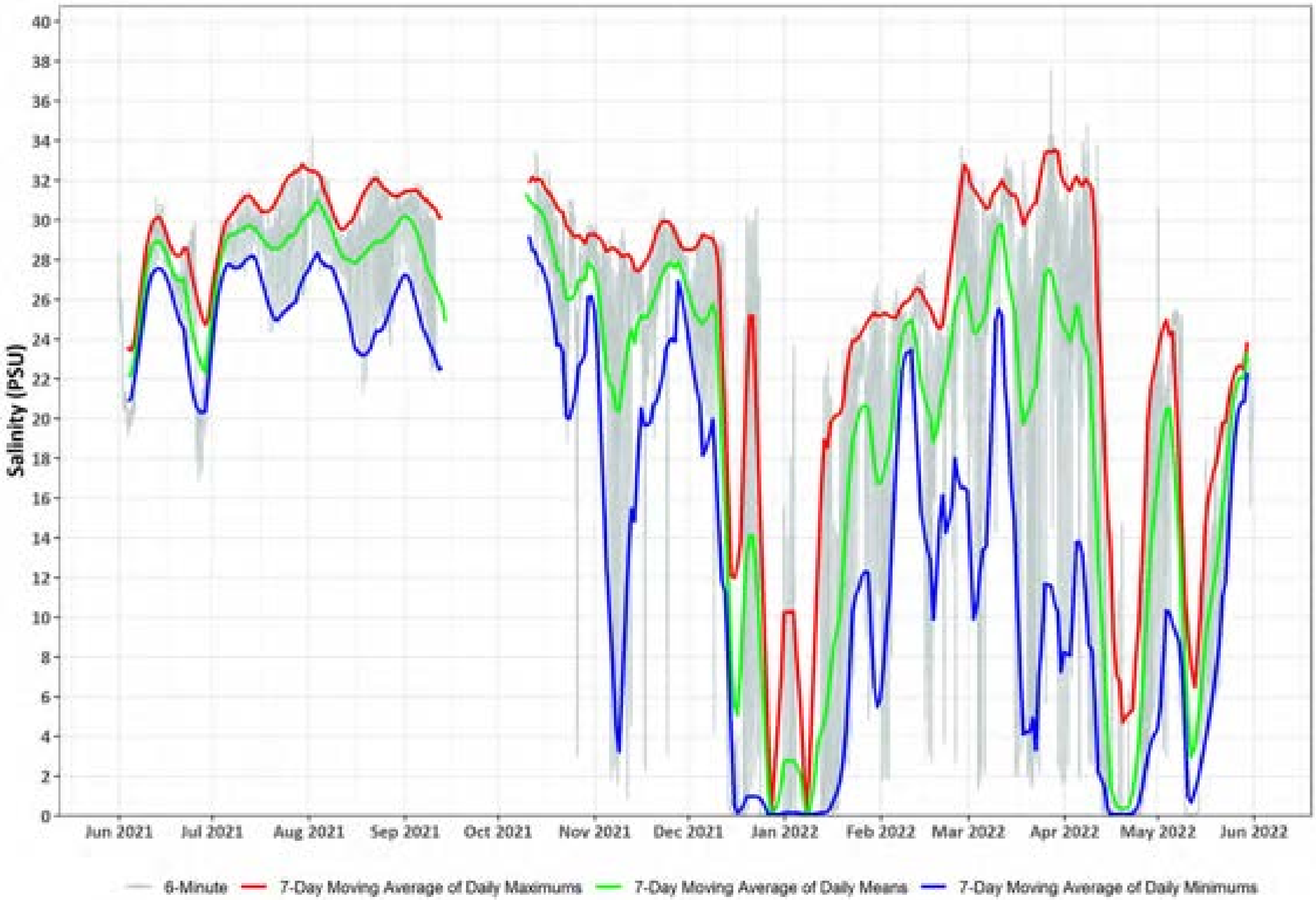


Figure 2-17. Seven-day average of daily maximum, mean and minimum salinity values at ER-2 during the monitoring period June 2021–June 2022.

Salinity stratification was detected at the lower Elk River monitoring sites (ER-1 and ER-2) during all seasons. During the summer months, ER-1 was stratified during 4 of 11 measurements. ER-2 was stratified whenever saline water was present (6 out 8 measurements). The entire water column was fresh during the two samples dates that no stratification was detected. The more consistent stratification at ER-2 may be due to larger influence of stream flows and fewer opportunities for vertical mixing. During the summer and fall, the upper layer is brackish (7–18 ppt) and during the winter and spring the upper layer is fresh (<5 ppt). The fresher zone of water is confined to the upper foot of the water column and the remainder of the water column is >20 ppt.

Table 2-4. Seasonal average of the daily minimum, mean, and maximum salinity values in Elk River. Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5–10 PSU, green), highly brackish (10–20 PSU, purple), saline (>20 PSU).

Site	Season	Seasonal average of daily salinity values (PSU)		
		Minimum	Mean	Maximum
ER-1	Fall	5.6	27.7	30.1
	Spring	0.1	18.0	24.1
	Summer	21.7	29.8	31.8
	Winter	0.1	17.4	23.3
ER-2	Fall*	0.9	26.8	29.8
	Spring	0.1	17.4	23.1
	Summer	16.9	27.9	29.7
	Winter	0.0	15.0	20.6
ER-3	Fall	0.1	1.3	7.4
	Spring	0.1	0.1	0.1
	Summer	0.1	2.3	12.6
	Winter	0.0	0.2	1.2

* Fall values for ER-2 based on incomplete data (partial months of September and October) due to logger malfunction.

Table 2-5. Seasonal average of the daily minimum, mean, and maximum salinity values in Swain Slough. Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5–10 PSU, green), highly brackish (10–20 PSU), saline (>20 PSU).

Site	Season	Seasonal average of daily salinity values (PSU)		
		Minimum	Mean	Maximum
SS-1	Fall	4.6	27.2	32.7
	Spring	0.2	19.6	26.0
	Summer	12.7	28.7	32.0
	Winter	0.0	20.4	30.8
SS-2	Fall	6.1	25.1	28.6
	Spring	0.3	12.0	15.8
	Summer	16.5	27.8	29.2
	Winter	0.1	14.2	20.2

Table 2-. Vertical distribution of salinity and temperature at ER-1. Dates shaded in light blue indicate measurements that detected salinity stratification (>5 ppt difference in the water column).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (°C)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (°C)
6/25/2021 20:24	0.2	28.4	20.7	11/24/2021 19:50	0.2	7.8	10.8
	1	28.5	20.5		1	22.1	10.3
	2	28.8	20		2	26.9	10.5
	3	28.8	19.9		3	28.6	10.6
7/15/2021 23:18	0.2	22.1	17.8		4	29.2	10.8
	1	22.1	17.9	12/17/2021 23:50	0.2	2.6	8.6
	2	25.0	18		1	2.6	8.6
	3	31.9	16.7		2	2.9	8.6
8/16/2021 22:18	0.2	30.4	20.2		3	2.9	8.6
	1	30.5	19.8		3.5	4.8	8.5
	2	30.6	19.4	2/24/2022 22:30	0.2	8.4	11.2
	3	30.9	19.1		1	8.4	11.1
9/10/2021 19:24	0.2	31.0	17		2	24.3	11.0
	1	31.3	16.7		3	27.9	10.8
	2	31.5	16.6		4	29.6	10.3
	3	31.6	16.5	4/15/2022 20:36	0.2	2.9	9.0
	4	30.9	16.6		1	2.7	9.0
10/7/2021 14:15	0.2	26.4	13.5		2	3.0	9.0
	1	26.7	13.5		3	24.0	9.7
	2	31.0	14.1		4	26.8	9.7
10/12/2021 21:50	0.2	30.5	13.6	5/31/2022 20:20	0.2	20.7	18.7
	1	31.0	13.2		1	20.9	18.6
	2	31.2	13.2		2	21.7	18.3
	3	31.3	13.1		3	21.9	18.3
	4	31.5	12.8		4	22.5	17.9
	4.5	31.6	12.7				

Table 2-. Vertical distribution of salinity and temperature at ER-2. Dates shaded in blue indicate measurements that detected vertical salinity stratification (>5 ppt difference in the water column). Salinity stratification was measured when brackish/salt water was present. Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5–10 PSU, green), highly brackish (10–20 PSU), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)
7/15/2021 18:36	0.2	7.1	15.1	12/17/2021 21:12	0.2	0.1	8.4
	1	21.8	17.2		1	0.1	8.3
	2	29.0	18.1		2	0.1	8.3
	3	29.3	18.3		3	0.1	8.3
8/16/2021 19:06	0.2	16.1	19	2/24/2022 19:00	0.2	3.0	6.7
	1	17.3	18.5		1	3.2	6.7
	2	26.7	19.4		2	22.5	10.6
	3	28.4	19		3	27.1	10.8
9/10/2021 18:06	0.2	13.7	15.6		4	27.7	10.9
	1	20.9	15.3	4/15/2022 18:36	0.2	0.1	8.4
	2	24.0	16.6		1	0.1	8.4
	3	27.0	16.7		2	0.1	8.4
10/12/2021 19:42	0.2	18.2	13.2		3	0.1	8.4
	1	22.3	13.1		4	0.1	8.4
	2	26.2	13	5/31/2022 18:36	0.2	2.1	15.3
	3	28.2	13.1		1	2.1	14.9
	4	28.1	13.2		2	26.2	16.5
					3	27.1	16.8
					4	27.2	16.8

The upstream most station (ER-3) has a significantly different salinity profile compared to downstream sites (ER-1, 2) (Figure 2-15). Although ER-3 is tidally influenced, ER-3 is fresh (salinity < 1 PSU) in the winter and spring when stream flows are sufficient to limit the upstream extent of the salt water (Figure 2-18). During low flow conditions that occur in the summer and fall, and occasionally for short periods of time in the winter and spring, the site is brackish during high tides greater than about 6.5 ft (Figure 2-19).

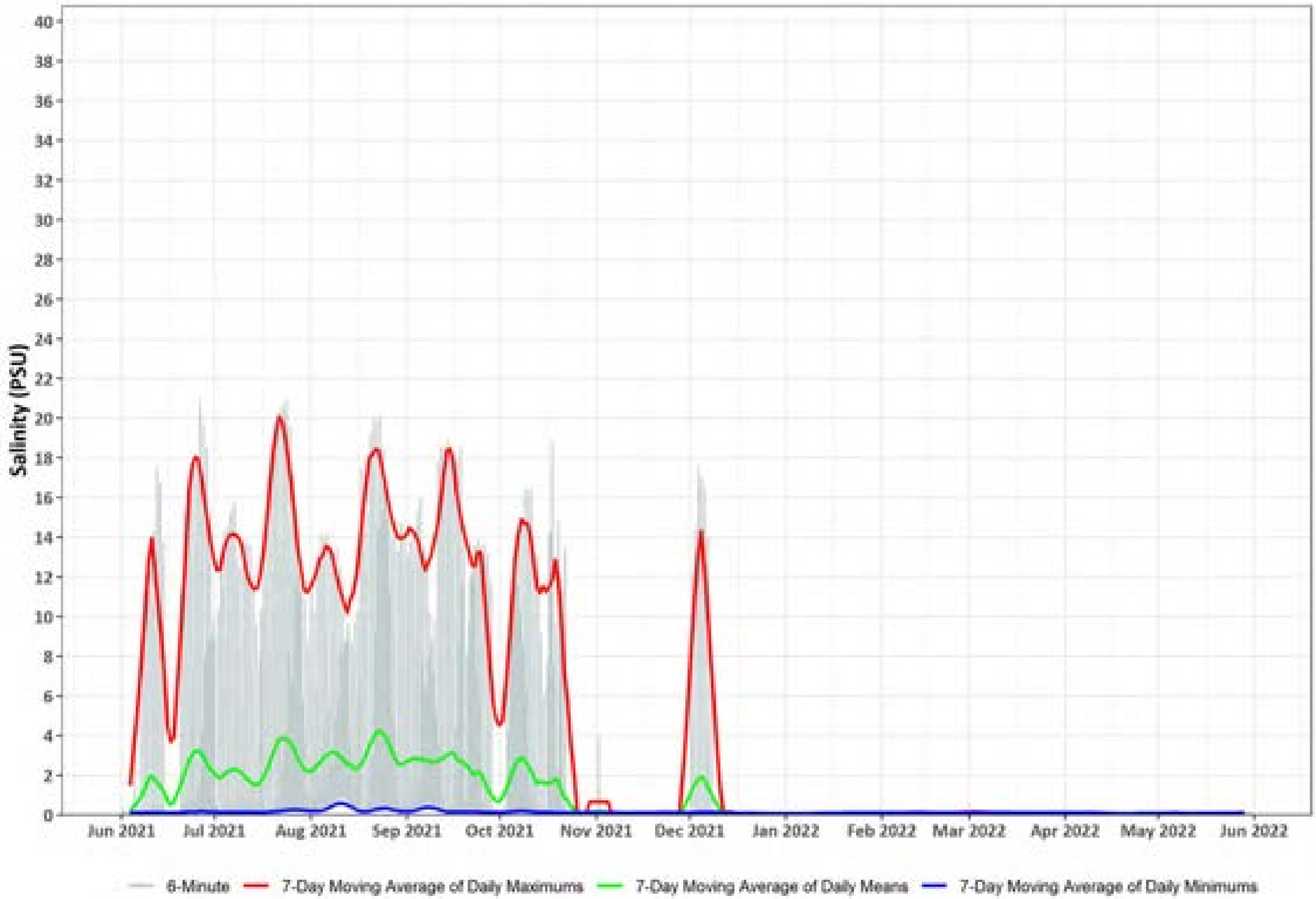


Figure 2-18. Seven-day average of daily maximum, mean and minimum salinity values at ER-3 during the monitoring period June 2021–June 2022.

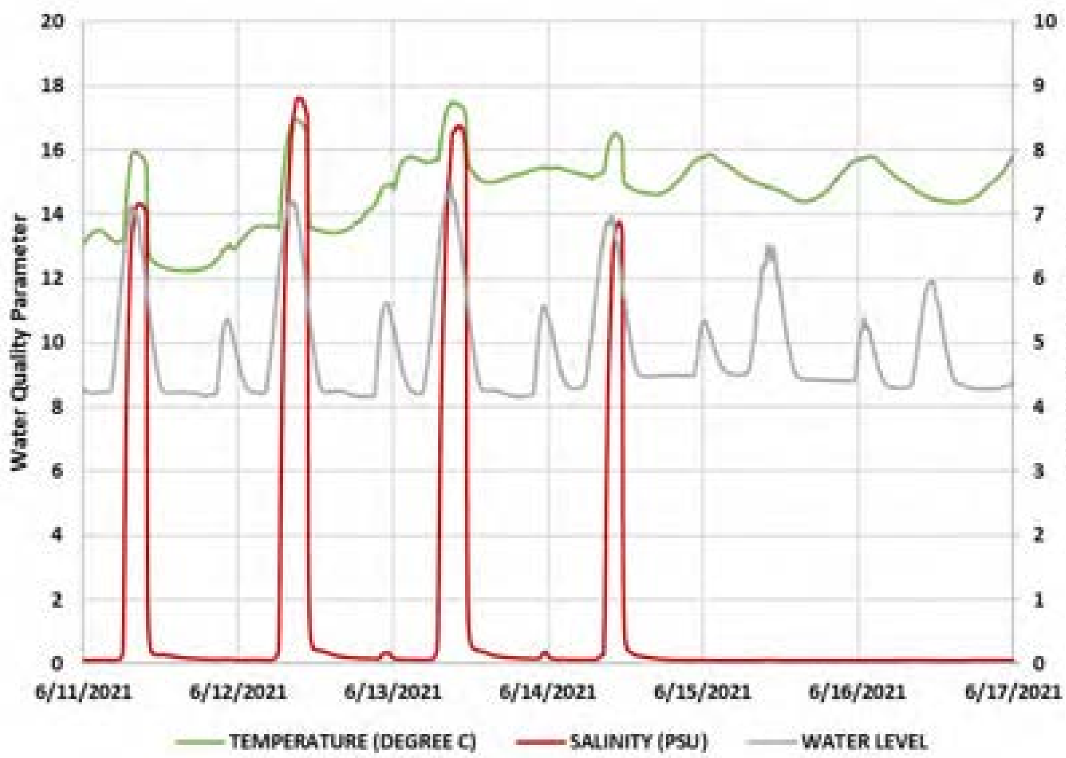


Figure 2-19. ER-3 salinity and temperatures fluctuations with and without the influence of saltwater at high tides (>6.5 ft) during summer low flow conditions.

Salinity stratification was not detected at ER-3 (Table 2-8). However, all measurements at this site occurred when salinities were less than 5 ppt. It is likely that stratification occurs for short period of time when tides are higher (>6.5 ft) and stream flows are lower.

Table 2-. Vertical distribution of salinity and temperature at ER-3. No significant salinity stratification was detected. Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5-10 PSU, green), highly brackish (10-20 PSU), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (°C)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (°C)
7/15/2021 17:48	0.2	0.1	12.9	12/17/2021 18:10	0.2	0.1	8.2
	1	0.1	12.9		1	0.1	8.2
8/16/2021 18:00	0.2	0.2	14.9		2	0.1	8.2
	1	0.2	14.9		3	0.1	8.2
9/10/2021 17:12	0	0.2	13.9		4	0.1	8.2
	1	0.2	13.9		5	0.1	8.2
10/12/2021 22:46	0.2	3.4	10.1	2/24/2022 17:48	0.2	0.1	4.9
	1	4.0	10.2		1	0.1	4.9
	2	4.4	10.2		2	0.1	4.9
	3	4.4	10.2	4/15/2022 17:36	0.2	0.1	8.1
11/24/2021 21:06	0.2	0.1	8		1	0.1	8.1
	1	0.1	8		2	0.1	8.1
	2	0.1	8		3	0.1	8.1
	3	0.1	8		4	0.1	8.1
				5/31/2022 17:30	0.2	0.1	12.1
					1	0.1	12.1
					2	0.1	12

Swain Slough follows the same general salinity pattern as ER-1 in the summer, fall and winter (Figure 2-15 and Figure 2-20). In the spring, the upstream site (SS-2) has substantially lower salinity levels than the downstream site (SS-1) and ER-1 and ER-2 (Figure 2-15, Figure 2-21, Table 2-5). Potential upstream freshwater sources that influence these lower salinity levels include numerous springs on the right valley wall, and small, presumable intermittent, tributaries that drain to Swain Slough (Figure 2-4).

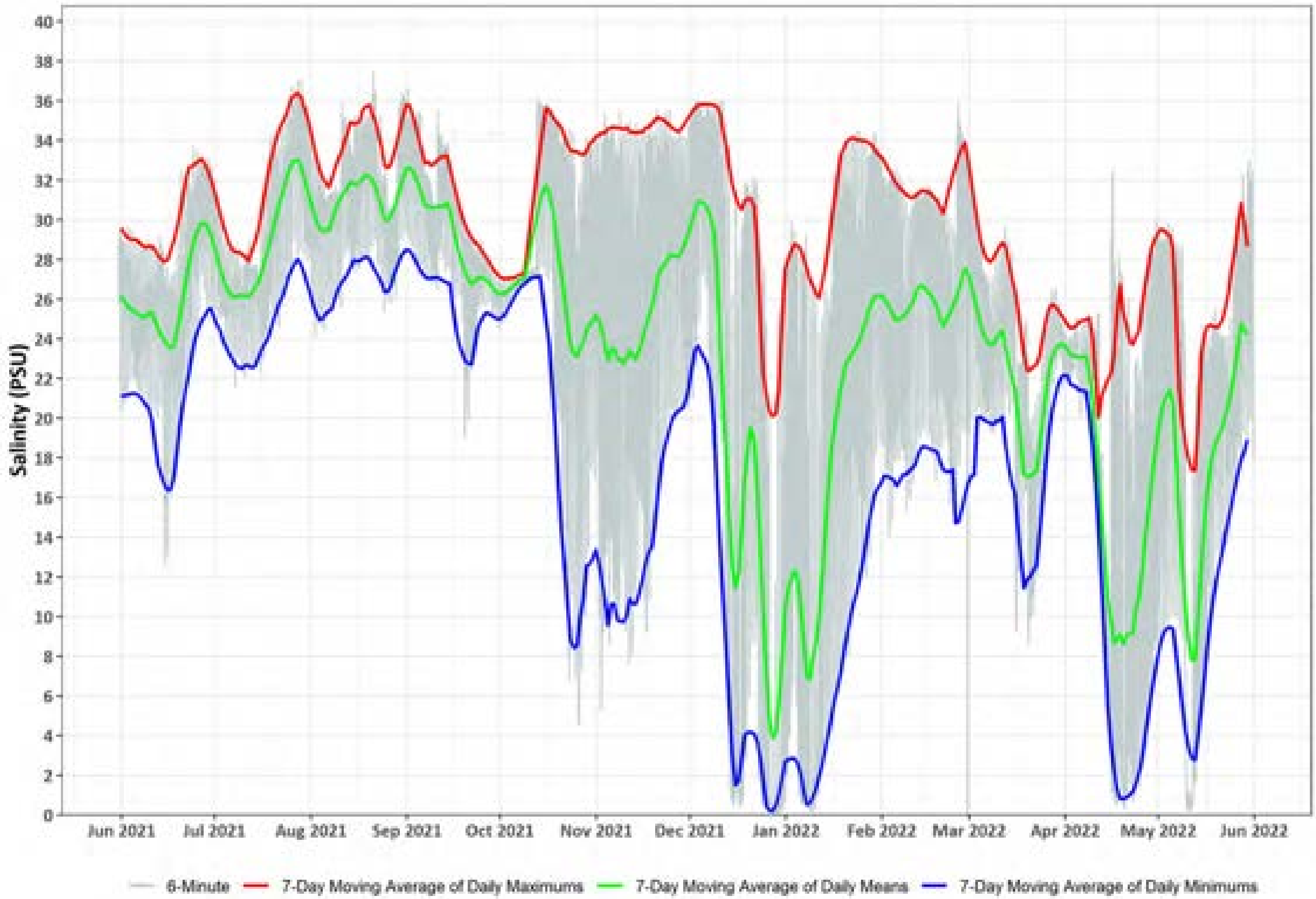


Figure 2-20. Seven-day average of daily maximum, mean and minimum salinity values at SS-1 during the monitoring period June 2021–June 2022.

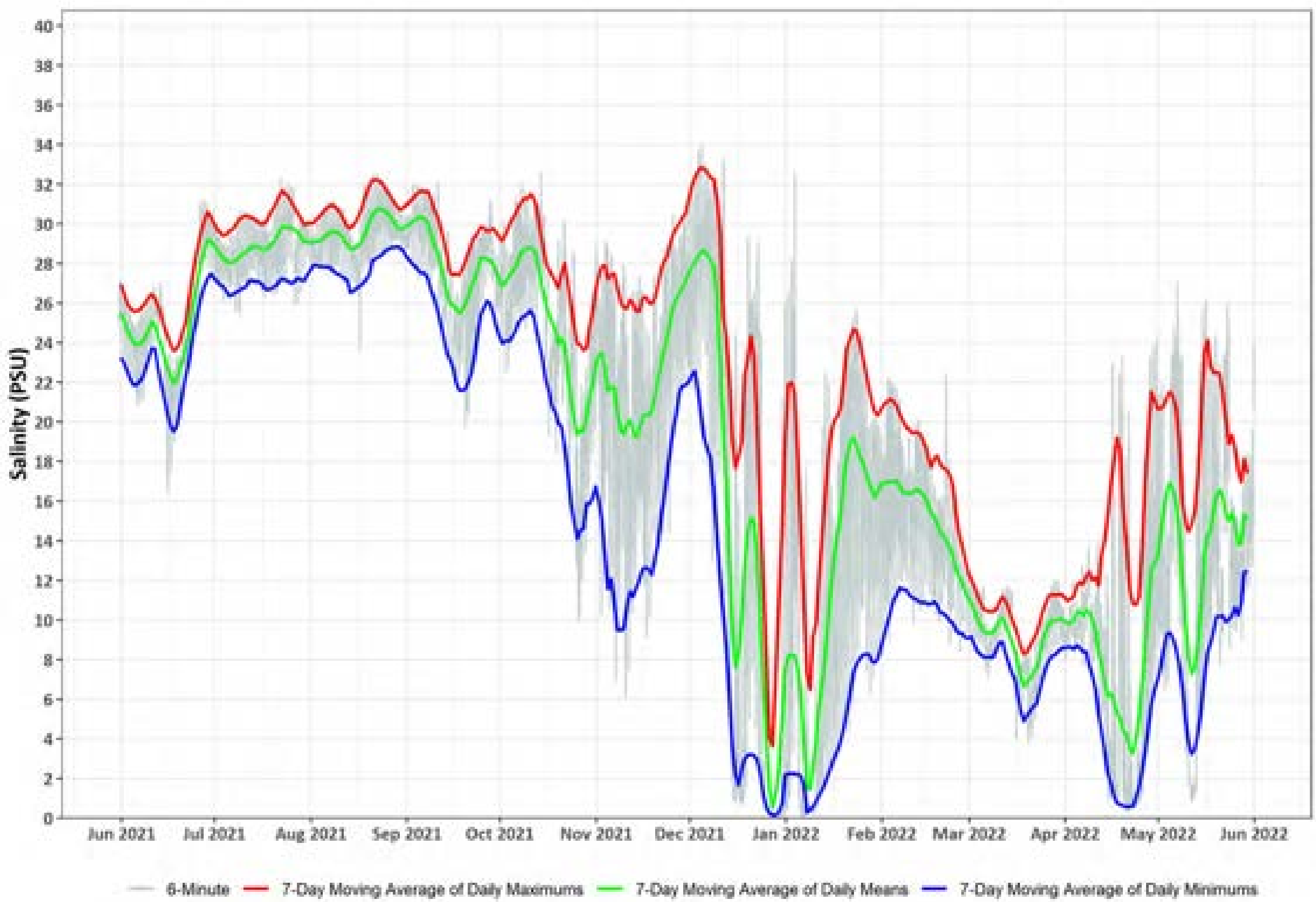


Figure 2-21. Seven-day average of daily maximum, mean and minimum salinity values at SS-2 during the monitoring period June 2021–June 2022.

Salinity stratification was infrequently observed in Swain Slough. At the downstream site (SS-1), stratification was observed in 2 of the 10 measurements and at the upstream site in 3 of the 10 measurements (Table 2-9 and Table 2-10). The stratified conditions were all measured in the late fall, winter, and spring. Stratified conditions were not measured during the summer, likely due to limited freshwater inputs.

The stratification observed at Swain Slough differs from the Elk River in that there is less variation between the top and bottom of the water column. Stratification occurs at SS-1 when salinities are low and range from 1.7-6.7 from top to bottom and when the water column is saline with salinity ranging from 21.3-29.5 (Table 2-9).

Table 2-. Vertical distribution of salinity and temperature at SS-1. Dates shaded in blue indicate measurements that detected salinity stratification (>5 ppt difference in the water column). Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5–10 PSU, green), highly brackish (10–20 PSU), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)
6/25/2021 20:54	0.2	32.7	18	12/17/2021 20:00	0.2	1.7	8.3
	1	32.7	17.9		1	1.7	8.1
	2	32.8	17.7		2	2	8
7/15/2021 19:12	0.2	24.4	18.5		3	5.3	8.1
	1	25	18.5		4	6.7	8.3
8/16/2021 20:00	0.2	29.6	20.6	2/24/2022 19:48	0.2	16.5	10.2
	1	29.6	20.4		1	16.5	10.2
	2	29.6	20.1		2	16.4	10.2
9/10/2021 18:36	0.2	31.2	16.6		2.5	16.4	10.2
	1	31.2	16.6	4/15/2022 19:36	0.2	1.1	9.7
	2	31.3	16.6		1	1.1	9.7
10/12/2021 21:00	0.2	30.6	12.9		2	2.7	9
	1	31.4	12.8		3	4.1	8.8
	2	31.4	12.8		4	4	8.8
	2.5	28.2	12.9	5/31/2022 19:36	0.2	20	18.4
11/24/2021 22:36	0.2	21.3	10.9		1	20	18.4
	1	23.8	10.8		2	19.8	18.5
	2	28.8	10.9				
	3	29.5	10.9				

Table 2-. Vertical distribution of salinity and temperature at SS-2. Dates shaded in blue indicate measurements that detected salinity stratification (>5 ppt difference in the water column). Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5-10 PSU, green), highly brackish (10–20 PSU), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)
6/25/2021 22:36	0.2	26.8	23.8	11/24/2021 23:24	0.2	22.4	11.2
	1	27.5	23.5		1	22.5	11.1
	2	28.5	21.6		2	23.5	10.5
	3	28.8	21.1		3	24.8	10.4
	4	28.9	20.8		4	27.5	10.8
	5	28.9	20.8	12/18/2021 0:30	0.2	1	7.8
7/15/2021 23:36	0.2	25.3	20.2		1	1	7.8
	1	25.4	20.1	2/24/2022 23:00	0.2	16.2	14.2
	2	27.4	19.1		1	25.7	12.9
	3	28.3	18.9	4/15/2022 21:24	0.2	1.4	10.4
	4	28.5	18.8		1	1.4	10.4
	5	26.6	19.8		2	1.5	10
8/16/2021 21:18	0.2	28	21.5		3	1.8	9.9
	1	28.1	21.5	5/31/2022 22:38	0.2	15	21.9
	2	28.1	21.4		1	16.4	22.1
	3	28.5	20.4		2	19.6	20.4
9/10/2021 20:24	0.2	28.5	18.6		3	21.4	21.2
	1	28.8	18		4	22.8	22.5
	2	29.6	17.6				
	3	29.9	17.4				
	4	30	17.3				
	5	30.1	17.3				
10/12/2021 23:42	0.2	28.2	14.6				
	1	28.6	14.5				
	2	29.3	14.1				
	3	29.7	13.9				
	4	30.2	13.6				
	5	30.4	13.5				

The southern portion of the ERWA is generally saline (>20 ppt) year-round with occasional freshwater and moderately brackish conditions in the winter and spring (Table 2-11 to Table 2-15). These results may be skewed toward more saline conditions because measurements were generally conducted between storm periods, when flows were low. Salinity stratification was not detected at DFW-1 (the primary inlet to the ERWA) or in the smaller ditches. However, salinity stratification was measured in DFW-2, located at the central pond in the ERWA, and in the leveed main ditch, upstream of DFW-1 on the same day.

Table 2-. Salinity and temperature at DFW-1. No salinity stratification was detected. Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5-10 PSU, green), highly brackish (10–20 PSU), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)
7/15/2021 20:40	0.2	29.9	21.3	11/24/2021 18:45	0.2	21.9	10.0
	1	30.0	21.0		1	23.8	10.2
8/16/2021 20:44	0.1	29.7	20.6		2	24.5	10.2
	1	29.7	20.6	12/17/2021 21:57	0.2	4.3	8.3
	2	29.2	20.8		1	4.3	8.3
9/10/2021 21:30	0.2	33.4	15.6	2/24/2022 20:30	0.1	23.5	12.1
	1	33.4	15.6		1	23.7	9.9
	2	33.4	15.6	4/15/2022 22:12	0.2	7.8	11.8
	3	33.4	15.6		1	8.0	11.6
	4	33.4	15.6	5/31/2022 21:08	0.1	21.4	19.2
9/11/2021 0:07	0.2	32.9	17.5		1	22.9	18.4
	1	33.0	17.2		2	24.1	18.0
	2	33.1	17.1				
	3	33.2	17.0				

Table 2-. Salinity and temperature at DFW-2 (pond). Dates shaded in blue indicate measurements that detected salinity stratification (>5 ppt difference in the water column). Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5–10 PSU, green), highly brackish (10–20 PSU, purple), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)
7/15/2021 21:36	0.2	37.9	22.0	12/17/2021 22:43	0.2	8.6	8.3
	1	35.9	21.0		1	18.5	11.9
8/16/2021 23:30	<1	43.0	27.3	2/24/2022 21:05	<1	27	10
9/10/2021 23:45	<1	43.7	25.2	4/15/2022 23:04	<1	25.4	12.4
10/7/2021 20:11	<1	44.4	20.5	5/30/2022 21:55	<1	27.5	30.3
11/24/2021 19:08	0.2	21.6	8.2				
	1	22.8	12.1				

Table 2-6. Salinity and temperature at DFW T-Main. Dates shaded in blue indicate measurements that detected salinity stratification (>5 ppt difference in the water column). Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5-10 PSU, green), highly brackish (10–20 PSU, purple), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)
7/15/2021 22:06	<1	37.4	20.6	12/17/2021 22:22	0.2	2.3	9.6
8/16/2021 23:08	<1	37.5	26.6		1	10.0	9.2
9/10/2021 22:05	0	30.6	18.7	2/24/2022 20:52	<1	25.8	12.0
	1	31.5	17.8	4/15/2022 22:46	<1	24.3	12.8
	2	32.5	16.9	5/31/2022 21:40	<1	20.7	27.4
10/7/2021 20:33	<1	31.5	14.7				
11/24/2021 18:58	<1	18.5	9.0				

Table 2-7. Salinity and temperature at DFW T-Minor. No salinity stratification was detected. Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5–10 PSU, green), highly brackish (10–20 PSU, purple), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (ºC)
7/15/2021 22:06	<1	37.4	22.2	11/24/2021 18:59	<1	18.7	9.1
8/16/2021 23:11	<1	40.3	27.2	12/17/2021 22:22	1	10.5	9.3
9/10/2021 21:45	0.2	32.1	17.1	2/24/2022 20:50	<1	25.1	14.4
	1	32.2	17.1	4/15/2022 22:46	<1	23.5	13.7
	2	32.1	17.2	5/31/2022 21:41	<1	26.7	26.6
10/7/2021 20:21	<1	30.9	15.6				

Table 2-8. Salinity and temperature at DFW-Y. No salinity stratification was detected. Values are color coded as freshwater to slightly brackish (< 5 PSU, light blue), moderately brackish (5-10 PSU, green), highly brackish (10–20 PSU, purple), saline (>20 PSU).

Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (^{o}C)	Date/Time (UTC)	Depth (ft)	Salinity (ppt)	Temp (^{o}C)
8/16/2021 22:57	0.2	28.6	23.6	2/24/2022 20:40	0.2	24.1	11.0
	1	28.6	23.7		1	24.9	9.5
9/10/2021 21:45	0.2	32.9	16.4	4/15/2022 22:30	0.2	10.0	12.2
	1	32.9	16.4		1	12.5	12.2
	2	32.9	16.4	5/31/2022 21:23	0.2	18.0	21.2
	3	32.9	16.4		1	18.2	21.1
10/7/2021 20:49	<1	33.3	14.3				

2.2.2.3 Temperature

Temperature data was collected at all 5 continuous monitoring sites on the Elk River and Swain Slough, as well as spot measurements within the ERWA. Temperature data at continuous monitoring sites is reported as a 7-day average of the minimum, mean, and maximum temperatures at the monitoring sites and are simply referred to as minimum, mean, and maximum. The instantaneous temperature measurements are reported in ERWA.

Temperature monitoring at Elk River sites (ER-1, 2, 3) show a similar seasonal pattern (Table 2-16 and Figure 2-22). The warmest temperatures occur in the summer and the coolest temperatures occur in the winter. The difference between winter and summer mean temperatures is 8.5^{o}C at ER-1, 10^{o}C ER-2, and 6.6^{o}C at ER-3 (Table 2-16). A longitudinal pattern of warm temperatures downstream, and cooler temperatures upstream persists throughout the seasons (Table 2-16).

Temperature varied longitudinally with cooler sites upstream and warmer sites downstream. ER-1 and ER-2 sites have similar temperatures, with ER-1 slightly warmer than ER-2, with the exception of minimum and mean summer temperatures which were cooler at ER-1 (Table 2-16). The temperatures at ER-1 showed regular fluctuations in sync with changes in water level and air temperature, while ER-2 had smaller fluctuations related to water level.

The upstream most site, ER-3, is substantially cooler than downstream sites, likely due to the dominance of cooler freshwater from upstream, adjacent springs, and substantial shade provided by dense vegetation. These cooler temperatures persist during tidal backwater conditions that raise water levels to about 6.5 ft. Within this range, temperatures follow a typical diurnal cycle. Higher tides (above ~6.5 ft, NAVD88) push salt/brackish water to the site and a spike in salinity and temperature occurs (Figure 2-19).

In contrast to the longitudinal pattern of warming in the downstream direction observed in the Elk River, Swain Slough warms in the upstream direction. The downstream Swain Slough site (SS-1) mean temperatures track closely with ER-1 with slightly warm temperatures (Table 2-16), particularly in late spring of 2022 (Figure 2-22). SS-2 was consistently warmer than SS-1 and ER-1 during the summer, fall and spring periods.

Vertical temperature stratification at the monitoring sites of more than 1°C was unusual in the Elk River and the lower Swain Slough (SS-1) and was only documented once at ER-2 when there was strong vertical salinity stratification with cooler freshwater at the top of the water column (Table 2-7). In contrast, temperature stratification of more than 1°C occurred frequently at SS-2 (Table 2-9) with cooler water at the bottom of the water column and warmer water at the surface, consistent with more typical thermal stratification from solar radiation or air temperature.

Table 2-. Seasonal average of the seven-day daily minimum, mean, and maximum temperature values Elk River. Values shaded according to temperatures (<5˚C dark blue, 5-10˚C light blue, 10-15˚C green, 15-20˚C orange, and >20˚C red).

Site	Season	Seasonal average of daily temperature values (°C)		
		Minimum	Mean	Maximum
ER-1	Fall	9.4	13.8	14.6
	Spring	7.7	12.8	14.7
	Summer	13.7	18.3	20.4
	Winter	5.6	9.8	10.7
ER-2	Fall*	9.0	13.1	13.4
	Spring	7.5	12.5	13.4
	Summer	16.5	19.6	20.3
	Winter	5.5	9.6	10.2
ER-3	Fall	6.7	11.7	12.8
	Spring	7.0	10.4	11.2
	Summer	11.1	14.5	17.1
	Winter	4.5	8.1	8.7

Table 2-. Seasonal average of the seven daily minimum, mean, and maximum temperature values Swain Slough. Values shaded according to temperatures (<5˚C dark blue, 5-10˚C light blue, 10-15˚C green, 15-20˚C orange, and >20˚C red).

Site	Season	Seasonal average of daily temperature values (°C)		
		Minimum	Mean	Maximum
SS-1	Fall	8.9	13.9	15.3
	Spring	8.0	13.8	16.9
	Summer	13.1	18.4	21.0
	Winter	5.8	9.9	11.1
SS-2	Fall	5.7	14.0	15.2
	Spring	8.2	15.0	18.4
	Summer	14.9	20.0	22.5
	Winter	5.5	9.9	11.1

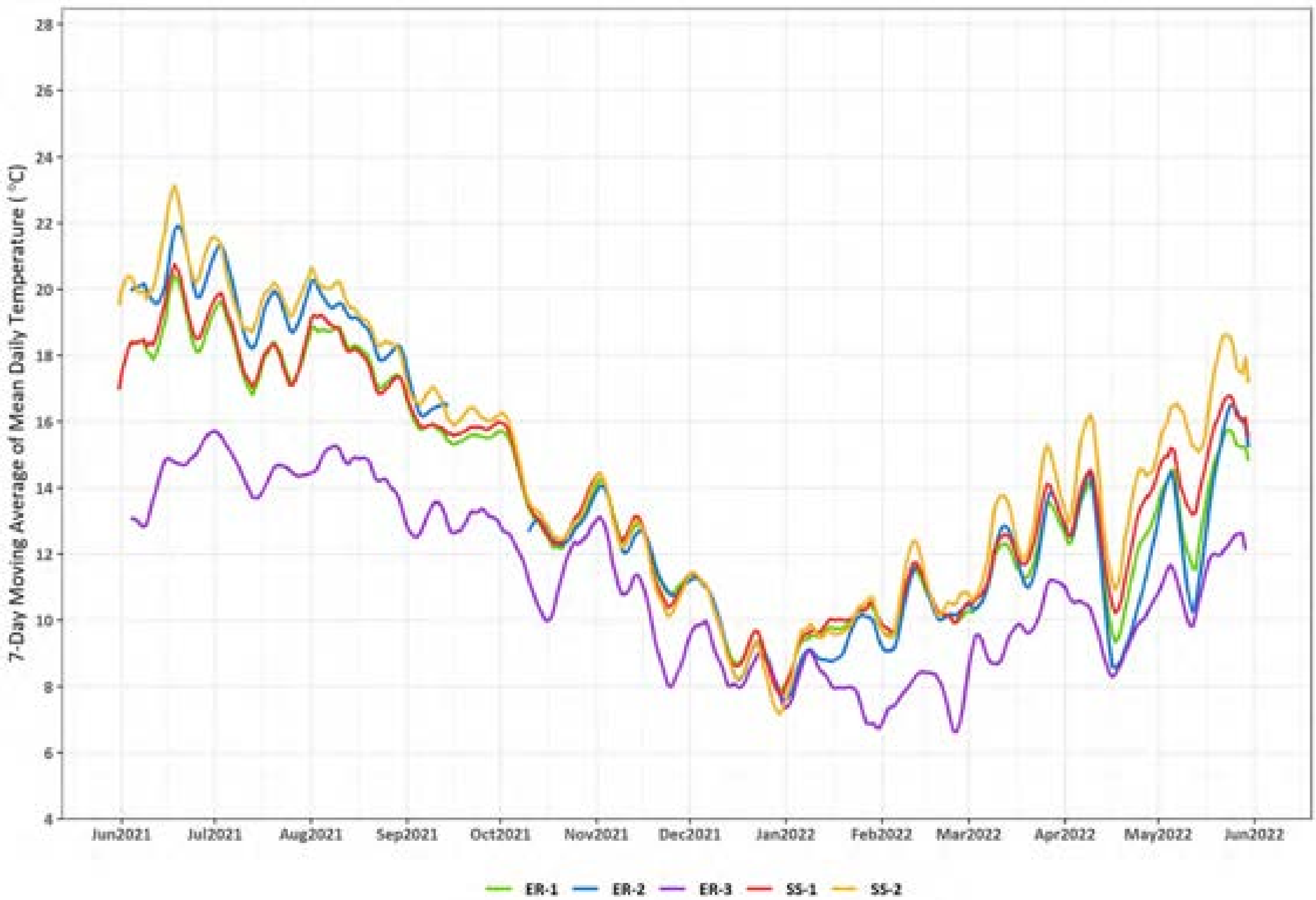


Figure 2-22. Seven-day mean temperature at continuous monitoring sites.

Spot measurements of temperature in the southern portion of the ERWA indicate that temperatures are generally warmer in the ERWA than in Elk River (Table 2-11 to Table 2-15). The central pond (DFW-2) (Table 2-12) can be considerable warmer (typically above 20°C and as high as 30°C) during the summer and fall. Temperatures cool in the winter and spring to less than 13°C. The primary leveed drainage channel (T-Main) (Table 2-13) is similarly warmer than the Elk River in the summer the channel with temperatures reaching 27°C. During the winter and early spring, temperatures are similar to Elk River.

2.2.3 Hydraulics

Please refer to section 3.5 and Appendix F for a detailed overview of existing condition hydraulics in PA-1.

2.3 Fish Utilization and Habitat

The lower reaches of coastal watersheds where streams transition into estuaries are particularly valuable for habitat restoration and recovery of anadromous salmonids (Jones et al. 2014, Wallace et al. 2015, Flitcroft et al. 2017), as well as the federally listed Tidewater Goby and state listed Longfin Smelt (Stillwater Sciences 2006, Garwood 2017). In addition to providing unique and productive habitats that promote life history diversity within a population, these reaches play an outsized role in influencing growth, survival, and population dynamics of anadromous species since the entire population of the watershed must pass through them (Koski 2009, Jones et al. 2014, Wallace et al. 2015).

Healey (1982) proposed the concept of "estuarine dependence" in which tidal marshes are considered a requisite rearing habitat for juvenile salmonids. Numerous studies have shown that favorable growth conditions in estuaries may enable juvenile salmonids to recruit disproportionately to the adult population compared to fish that rear in upstream habitats, because larger individuals have higher ocean survival rates (Beck et al. 2001, Ricker 2003, Miller and Sadro 2003, Bond 2006, Wallace et al. 2015). For example, the life-cycle monitoring station on Freshwater Creek operated by CDFW found that approximately 40% of the Coho Salmon smolts produced from the basin reared in the stream-estuary ecotone, and juveniles that reared in the stream-estuary ecotone were larger than those rearing in stream habitat upstream (Wallace et al. 2015)[3]. Factors hypothesized to contribute to the disproportionate success of estuarine reared fish include higher growth rates resulting from abundant invertebrate food and favorable water temperatures, suppressed predation resulting from high turbidity and deeper channels, and a favorable transition area for smoltification.

The amount and quality of fish habitat in Planning Area 1 has been significantly reduced by conversion of former tidelands to agricultural land uses. Much of the historically extensive tidal marshlands in lower Elk River are currently used for cattle and dairy ranching. Remaining habitat is impaired by sediment aggradation, flood control levees, and tide gates that reduce the tidal prism and impair fish movement into and out of sloughs and other off-channel areas. Elk River east of US Highway 101 is constricted by levees and the Northwestern Pacific railroad grade and lacks access to off-channel rearing habitats due to floodplain disconnection. Habitat in the stream-

[3] An ecotone is a region of transition between two biological communities; ecotones between two habitats are often richer in species than surrounding communities. The "stream-estuary ecotone" is the zone from the margin of Humboldt Bay where channels become surrounded by mudflats, upstream to the upper limit of tidal influence, at approximately the upper boundary of MSR 2.

estuary ecotone has been further simplified by removal or modification of streamside riparian vegetation. The impairment and loss of productive tidal marsh and estuarine rearing habitat has likely contributed to the acute decline of salmonid population abundance in the Elk River watershed (HBWAC 2005; NMFS 2014, 2016).

For this reason, restoring fish habitats in Planning Area 1 (the stream-estuary ecotone) is a key component of the overall strategy for recovering fish populations in the Elk River watershed. In this section, we summarize the known seasonal distribution and life history characteristics of focal fish species and (Section 2.3.1) and characterize existing fish habitat conditions in Planning Area 1 (Section 2.3.2).

2.3.1 Focal fish species

To support interpretation of the fish habitat assessment, a summary of observed seasonal utilization in lower Elk River, general estuarine life history, and preferred habitat characteristics are provided for each focal species in the sections that follow. The focus of the habitat assessment is on juvenile salmonids, but other special status species are also included. Focal species include Coho Salmon *Oncorhynchus kisutch*)., Chinook Salmon (*Oncorhynchus tshawytscha*), steelhead *Oncorhynchus mykiss*), Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*), Tidewater Goby (*Eucyclogobius newberryi*), and Longfin Smelt (*Spirinchus thaleichthys*).

In addition to these focal species, the Elk River tidal estuary provides habitat for numerous other species of native fish, amphibians, and invertebrates whose habitats have been diminished in the Elk River, and which could benefit from habitat restoration and enhancement. Over 30 species of fish have been documented in brackish portions of lower Elk River (M. Wallace, CDFW, unpub. data, 2005–2009).

2.3.1.1 Salmonids

Seasonal utilization of the lower (MSR1) and upper (MSR2) portions of the mainstem Elk River by juvenile salmonids is summarized in Table 2-18 based on monthly sampling conducted by Wallace and Allen (2009) during 2007 and 2008.

Table 2-9. Observed seasonal presence of juvenile salmonids in lower and upper portions of Planning Area 1. Based on seining and minnow trapping conducted by Wallace and Allen (2009).

Reach[1]	Species life stage[2]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Lower (MSR1)	Chinook Age-0												
	Coho Age-0												
	Coho Age-1												
	Steelhead Age-1+												
	Cutthroat Age-1+												

Reach[1]	Species life stage[2]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Upper (MSR2)	Chinook Age-0												
	Coho Age-0												
	Coho Age-1												
	Steelhead Age-1+												
	Cutthroat Age-1+												

1 The “Lower” and “Upper” reaches sampled by Wallace and Allen (2009) loosely coincide with MSR1 and MSR2, respectively.
2 Age class designations are based on fish length data provided by Wallace and Allen (2009).

Coho Salmon

Based on multi-year sampling of Humboldt Bay tributaries, including lower Elk River, Wallace et al. (2015) described three life history strategies employed by juvenile Coho Salmon in the stream-estuary ecotone, including (1) young-of-year (age-0) fish that arrive in the spring soon after emergence and reside primarily in the upper portion of the stream-estuary ecotone during the summer and early fall; (2) age-0 juvenile coho that migrate to the stream-estuary ecotone in the fall as stream flows rise and rear in adjacent off-channel and tributary habitats during the winter and following spring; and (3) age-1 smolt that emigrate through the stream-estuary ecotone in spring after rearing primarily in upstream riverine reaches. These findings are consistent with timing of Coho Salmon utilization observed during intensive monthly sampling conducted in lower Elk River (Wallace and Allen 2009; Table 2-18). Variations of these life history strategies, including overwintering in adjacent non-natal streams or moving upstream out of the lower mainstem reaches to overwinter, may also occur (Miller and Sadro 2003, Koski 2009, Jones et al. 2014).

Recent monitoring in Martin Slough—where no Coho Salmon spawning habitat is thought to exist—indicates significant numbers of juvenile Coho Salmon from Elk River pass through lower Elk River and Swain Slough before rearing in Martin Slough during winter rearing and spring (Allen et al. 2016, Wallace et al. 2018, Natural Resources Services 2022). Juvenile Coho Salmon were documented in these habitats during every month of monitoring, which was conducted from November through May, but were most abundant from February through April (Natural Resources Services 2022). Notably, some juvenile Coho Salmon from other Humboldt Bay tributaries move into lower Elk River on their way to the ocean. In late-May 2008, Wallace and Allen (2009) captured two age-1 Coho Salmon that were tagged in Freshwater Creek, one in early April and one in early May. Restoration of more diverse and connected tidal wetlands and off-channel habitats in the stream-estuary ecotone may also promote additional life history diversity, as has been observed following large scale estuarine restoration (Flitcroft et al. 2016).

The physical habitat characteristics preferred by Coho Salmon in the stream-estuary ecotone are generally the same as in upstream fluvial reaches, with most individuals inhabiting areas with low-velocity habitats with escape cover. For example, in an intensive study of coho salmon estuarine habitat use, Tschaplinski (1987) found that at low tide the largest number of age-0 coho in locations with water velocity <1 ft/s (but on average 0.3 ft/s), pools with depths ranging from about 1.5–7 ft, and escape cover provided by large logs and rootwads or undercut banks, often containing overhanging vegetation.

Salinity is also expected to be a primary factor driving seasonal utilization and distribution patterns of Coho Salmon and other fish in Planning Area 1 and other stream-estuary ecotones (Otto 1971, Wallace and Allen 2009, Koski 2009, Flitcroft et al. 2016). Pre-smolt juvenile Coho Salmon in the lower reaches of Humboldt Bay tributaries have primarily been documented rearing in habitats <5 ppt (Wallace and Allen 2009). However, laboratory studies of Coho Salmon indicate salinity tolerance increases substantially after being acclimated to dilute salinities and increases with size, with juvenile coho surviving (near 100% survival) salinities of approximately 20 ppt during the spring through fall and 25 ppt in the winter (Otto 1971). Despite the ability to tolerate these higher salinities, in these lab studies, growth was inhibited at values greater than about 10 ppt (Otto 1971). Various other studies indicate that Coho Salmon can survive and grow rapidly in estuarine areas prior to undergoing transformation to the smolt stage (Tschaplinski 1987, Koski 2009).

Chinook Salmon

As with Coho Salmon, Chinook Salmon have been shown to display a wide range of juvenile life history strategies (Bouret et al. 2016), but most fall Chinook Salmon rearing in coastal California streams primarily display the ocean-type life history where juveniles migrate to the estuary within weeks or months of emergence from redd gravels (Reimers 1971, Healey 1991). Fall Chinook Salmon fry generally emerge from redd gravels from March to May and spend several weeks or months in freshwater before outmigrating to the estuary (Reimers 1971, Healey 1991). The species is largely dependent on estuarine and tidal marsh habitats, where they typically feed and grow for extended periods before migrating to sea (Reimers 1971, Healey 1991, NMFS 2016). In the Elk River, Wallace and Allen (2009) documented juvenile Chinook Salmon in the stream-estuary ecotone from May–September, with August and September observations occurring only in MSR1 (Table 2-18). A small number of juvenile Chinook Salmon were documented in Martin Slough in May 2017 during regular monthly sampling (Wallace et al. 2018); however, no individuals were captured during similar sampling conducted from 2014–2016 (Allen et al. 2016 and Wallace et al. 2018) and 2020–2021 (Natural Resources Services 2022). No Chinook Salmon spawning habitat exists in Martin Slough, which means any individuals rearing there originated in Elk River and passed through lower Elk River and Swain Slough to reach Martin Slough.

In the Salmon River estuary of Oregon, Bottom et al. (2005) identified a range of juvenile Chinook Salmon migration strategies, including (1) individuals that entered the estuary and tidal marsh habitats in the early spring, soon after emergence; (2) juveniles that reside in fresh water for several months, enter the estuary in June or July and remain for several weeks to several months before entering the ocean; and (3) juveniles that enter the estuary in the fall after and reading primarily in upstream freshwater reaches. This long-term study found that estuarine wetland restoration increased variation in estuarine rearing strategies, enhancing overall life history diversity and resilience of Chinook Salmon in the watershed (Bottom et al. 2005).

Characteristics of preferred estuarine rearing habitats for Chinook Salmon have not been well described, but the species appears to utilize salt marshes, tidal sloughs, and mainstem portions of the estuary (Reimers 1971, Bottom et al 2005, Hering et al. 2010). Reimers (1971) found that in early spring most juvenile Chinook Salmon in the Sixes River estuary in Oregon were near shore and associated with logs and debris, but by June, they were more widespread throughout the estuary (not just near shore). Levy and Northcote (1981, as cited in Healy 1991) found that in that juvenile Chinook Salmon were more abundant in tidal channels that had lower banks and provided cover during low tide. Hering et al. (2010) documented extensive movement of juvenile

Chinook Salmon between large tidal slough and a smaller tidal channel leading to tidally flooded salt marsh habitat. Movement into the smaller channel generally peaked during mid- to late flood tides (i.e., 1–2 h before high tide) and movement out of the channel peaked late during ebb tides (i.e., 3–4 h after high tide). Little movement occurred when water depth was less than approximately 1.3 ft. This study indicates that juvenile Chinook Salmon in the estuary move frequently in response to tidally driven habitat conditions. In general, Chinook Salmon fry can initially tolerate salinities less than 20 ppt and osmoregulatory capabilities increase rapidly as individuals are exposed to brackish water (Healey 1991).

Steelhead

Like Coho and Chinook salmon, steelhead display diverse juvenile life history strategies and have been shown to extensively utilize habitats in stream-estuary ecotone (Shapovalov and Taft 1954, Barnhart 1991, Bond et al. 2008, Hayes et al. 2008). Steelhead can grow rapidly in the estuary, and the component of the population rearing in these habitats can contribute disproportionately to the returning adult population (Bond et al. 2008, Hayes et al. 2008). Depending partly on growing conditions, steelhead may migrate downstream to estuaries as age 0+ juveniles or may rear in streams for two or more years before outmigrating to the estuary and ocean (Shapovalov and Taft 1954). Steelhead migrating downstream as juveniles may rear for one month to a year in the estuary before entering the ocean (Shapovalov and Taft 1954, Barnhart 1991). In lower Elk River Wallace and Allen (2009) documented age 1+ juvenile steelhead in all months except November but captures in MSR1 were concentrated in the spring (Table 2-18). Small numbers of juvenile steelhead have been documented in Martin Slough during recent intensive sampling, but only in 2 of 6 years sampled (Allen et al. 2016, Wallace et al. 2018, Natural Resources Services 2022). These individuals were captured in April and May. Due to the lack of steelhead spawning habitat in Martin Slough, these individuals likely originated in Elk River and had to pass through Swain Slough to reach Martin Slough.

Characteristics of preferred estuarine rearing habitats for steelhead have not been well described, But are presumably similar to other salmonids in that they require sufficient escape cover and velocity refugia during higher flows. Recent research shows that juvenile steelhead can exhibit diel movements within estuaries in response to temperature and dissolved oxygen patterns, with movement to upper estuary habitats at dawn and movement to lower estuary habitats at dusk (Bond et al. 2021).

Coastal Cutthroat Trout

Coastal Cutthroat Trout display a wide array of life history strategies, with significant variation in migratory behavior between and among populations (Moyle et al. 2015). In rivers, this life history diversity can loosely be divided into three main groups: (1) anadromous (sea-run) life history, (3) potadromous (migratory within freshwater portions of the river system), and (4) stream-resident. The various life history forms require a wide diversity of marine, estuarine and freshwater habitats to exploit food and survive. Sea-run cutthroat trout migrate upstream to spawn in freshwater, but they are not strictly anadromous because they can make numerous movements back and forth between fresh and salt water to feed. For this reason, they are heavily reliant on estuaries and can spend prolonged periods (months) there, often moving in and out of fresh water, likely in response to feeding opportunities and rearing habitats (Moyle et al. 2015). Coastal Cutthroat trout have similar habitat requirements to those of resident Rainbow Trout and steelhead.

Because of their diverse life histories and frequent movements, Coastal Cutthroat Trout can be found in the in estuaries and the lower reaches of streams throughout the year. In Elk River, Wallace and Allen (2009) captured the species in MSR2 in all months except February and

March, but in MSR1 they only captured them from May through July (Table 2-18). All individuals captured ranged in length from about 130 millimeter (mm) (5 in) to >300 mm (12 in), indicating that they were age 1 or older. Small numbers of Coastal Cutthroat Trout have also been captured during all seasons of sampling of Martin Slough (Allen et al. 2016, Wallace et al. 2018, Natural Resources Services 2022).

2.3.1.2 Non-Salmonid focal species

Tidewater Goby

Tidewater Goby are a small, short-lived (generally 1 year), estuarine-adapted fish that can tolerate large temperature and salinity ranges (Swift et al. 1989; Tetra Tech, Inc. 2000). The species generally requires stable lagoon or off-channel habitats, particularly during their relatively short larval stage (Lafferty et al. 1999a, Chamberlain 2006). Tidewater Goby are highly susceptible to predation by piscivorous fish and amphibians, especially introduced species (Stillwater Sciences 2006).

Tidewater Goby utilize the stream-estuary ecotone throughout their life cycle. During the juvenile and adult life stages, preferred habitat consists of low-velocity (but not stagnant), shallow water in seasonally disconnected or tidally muted lagoons, estuaries, and sloughs. Juveniles and adults can be found year-round, although they are most abundant in summer and fall. Tidewater Goby can be flushed downstream during high flow events, but can persist in low-velocity refugia habitat, which generally consists of off-channel sloughs and wetlands (Lafferty et al. 1999b). Substrate preference for juvenile and adult rearing is sand, mud, gravel, and silt, particularly associated with submerged vegetation. Which is likely used for cover (Stillwater Sciences 2006). Juvenile and adult Tidewater Goby are reported to prefer water temperatures of 12–24ºC (54–75°F) within a range of 6–25ºC (42–77°F) (Stillwater Sciences 2006). Juveniles and adults generally prefer salinities <15 ppt, but have been documented in waters ranging from 0–51 ppt (Stillwater Sciences 2006). Juvenile and adult Tidewater Goby appear to prefer shallow depths (< 1 m [3 ft]) near emergent vegetation, possibly to avoid predation by wading birds and piscivorous fish (Moyle 2002).

Reproduction and spawning typically occur during spring and summer in shallow, slack waters of seasonally disconnected or tidally muted lagoons, estuaries, and sloughs. Males dig burrows and guard eggs, most commonly in early spring and late summer in some areas (Stillwater Sciences 2006). Larvae, eggs, and males in burrows are likely less tolerant of floods, lagoon breaching, or strong tidal exchange. Preferred water temperatures during reproduction are 15–24°C (59–75°F), with a range of 2–27°C (36–81°F) (Stillwater Sciences 2006). Preferred salinities during spawning are generally <15 ppt, but range from 5–25 ppt (Stillwater Sciences 2006). Preferred depths for reproduction range from approximately 0.2 m to 1 m (0.7–3.3 ft) and preferred substrates appear to be sand, coarse sand, and sand/silt (Stillwater Sciences 2006).

Although Tidewater Goby are tolerant of a wide range of habitat conditions, they are generally most abundant and persist in habitats with a narrower range in habitat parameters during specific life stages (Stillwater Sciences 2006). Physical structure and location of Tidewater Goby habitat may be more important to their survival and persistence than specific water quality parameters (Chamberlain 2006). Persistence of Tidewater Goby populations is greatest in large wetlands and distance between extirpated habitats and larger wetland source populations affects dispersal and potential for recolonization (Lafferty et al. 1999a,b). Flood and breaching events can result in dispersal between disconnected estuarine habitats, although low survival likely limits dispersal (Stillwater Sciences 2006).

Seasonal distribution and relative abundance of Tidewater Goby in lower Elk River and Swain Slough is not well described. No Tidewater Goby were captured, during multiple years of seining at several sites in MSR1 and the lower portion of MSR2 (M. Wallace, CDFW, unpub. data, 2005–2009). However, large numbers of Tidewater Goby were captured during in restored habitats in Martin Slough during monthly sampling conducted in fall, winter, and spring (Natural Resources Services 2022).

Longfin Smelt

Longfin Smelt (LFS) were listed as threatened under the California Endangered Species Act in 2009 (CDFG 2009). This euryhaline, anadromous species exhibits complex life history patterns, using a variety of habitats during its approximately 2-year life cycle, from nearshore waters to estuaries and the stream-estuary ecotone (Rosenfield 2010, Garwood 2017). LFS live along the Pacific Coast of North America from Prince William Sound, Alaska to the San Francisco Estuary (Rosenfield 2010). In Humboldt Bay, LFS have been documented in all the major tributaries including Mad River Slough, Jacoby Creek, Freshwater Slough, Elk River, and Salmon Creek (Garwood 2017). In lower Elk River, the species was documented in MSR1 from January–March 2016 (M. Wallace, CDFW, unpub. data, 2006; Garwood 2017). The life stage of these individuals was not reported. LFS were not reported from other recent monitoring efforts in lower Elk River and Martin Slough (Wallace and Allen 2009, Allen et. al 2016, Wallace et al. 2018), but juvenile smelt of unknown species were reported in Martin Slough from late fall through spring (Natural Resources Services 2022).

Except for an unpublished larval LFS study conducted by CDFW between 2016–2018, information on the life history of the species in the Humboldt Bay region is limited relative to the San Francisco Estuary where it has been well studied (Rosenfield 2010, Garwood 2017). For this reason, the life history description presented draws heavily on information from the San Francisco Estuary (including the Sacramento-San Joaquin Delta) synthesized by Moyle (2002) and Rosenfield (2010).

LFS, which are semelparous, are thought to spawn in or near the mixing zone between fresh and brackish water in the upper portions of the estuary. Evidence from the Sacramento-San Joaquin Delta suggests spawning locations likely shift depending on freshwater inflow entering the stream-estuary ecotone (Rosenfield 2010). LFS eggs are adhesive and are thought to be deposited on sandy and gravel substrates. Eggs are deposited from late-fall to early spring, and generally incubate at water temperatures of about 7–15°C (Moyle 2002). LFS were not captured in Elk River during 2016–2018 sampling of Humboldt Bay tributaries, but based on capture of larvae in nearby Freshwater Creek, spawning likely occurred from late December through February or early March in those years (J. Ray, CDFW, pers. comm., 10 August 2022). In Freshwater Creek, based on larval capture locations, spawning likely occurred in fresh water near the upper extent of tidal influence (J. Ray, CDFW, pers. comm., 10 August 2022).

The embryo incubation period for LFS is thought to be from about 4–6 weeks, depending on water temperature (Moyle 2002). Salinity requirements for developing eggs are not well described, but the distribution of sexually mature adults in or close to fresh water suggests lower salinities are required for egg development (Moyle 2002, Rosenfield 2010). After hatching from eggs, the small (5–8 mm) larvae are buoyant and generally distributed near the surface of the water column in fresh and brackish waters (Moyle 2002, Rosenfield 2010). Larval LFS have a relatively low salinity tolerance and are most closely associated with salinities of 2 ppt. Upper salinity tolerance is not well described, but larval abundance rapidly declines with increasing salinities up to 15 ppt (Moyle 2002, Rosenfield 2010). Larvae can be detected over a protracted period, but they are most common in the winter and spring. In lower mainstem Freshwater Creek, in 2016 and 2017, recently hatched (6–7 mm) larval LFS were captured from mid-January through mid- to late March, with peak capture in late January and early February (J. Ray, CDFW, pers. comm., 10 August 2022). Larvae are weak swimmers and susceptible to transport to locations with unsuitable environmental conditions (e.g., high salinities) by stream flows and tidal currents (Moyle 2002, Rosenfield 2010).

Metamorphosis from the larval to juvenile form, which is strongly influenced by water temperature, may begin as quickly as 15 days post-hatch but more commonly requires 3 months. Juvenile and pre-spawning adult LFS are widely distributed throughout the year in brackish and marine environments. Juveniles and pre-spawning adults can be found across a wide range of salinities, from fresh water to pure sea water, but they generally prefer salinities from 15–30 ppt. During the summer, they can inhabit water as warm as 20°C, but generally select 16–18°C. In the Sacramento-San Joaquin Delta, both juveniles and adults are typically found at greater densities in deeper habitats (>7 m) relative to shallower habitats. Juveniles and adults appear to migrate seasonally, downstream during summer months and upstream in the late-fall and winter. Adults are thought to become sexually mature as they migrate towards spawning locations.

2.3.2 Fish habitat characterization

This section describes existing fish habitat conditions in Planning Area 1, with an emphasis on characterizing juvenile salmonid rearing habitat. The assessment focuses on juvenile summer and winter salmonid rearing habitats since spawning habitat is not present in the low gradient and fine sediment dominated channels of the stream-estuary ecotone. Field assessments of physical habitat conditions for salmonids were conducted during both the dry (summer habitat) and wet (winter habitat) seasons to help understand habitat factors limiting salmonid population productivity and identify opportunities for and constraints to restoring fish habitat. Results from salinity and water temperature monitoring (Section 2.2.2) are also summarized as they relate to water quality constraints on fish utilization in Planning Area 1.

In most of Planning Area 1, clear geomorphic habitat units could not be identified due to the channelized, tidally influenced, and relatively homogeneous nature of the channel (uniform width, depth, and substrate). For this reason, traditional mesohabitat typing (e.g., pool, riffle, flatwater) was not feasible. Thus, for the purposes of characterizing and describing fish habitat conditions, the main channels of lower Elk River (MSR1 and MSR2) and Swain Slough (SS) were delineated into channel segments based on tributary and off-channel habitat junctures, unique geomorphic or riparian characteristics, or other notable changes in channel conditions (Figure 2-23). These segments ranged in length from approximately 400 ft to 2,500 ft. Primary off-channel features connected to the main channels of Elk River and Swain Slough were also identified and characterized and are shown in Figure 2-23.

Figure 2-23. Channel segment used to characterize fish habitat in Planning Area 1.

Summer rearing habitat for salmonids was assessed from September 28 through October 1, 2021, when stream flow was representative of typical late-summer and early fall habitat conditions. A mix of boat and bank surveys were used to access channels in the planning area in both summer and winter. The summer habitat assessment focused on describing relative quantity of escape cover for juvenile salmonids and other fish in each channel segment provided by water depth, overhanging terrestrial vegetation, aquatic vegetation, large wood, small woody debris, and other cover elements. Observations and notes on relative level of canopy cover, presence and relative quantity of large wood, water velocity, tidal influence, and other fish habitat characteristics were also collected. Notes on anthropogenic disturbances and restoration opportunities and constraints were also recorded. GPS coordinates were collected at the downstream boundary of each channel segment and representative photographs of channel characteristics and physical habitat conditions were taken.

Salmonid winter rearing habitat was assessed from January 12–14, 2022, during a relatively dry period with a relatively low winter base flow (Section 2.2.2.1). The winter assessment focused on characterizing relative quantity and quality of low-velocity winter rearing habitat for juvenile Coho Salmon and other salmonids, including: (1) availability of in-channel low-velocity habitat; and (2) level of connectivity with off-channel features such as alcoves, side channels, and adjacent tidal marshes and floodplains. The degree of off-channel habitat connectivity was qualitatively characterized at representative locations by observing inundation of off-channel features at the surveyed flow and tidal stage and by assessing potential for inundation at higher streamflows and tides. Information from the geomorphic (Section 2.1) and surface water assessments (Section 0) were also used to help characterize off-channel winter habitat conditions in the planning reach and ascertain restoration potential.

For summarizing fish habitat conditions herein, river and slough channels and adjacent off-channel habitats within Planning Area 1 were subdivided into the following areas, each of which is characterized in the sections that follow:

- MSR1 – the lowest reach of mainstem Elk River that is dominated by saline or brackish water. The assessed portion of MSR1 includes main channel segments ER1–ER9.
- MSR2 – the reach of mainstem Elk River upstream of MSR1 that is tidally influenced but dominated by fresh water and includes main channel segments ER10–ER13.
- Swain Slough – the primary slough channel that enters the Elk River estuary at the HWY 101 bridge and includes main channel segments SS1–SS6 and other ditches or off-channel features draining into Swain Slough.
- Other – other assessed off-channel features and tributaries.

2.3.2.1 MSR1

Approximately 2 miles of mainstem Elk River were assessed within MSR1, from the HWY 101 bridge upstream to the MSR2 boundary (Figure 2-24). In general, MSR1 is characterized by a broad, homogenous tidal slough channel with a high width-to-depth ratio, silt-dominated bed substrate, and near vertical banks associated with constructed levees along significant portions of the reach (Section 2.6, Appendix A). Throughout much of MSR1, the channel is confined by these levees, limiting natural channel processes and connectivity with relic slough channels, tidal marshes, and other off-channel habitats. Wetted borrow ditches run along most of the levees on the side opposite from the main channel. These ditches are channelized and have infrequent connections with the main channel, but in some places may function like tidal slough channels (e.g., ER1.1). Channel width in MSR1 gradually decreases in the upstream direction, ranging from approximately 150 ft in ER1 to 40 ft in ER9. MSR1 can experience daily tidal fluctuations of 4–8 ft (Section 2.2.2), which has significant bearing on habitat conditions and fish utilization patterns in the reach. For example, many of the higher quality rearing habitats that provide low velocities, escape cover, and feeding opportunities are associated with channel margins, alcoves, inset benches, and tidal sloughs, and these habitats may become dewatered or too shallow to support salmonid rearing during lower tidal stages. Because of tide-driven temporal shifts in habitat characteristics, fish are likely to move to find suitable rearing habitats at different tidal stages. The area of suitable salmonid rearing habitat in MSR1 is generally expected to be greatest at higher tidal stages and diminish at lower stages. Studies in other estuaries indicate that available habitat during low tides likely limits fish carrying capacity (Tschaplnski 1987). For this reason, providing rearing habitat and cover at lower tides is an important consideration for habitat restoration in MSR1.

Summer habitat

In channel segments ER1–ER4 (the lower 4,720 ft of the assessed portion of MSR1), quality of physical summer rearing habitat for salmonids, Tidewater Goby, and other fish is, in general, relatively poor due to the homogenous and straight channel, steep banks, limited hydraulic and depth complexity, and lack of in-channel and riparian cover (Figure 2-24). In ER1–ER4, other than some shallow, grassy margins and small bank indentations along the main channel that are wetted during higher tides, the primary habitats with escape cover and lower velocities are associated with the ER.1 ditch network, alcove-like features present where drainage ditches enter the channel (e.g., ER2.1, ER2.2, ER3.1, ER4.1), and a single, small island at the upstream end of ER3. A network of partially wetted drainage ditches, relic slough channels, and depressions occurs throughout the ERWA adjacent to MSR1. These channels connect to the Elk River via tide gates at ER2.1, ER2.2, and ER3.1, but tidal exchange and fish access to these features are limited by dilapidated tide gates and low habitat complexity along with high salinities would limit juvenile salmonid rearing in these ditches during the summer (Section 2.2.2; Table 2-12 and Table 2-13). It was not possible to view the entire channel at the surveyed tide due to depth and turbidity, but except for a few pieces of submerged large wood observed in ER4, very little in-channel cover was observed in channel segments ER1–ER4. Additionally, no canopy cover or significant escape cover from riparian trees was observed. Because of the simplified channel and minimal off-channel habitat connectivity, high water velocities during higher ebb and flood tides may limit overall capacity of the channel to support juvenile Coho Salmon and other fish during the summer.

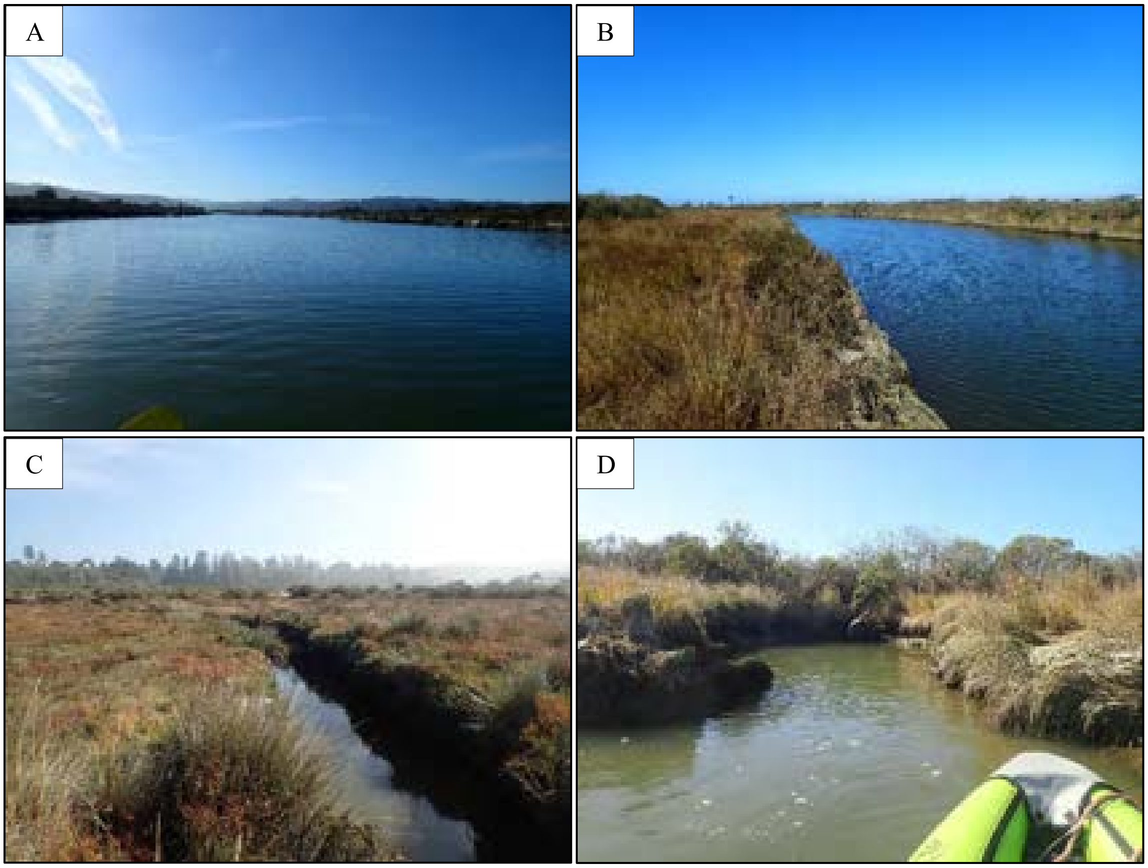


Figure 2-24. Photos from September 2021 showing representative main-channel summer fish habitat conditions in ER1 (A) and ER4 (B) and examples of accessible off-channel habitat features in ER1.1 (C) and ER3.1(D). Note: tidal stage was relatively high when these photos were taken.

In channel segments ER5–ER7, overall fish habitat quantity and quality continues to be limited by the simplified, straight channel bordered by relatively steep banks and limited off-channel habitat. Main-channel salmonid summer rearing habitat quality improves somewhat relative to ER1–ER4 due to long patches of continuous riparian trees with overhanging branches on the right bank of ER5 and ER6 and on the left bank of ER7. These branches provide both overhead and in-channel escape cover for juvenile fish (Figure 2-25). Based on observations during the winter survey, which was conducted at a lower tidal stage than the summer survey, the area of suitable salmonid rearing habitat provided by these overhanging branches is expected to be greatest at higher tidal stages, when they and the few gradually sloping banks become more inundated. It was difficult to fully assess in-channel cover at the surveyed tide due to depth and turbidity, but other than several pieces of submerged large wood in ER7, most cover was associated with channel margins (branches from live trees and grasses).

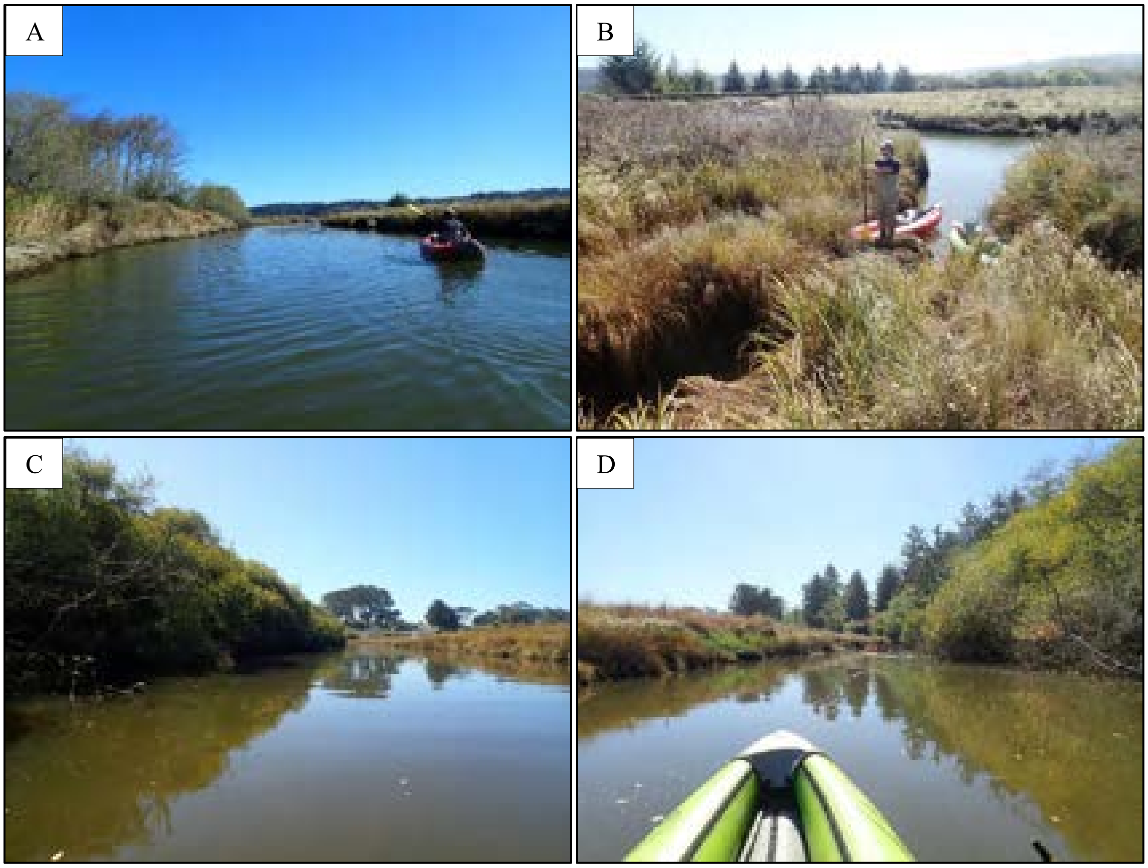


Figure 2-25. Photos from September 2021 showing representative main-channel summer fish habitat conditions in ER5 (A), an alcove habitat associated with a tide gate at ER5.1 (B), and examples of overhanging riparian cover in ER6 (C) and ER7 (D). Note: tidal stage was relatively high when these photos were taken.

In channel segments ER8–ER9 (the upper 2,260 ft of MSR1), overall quality of summer rearing habitat for salmonids increases substantially due the presence of thick riparian trees with complex overhanging and in-channel branches on one or both banks (Figure 2-26). Additionally, several pieces of in-channel large wood that provide high quality habitat were observed in both ER8 and ER9. The channel in these segments is still relatively homogeneous, with steep banks on both sides and is narrower and deeper relative to downstream segments. In many places, overhanging branches provide shade and escape cover for fish across much of the narrow channel. However, in several sections of the right bank of in both ER8 and ER9, the riparian zone is interrupted by several long areas of grassy bank with few trees and little fish cover. No connected alcoves, tidal sloughs, or other features that provide flow refugia or off-channel rearing opportunities were documented in ER8 or ER9. A seasonally wetted drainage ditch, ER9.1, enters Elk River at the ER8/ER9 boundary via a tide gate, but is not currently accessible to fish. This location, which historically had a connected tidal slough channel (Figure 2-3), is fed by springs/seeps draining the hillslope. As described below, if restored, it has potential to provide high quality off-channel rearing habitat.

Overall, suitable habitat for Tidewater Goby is limited in MSR1 because the species requires relatively stable and shallow low-velocity habitats in connected off-channel sloughs and wetlands. The primary habitats with potential to support Tidewater Goby under existing conditions are associated with the ER.1 ditch network and alcove-like features present where drainage ditches enter the channel (e.g., ER2.1, ER2.2, ER3.1, ER4.1, ER5.1, ER6.1). Additionally, many of existing, but largely disconnected, ditches and relic slough channels in the ERWA have potential to provide high quality goby habitat if restored. The drainage ditch and relic slough associated with ER9.1 also has potential to provide goby habitat if reconnected.

Figure 2-26. Photos from September 2021 showing a steep, grassy bank on the right bank of ER8 and overhanging riparian branches on the left bank (A) complex overhanging and in-channel tree branches on a near-vertical bank in ER8 (B), and section of ER9 with patchy riparian on both banks (C).

Winter habitat

The same channel characteristics that limit summer rearing habitat quality for salmonids and other fish in much of MSR1 (homogenous and straight channel, steep banks, limited hydraulic and depth complexity, lack of in-channel cover) also limit winter rearing habitat quality. MSR1 has minimal in-channel velocity refugia, limited escape cover, and lack of connected off-channel rearing habitat.

At the relatively low stream flow and moderate tidal currents surveyed, small areas of relatively low-velocity habitat (<1.0 ft per second) were observed along the channel margins and the few alcove-like habitats present in MSR1. However, because of the straight channel, with relatively steep banks, and very little large wood, even moderate winter and spring high-flow events are expected to produce in-channel water velocities that exceed values needed by Coho Salmon for rearing (<0.6 ft per second ft/s; Beecher et al. 2002). Lack of in-channel cover and velocity refugia is also expected to restrict suitable habitat area for other fish species in the reach during higher flows.

The primary areas with potential to provide velocity refugia during higher stream flows include (1) the ER.1 ditch network, the alcove-like features present where drainage ditches enter the channel (e.g., ER2.1, ER2.2, ER3.1, ER4.1, ER5.1, and ER6.1 (2) small areas in ER6, ER7, ER8, and ER9 that have both relatively gradual slopes and complex, overhanging, in-channel riparian branches or large wood along the bank, and (3) the few pieces of in-channel large wood big enough to potentially provide small areas of low velocity habitat (Figure 2-25). A series of 20–40 ft wide "inset benches" (bounded by levees) located along the right bank in ER3 and ER5 have gradual bank slopes (after an initial step up from the active channel). These sites may also provide velocity refugia when they are flooded during higher flows (Figure 2-27).

The network of drainage ditches, relic slough channels, and depressions in the ERWA have potential to provide large areas of high-quality winter refugia and rearing habitat depending on flow and tidal stage, but the current habitat is generally in poor condition. Additionally, as described above, ER9.1 is not currently accessible to fish, but if restored, has potential to provide a large area of high-quality, off-channel salmonid winter rearing habitat. During the relatively dry winter period, a significant amount of fresh water was observed entering the ditch via the adjacent hillslope, which would help maintain water quality at the site if it were made accessible to fish (Figure 2-28).

Figure 2-27. Examples of locations in MSR1 that have potential to provide high flow refugia for fish in MSR1, including connected borrow ditch at ER1.1 (A), large alcove associated with ER2.2 (B), large wood along both channel margins in ER7 (C), relatively gradually sloped bank with in-channel willow branches in ER9 (D), and inset bench on right bank in ER5 (E).

Figure 2-28. Photo from January 2022 showing the lower portion of the drainage ditch at ER9.1.

Water quality

Despite the presence of suitable physical habitat for juvenile salmonid rearing in MSR1, utilization of this reach is likely seasonally limited by high salinities and water temperatures. Continuous water temperature and salinity data collected in MSR1 in 2021 and 2022 (Section 2.2.2) provide an indication of seasonal suitability for salmonids and other fish species. MSR1 is characterized by brackish water, with channel bottom salinities varying from about 20–30 ppt during the dry season and ranging from about 0–26 ppt during wetter periods, with lower values associated with higher flows during lower tides. In general, high salinities are expected to inhibit most rearing by non-smolt juvenile salmonids during much of the dry season. Results of fish monitoring conducted in the reach confirm that few rearing juvenile salmonids use MSR1 during the summer and early fall, except for Chinook and Coho smolt, which have higher salinity tolerances than fry and parr (Wallace and Allen 2009; Table 2-18).

During wetter periods in the winter and spring, salinities in MSR1 can be low enough to support juvenile salmon rearing and it is likely that some individuals move in and out of this reach in response to fluctuating salinities resulting from variable flows and tides. Additionally, during both wet and dry seasons, significant salinity stratification can occur, with the surface layer having considerably lower salinities relative to the channel bottom (where the continuous data were collected). For example, at the water quality monitoring site ER-2 (channel segment ER6), spot-measured salinity in September 2021 was 13.7 ppt near the surface and 27 ppt near the bottom. At the same site, in both February and late-May 2022, salinity was about 3 ppt near the surface and 27 ppt near the bottom. It is likely that the presence of less saline surface layers allows juvenile salmonids to acclimate to higher salinities and rear in or move through the reach prior to undergoing smoltification.

Water temperatures in MSR1 generally remain below levels tolerated by juvenile Coho Salmon and other salmonids (approximately 18°C), but in 2021, daily mean temperatures exceeded 20°C and daily maximums exceeded 22–24°C at monitoring sites ER-1 and ER-2 during June and July. Additional temperature monitoring in the reach would be valuable to understand whether these higher values occur in other water years. Limited depth stratified spot measurements indicate thermal stratification can occur in MSR1 during some periods, with surface values from 2–4°C cooler than bottom values during some (but not all) measurements.

2.3.2.2 MSR2

Approximately 1 mile of mainstem Elk River and adjacent off-channel features were assessed for fish habitat in MSR2 (Figure 2-21). In general, MSR2 is considered the upper part of the stream-estuary ecotone and is tidally influenced at stages greater than about 4 ft but dominated by fresh water. Similar to upstream reaches, MSR2, which is dominated by homogeneous silt-sand substrates, has been impacted by channel and habitat simplification resulting from agricultural land uses, large wood removal, and sediment aggradation. The channel is relatively narrow (20–50 ft) with steep banks and is entrenched by 6–8 ft relative to the adjacent pastures throughout much of MSR2, limiting floodplain connectivity. The riparian corridor is constrained to a narrow strip, primarily composed of willow and alder on the stream bank and, in many places encroaching on the channel. Stream banks are degraded by cattle grazing in places. In general, salinities and water temperatures remain sufficiently low to support year-round rearing by juvenile salmonids. More detailed observations of summer and winter habitat for juvenile salmonids are provided in the sections that follow.

Summer habitat

Despite the anthropogenically impacted and simplified channel, suitable summer rearing habitat for juvenile salmonids is abundant and widespread in MSR2 relative to MSR1. Large areas of summer rearing habitat with sufficient depth and extensive escape cover are present and ample riparian shading was observed throughout the reach (Figure 2-29). A comprehensive large wood survey could not be conducted due to the extremely dense riparian that choked the channel in much of the reach, but very few pieces of functional large wood and no channel spanning wood jams were observed.

Channel segment ER10 is characterized by a straight, homogenous channel bounded by cattle pasture on both sides and contains an extremely dense willow-dominated riparian zone that overhangs the entire wetted channel in most areas. In many places, thick willow branches interacted with the low-flow channel. These branches provide a high amount of overhead and in-channel escape cover for rearing juvenile salmonids. While very few pieces of large wood were observed, some larger willows growing along the bank may function like large wood. At the outgoing tidal stage of about 4 ft when ER10 was assessed, some short riffle-like features and shallow, hydraulic control points separating habitats were observed, suggesting minimal tidal influence at that stage.

In channel segment ER11 the hillslope impinges along the left bank of the channel. The riparian zone is still relatively dense and contiguous in ER11 but has more diversity and the understory and channel are more open relative to ER10. Several pieces of functional large wood were observed, creating some local scour and fish cover. Significant erosion resulting from cattle was observed in portions of ER11, from the left bank hillslope, extending into the channel, creating local silt inputs, and potentially impairing water quality.

The dense riparian vegetation in channel segment ER12 is similar to that observed in ER10: the channel is choked with live willow that interacts with the fine-sediment dominated channel. Overall, summer rearing habitat for salmonids in ER12 is abundant and relatively high quality, except for several relatively long (50–100 ft) and homogeneous sections of shallow (<0.5 ft) and flowing flatwater habitat. ER12.1 is a significant off-channel drainage fed by springs draining the adjacent hillslopes that enters ER12 via a culvert and tide gate that excludes fish. As detailed below, this site has significant potential for fish habitat restoration, particularly for winter off-channel habitat. A ditch draining the adjacent cattle pasture enters ER12 through a long culvert (without a tide gate) on the right bank at ER12.2.

Channel segment ER13 runs along the base of the hillslope on the left bank, with continued flat cattle pasture on the right bank. Portions of the segment have extensive escape cover and sufficient water depth to support summer rearing habitat for salmonids, however, several very shallow and apparently stagnant sections with unsuitable salmonid habitat were observed in ER13. Several shallow locations had thick aquatic vegetation, which in one place spanned the channel and appeared to obstruct fish movement. In general, the channel in ER13 is more open with larger and less dense riparian trees relative to downstream segments. The channel is still entrenched, but portions of the bank have failed, creating small inset benches and increasing channel complexity in places. While the bed substrate is still silt-dominated, patches of sand and small gravel were observed in the upper portion of ER13. A significant spring/drainage was observed flowing off the left bank hillslope and entering the channel at the downstream end of ER13.

Despite the generally abundant and high-quality summer rearing habitat observed for salmonids, restoration actions that increase the depth and complexity of pools and mitigate for in-channel cattle impacts would be valuable in portions of MSR2. Implementing restoration actions that improve winter rearing habitat—such as through the addition of large wood—will also improve summer habitat.

Overall, suitable habitat for Tidewater Goby is limited in MSR2 because the species requires relatively stable and shallow low-velocity habitats in off-channel sloughs and connected wetlands, which are rare in the reach. The drainage ditch and relic channel associated with ER12.1 has potential to provide goby habitat if restored.

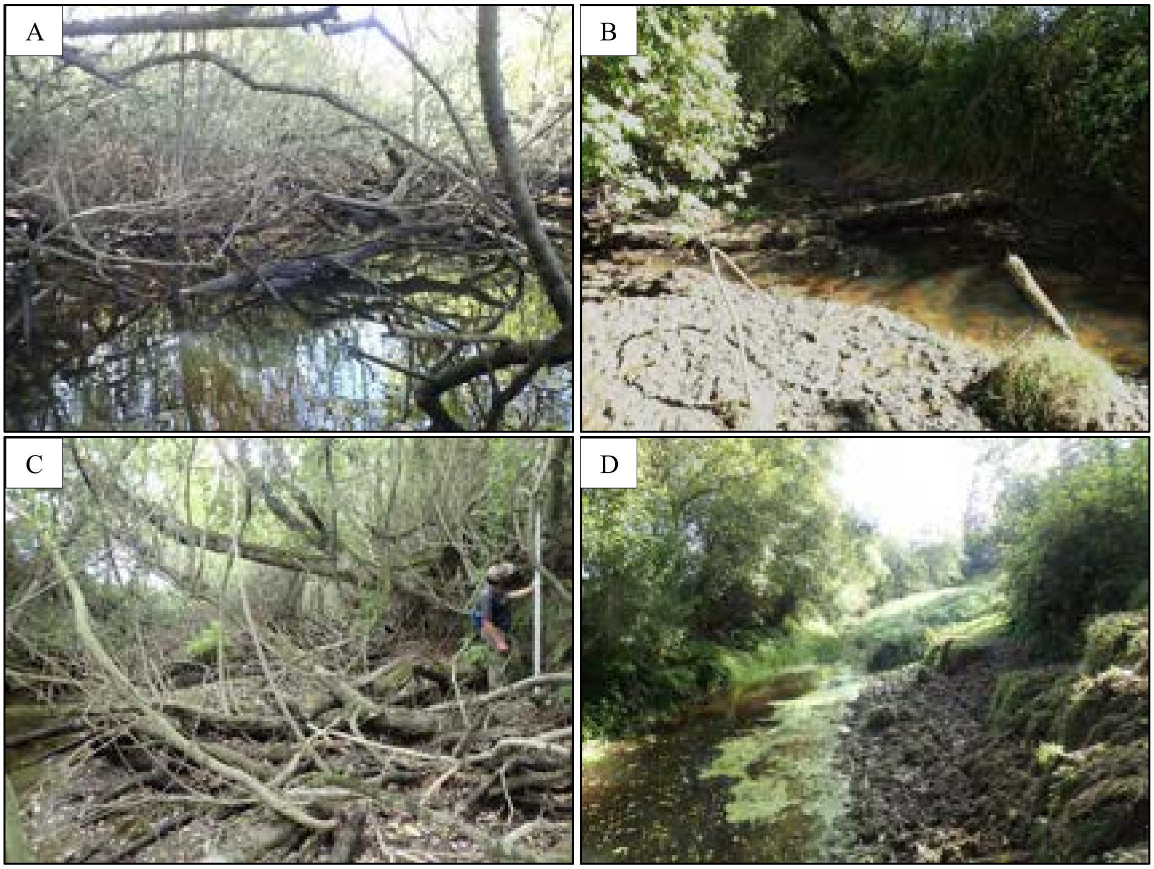


Figure 2-29. Representative summer rearing habitat in MSR2. Dense willow branches and small woody debris covering much of the channel in ER10 (A), a more open section in ER11 with some functional large wood and cattle impacts in the channel (B), dense in-channel branches and entrenched channel in ER12 (C), and shallow, stagnant section of ER13 with in cattle impacts (D).

Winter habitat

Overall, quality of winter habitat in MSR2 is relatively poor, with minimal in-channel flow refugia due to low large wood densities, essentially no connected off-channel habitat features, and severely restricted connectivity with adjacent floodplains. During the winter habitat assessment conducted in January 2022 at a moderate winter baseflow, small areas of relatively low-velocity habitat (<1.0 ft per second) were observed along the channel margins in a few locations where banks were more gradually sloped and dense willow branches or large wood were present (Figure 2-30). However, because of the entrenched channel and limited functional large wood, even moderate high-flow events are expected to produce water velocities that exceed values preferred by Coho Salmon for rearing (approximately 0.6 ft per second ft/s; Beecher et al. 2002) throughout much of the reach. In some locations, it is possible that the extremely dense in-channel willow trunks and instream branches create low-velocity refugia along the channel margins or slow upstream water velocities through backwatering. Several groups of large wood pieces that were observed also likely create some in-channel flow refugia at higher flows.

Figure 2-30. Examples of low-velocity in-channel habitat in MSR2 observed during the January 2022 survey conducted at a moderate winter base flow. Dense in-channel branches and small wood pieces in ER10 (A) and a piece of large wood creating alcove-like habitat at the observed flow in ER11 (B).

No alcoves, side channels, or other off-channel winter habitat features accessible to fish were observed in MSR2. The primary opportunity to restore off-channel fish habitat in MSR2 involves re-connecting the existing low-elevation drainage present at ER12.1, which runs along the hillslope west of ER12 for approximately 1,300 ft before entering the channel via a culvert and tide gate (Figure 2-31). During the January 2022 assessment, during a relatively dry winter period, the entire length of this drainage was wetted and significant flow was observed at both at the upstream/south end of the feature and where it entered the culvert through a shallow riffle at the south end. Additionally, a large (~30 x 200 ft) and relatively deep (max depth = 1.5 ft) ponded area was documented at the south end of the feature. Simply removing or modifying the existing tide gate to allow fish access to the existing low elevation feature fed by freshwater would provide a large area of high-quality off-channel winter rearing habitat in a reach where little is present.

Figure 2-31. Large area of existing off-channel habitat at ER12.1 that is inaccessible to fish due to a tide gate.

Water quality

Continuous water temperature and salinity data collected at site ER-3 near the ER11/ER12 boundary in MSR2 (Section 2.2.2) indicate that, although water levels rise and fall with the tide, the site is freshwater dominated in the winter and spring when stream flows limit the upstream extent of saltwater influence. However, during summer and fall low flow conditions, the site becomes brackish during higher tidal stages (typically greater than about 6.5 ft). In 2021, daily maximum bottom salinities ranged from near 0 ppt during days with lower high tides to 21 ppt at higher tides (Figure 2-18, Figure 2-19). High densities of age-0 Coho Salmon documented in

MSR2, suggests salinity does not prevent fish utilization of the reach during the low flow period (Wallace and Allen 2009; Table 2-18). While salinity stratification was not documented by limited spot measurements in 2021 and 2022 (Table 2-8; note measurements only conducted during lower tides or higher flows), it is likely that a significant freshwater surface layer is present in much of MSR2 during high tides, allow juvenile salmonids to persist. Fish may also move upstream during high tides to avoid high salinities. Water temperatures in MSR2 remain below levels that can be stressful to salmonids and are substantially cooler than measured in MSR1, with daily mean temperatures at the ER-3 monitoring site never exceeding 16°C during 2021 and 2021.

Although water quality information is limited in these reaches, winter water quality is known to be significantly impaired by high suspended sediment concentration and turbidity (California Trout et al. 2019).

2.3.2.3 Swain Slough downstream of Elk River Road tide gate

Approximately 0.9 miles of mainstem Swain Slough and adjacent off-channel habitats within Planning Area 1 were assessed for fish habitat, from its confluence with Elk River upstream to the tide gate at Elk River Road (SS1–SS6; Figure 2-23).

In general, mainstem Swain Slough is characterized by a relatively broad, homogenous tidal slough channel with steep banks confined by constructed levees along significant portions of the reach (Figure 2-40). As with lower Elk River, the channel is confined by these levees, limiting natural channel processes and connectivity with relic slough channels, tidal marshes, and other off-channel habitats. Wetted borrow ditches run along most of the levees. These features are channelized and have infrequent connections with the main channel (either thorough small gaps in the levees or during high tide), Channel width in Swain Slough gradually decreases in the upstream direction, ranging from approximately 60 ft in SS1 to 20 ft in SS6. Swain Slough tidal patterns and water levels closely tracks those recorded at the ER-1 monitoring site, except during high flow events with significant freshwater inflows from Martin Slough (Section 2.2.2). Daily tidal fluctuations of 4–8 ft are expected to have significant influence on habitat conditions in Swain Slough, with a greater area of habitat with high-quality cover on the channel margins available at higher tidal stages. As with MSR1, available habitat during low tides is expected to limit overall fish carrying capacity. Observations of summer and winter fish habitat, focused on juvenile salmonid rearing, and the likely influence of salinity and water temperature on fish utilization in Swain Slough are summarized below.

Summer habitat

As with MSR1, because of high salinities, utilization of Swain Slough habitats by salmonids during the summer is expected to be primarily limited to the smolt life stage as they transition to Humboldt Bay and the ocean. At relatively high tidal stages, including during the September 2021 survey, there is a significant amount of juvenile fish escape cover and low velocity habitat along much of the margins Swain Slough. High quality fish cover is provided by extensive overhanging and in-channel riparian tree branches present along much of the right bank in SS2 and SS3 (Figure 2-32). Additional cover is provided by flood grasses and other vegetation that occur along much of the channel, including some relatively large inset benches with gradual slopes and small alcove-like features in SS4, SS5, and SS6 that provide large areas of 1–2 ft deep, lower velocity habitats with cover during higher tides. Little connected off-channel habitat is currently present in Swain Slough due to the levees that run along the channel. A relatively large salt marsh that contains an off-channel pond is present at SS3.1. Tidal connectivity and fish access to this site appears to be severely limited by an old tide gate and drainage ditch running through the marsh. As detailed under winter habitat below, this site has potential to provide a large area of high-quality fish rearing habitat. The borrow ditches that run along much of Swain Slough appear to be connected to the main channel only at high tidal stages, but there are a few locations, such the left bank of SS4 where the levees have partially failed, allowing more frequent tidal inundation and potentially providing fish off-channel fish habitat at more moderate tidal stages.

At lower tidal stages, many of these margin habitats become dewatered and fish would need to move to find cover provided by in-channel features. Observations from a relatively low tidal stage during the January 2022 winter habitat survey indicate that the low-flow channel in much of Swain Slough is relatively shallow during low tides and contains very little in-channel escape cover or hydraulic diversity. In SS1 and SS2, some fish cover is provided by mid-channel patches of eelgrass (Section 2.4). Except for two large logs in SS3 that create some scour and fish cover, no large wood was observed in the low-flow channel.

Overall, suitable habitat for Tidewater Goby is currently limited in Swain Slough because the species requires relatively stable and shallow low-velocity habitats in connected off-channel sloughs and wetlands. The primary habitats with potential to support Tidewater Goby under existing conditions include the large alcove at SS4.1 and locations with levee failures where borrow ditches are connected. Some of the smaller alcove life features that occur along the margins SS4 and SS5 may also provide some habitat, but most of these features likely go dry during low tides.

Figure 2-32. Photos from September 2021 showing representative main-channel summer fish habitat conditions in Swain Slough. Looking upstream at straight channel in SS2 confined by a levees on the left bank and more gradual bank with riparian cover on the right bank (A), looking downstream at overhanging riparian cover along both banks in SS3 (B), looking upstream at flooded vegetation along the margins of SS5 during a relatively high tidal stage (C), and looking downstream from the tide gate at the end of SS6 (D).

Winter habitat

During wetter periods of winter and spring with more freshwater influence, like MSR1, Swain Slough has potential to support rearing age-0 juvenile salmonids and other freshwater-dependent or brackish species (Table 2-18). Winter habitat complexity and fish escape cover in the Swain Slough channel during moderate winter flows is similar to that described for summer habitat: relatively large areas of high-quality habitat are accessible along the channel margins during higher tidal stages and minimal in-channel habitat is available during lower tides (Figure 2-32 and Figure 2-33). During high winter flows, when significant freshwater enters Swain Slough via Martin Slough and upstream drainages, water velocities in much of the channel may become too high to support juvenile salmonid rearing. As described above, access to off-channel and floodplain habitats that provide velocity refugia is limited by the levees that run along much of Swain Slough. During high flow conditions, some high-flow refugia habitat appears to be present along the more natural bank margins that occur along the right bank of SS2 and SS3, which has sections with relatively gradual slopes (up to the base of the adjacent hillslope) with thick overhanging tree branches and some bankside large wood (Figure 2-33). Fish may also find velocity refugia where the levees have failed, and they can access the network of borrow ditches and adjacent lower elevation floodplains. However, fish stranding could be an issue when flows recede and the ditches become disconnected.

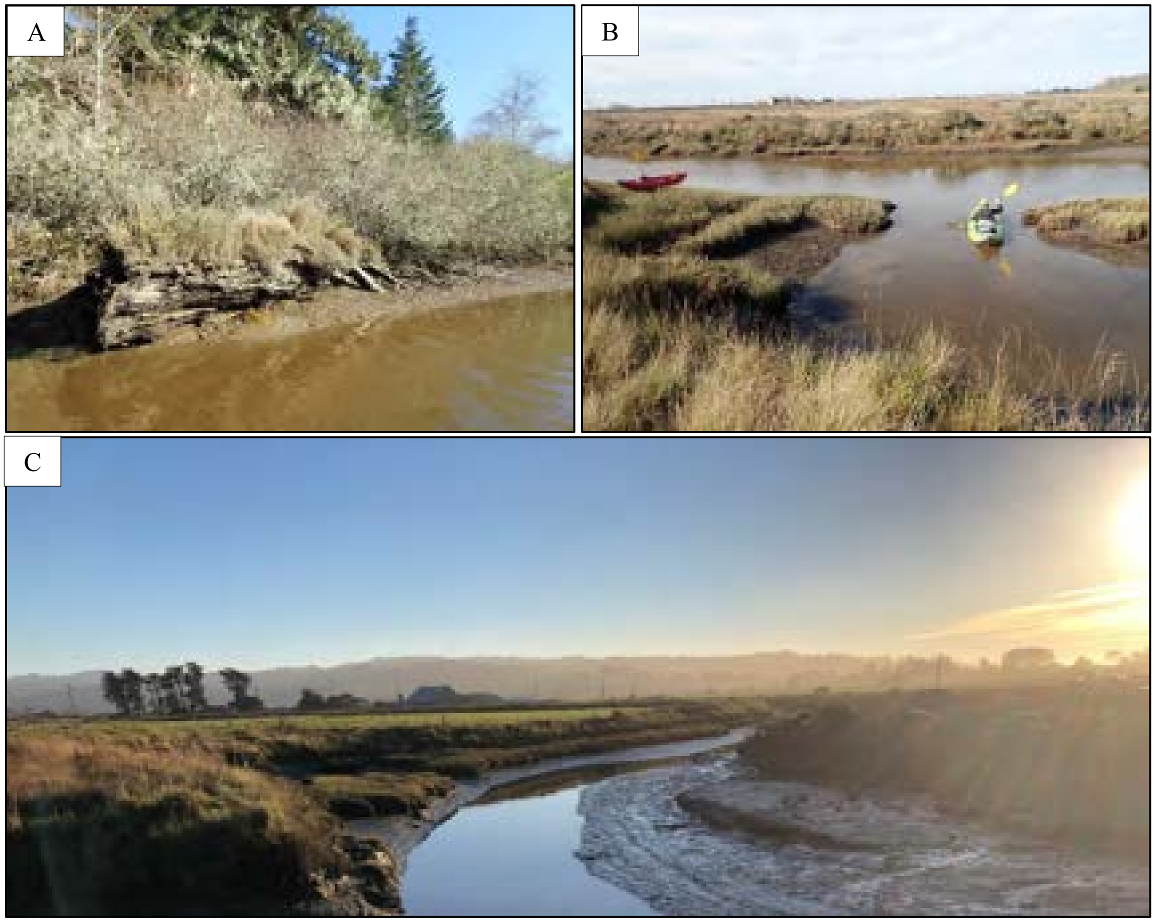


Figure 2-33. Photos of from the January 2022 fish habitat assessment of Swain Slough. Examples of potential high flow refugia habitat, including large wood located on the relatively gradually sloping right bank of SS3 (A) and an alcove at SS4.1 (B) and representative area with shallow water and low in-channel habitat complexity that occurs during lower tidal stages in SS4 (C).

The salt marsh that occurs east of the SS2/SS3 boundary (SS3.1), is currently largely disconnected; however, it has high potential to provide a large area of high-quality fish habitat adjacent to lower Swain Slough (Figure 2-34). The approximately 1-ac marsh is fed by a small drainage originating in the adjacent wooded hillslopes that provide significant freshwater inputs to the site during the wet season. Most of this water appears to drain into a narrow (2 ft) and very entrenched (3–5 ft deep) drainage ditch that runs across the meadow before terminating in Swain Slough through a small tide gate at the base of a channel-side levee. An existing, small (40x40 ft) brackish pond is present on the eastern edge of the marsh. It does not have an obvious inlet or outlet channels but appears to be tidally connected at some tidal stages (was brackish during September site visit) and likely receives some freshwater from the adjacent hillslopes. The site appears to become inundated at the highest tidal stages that flood the berm that runs along this channel/marsh margin (Figure 2-1). However, field observations suggest the marsh is inaccessible to fish at most tidal stages. It is unclear how frequently the site floods during winter flow events but appears to be disconnected by the relatively high elevation berm at most flows. This site has significant potential for restoration of high quality and valuable fish habitat since it is an undeveloped low-elevation salt marsh habitat with an off-channel pond in the lower estuary that could be fed by significant freshwater. If restored, this site could provide high flow refugia habitat during flood events and persistent off-channel rearing habitat for salmonids and other fish during the winter and spring.

Figure 2-34. Photos of disconnected off-channel salt marsh (A), associated pond (B), small tributary flowing into marsh (C), and old tide gate that enters Swain Slough (D).

Water quality

As with MSR1, during the summer and early fall, high salinities (>20 ppt) in Swain Slough are expected to limit fish use to species and life stages (i.e., smolt) than can tolerate salt water (Section 2.2.2). During wetter periods in the winter and spring, salinities in Swain Slough can be significantly lower especially at the SS-2 monitoring station (channel segment SS6), where daily values fluctuating between a low of near zero and a high of 6–10 ppt during periods with higher flows during lower tides. During these periods, Swain Slough may support age-0 and pre-smolt juvenile salmon rearing; though it is likely that some individuals move in and out of this reach in response to fluctuating salinities resulting from variable flows and tides. Additionally, the duration that Swain Slough provides suitable salinities is expected to be significantly longer during wet winters relative to the dry winter of 2021–2022 when water quality monitoring was conducted. Restoration efforts that reconnect freshwater sources to Swain Slough and provide fish access to nearby freshwater dominated habitats are expected to extend the duration of salmonid rearing. Additionally, significant salinity stratification may also allow salmonids to persist in the reach during some periods when bottom salinities are high. However, in contrast to MSR1, limited depth-stratified sampling in 2021 and 2022 suggests minimal thermal stratification in Swain Slough (Section 2.2.2.1).

Water temperatures recorded at Swain Slough monitoring sites (SS-1 and SS-2) were similar to those recorded at MSR1 monitoring sites (ER-1 and ER-2). Daily mean water temperatures at both sites remained above 18°C for much of the summer 2021, with temperatures at SS-2 being higher than at SS-1 (Section 2.2.2.2). Limited depth-stratified measurements showed essentially no thermal stratification at the Swain Slough monitoring sites.

2.3.2.4 Other locations assessed

Eastern off-channel habitat

A disconnected relic slough feature that is fed by two small tributaries (T1 and T2) and borders cattle pasture on the east side of Elk River Road, was also assessed due to its potential for fish habitat restoration (Figure 2-23; Figure 2-35). This site consists of two channel-like depressions that are mostly dry in the summer but appear to remain wetted for much of the winter and spring. The northern channel, T1, is fed by a seasonal drainage from the north, a small tributary, and at least one spring entering from hillslope to the east of the channel. The T1 channel is approximately 1,900 ft long and flows north and west before passing through a culvert under Elk River Road and entering a drainage ditch (SS7) that flows into Swain Slough (Figure 2-23, Section 2.6, Appendix A). The southern channel, T2, is fed primarily by a tributary flowing from the southeast hillslope that enters a depression along the southern edge of the cattle pasture before passing through a culvert under Elk River Road and eventually flowing into Swain Slough via a drainage ditch that follows the west side of Elk River Road (Figure 2-23, Section 2.6, Appendix A). This feature includes about 400 ft of ponded habitat on the edge of the cattle field, including a relatively deep (1 ft) section partially within the adjacent riparian forest (Figure 2-35). Neither of these relic channels are currently accessible to fish but contribute valuable freshwater to Swain Slough and have potential to provide high quality winter rearing habitat for salmonids if reconnected.

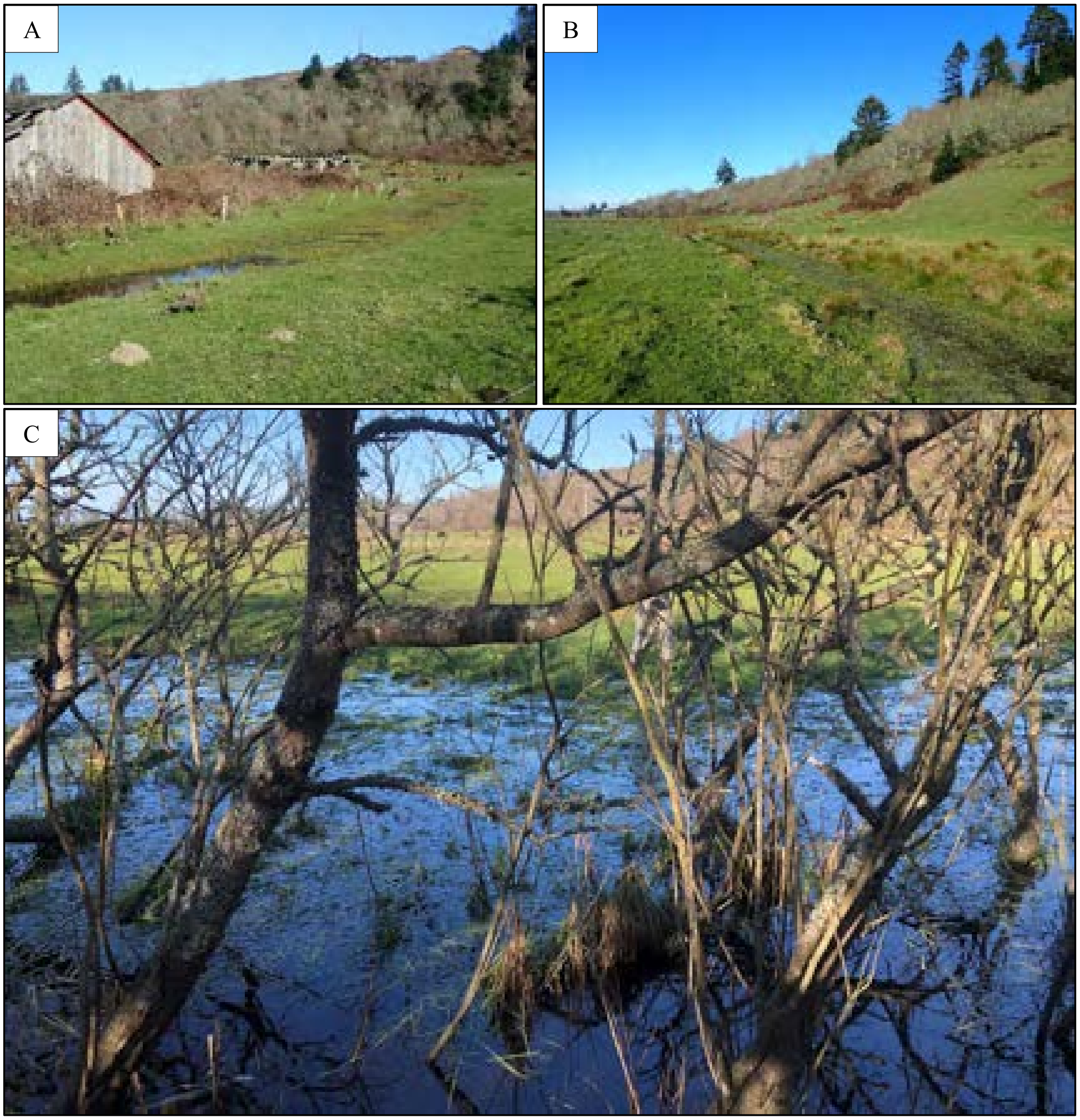


Figure 2-35. Relic Swain Slough channel complex east of Elk River Road. T1 channel near Elk River Road(A) and along hillslope (B) and deep depression along riparian forest associated with T2.

Orton Creek

Orton Creek is a small perennial tributary draining an area of approximately 1.5 square kilometers (km^2) (0.6 square miles [mi^2]) (Figure 2-23) east of Elk River Road. After crossing Elk River Road through a culvert that is a barrier to fish movement just east of Planning Area 1, the stream flows west for approximately 900 ft before entering a culvert that routes it southwest for approximately 1,400 ft to Elk River near the end of Showers Road. Historical aerial photographs and terrain analyses indicate that the stream likely flowed into Swain Slough before being re-routed (Figure 2-3). Although the contributing drainage area and stream channel are relatively small (approximately 3–4 ft wetted width in January), Orton Creek delivers a significant amount of fresh water to the planning area. Notably, the stream was wetted and had detectable flow during a site visit in August 2021, following a historically dry winter. During the winter habitat assessment on January 14, 2022 following a relatively dry period (7 days without rain), stream flow measured near the culvert inlet was near 0.4 cfs. The portion of the channel in the planning area that is above ground currently has a relatively small area of suitable salmonid rearing habitat due to its small size. The channel is narrow and has limited connectivity with the flood plain since it is generally entrenched by 3–6 ft relative to the adjacent pasture. The channel consists of alternating short riffles and pools with depths generally <1 ft during January. Bed substrate includes a mix of silt, sand, and small gravels. Water temperature in Orton Creek was 12.5°C on at 12:40pm on October 1, 2021 and 8°C at 12:14 pm on January 14, 2022. Despite limited existing physical habitat for fish, reconnecting freshwater flows from Orton Creek to a relic Swain Slough channel would have high value by lowering salinities and helping to maintain water quality in restored channels. Additionally, if the channel were restored, Orton Creek could provide some high-flow refugia for salmonids and provide quality spawning habitat for Coastal Cutthroat trout and potentially other salmonids.

Figure 2-36. Photos of Orton Creek and the culvert connecting it with Elk River. Riparian zone near culvert inlet (A), wetted channel during January 2022 flow measurement near culvert inlet (B) culvert inlet during August 2021 site visit (C) and culvert outlet and flow into Elk River during September 2021 habitat assessment.

2.4 Vegetation and Special-status Plants

The purpose of the vegetation classification and botanical surveys was to document the presence of any special-status plant species and sensitive natural communities with potential to occur within the planning area as well as to document and map the existing vegetation types. Special-status plant species are defined as those listed, proposed, or under review as threatened or endangered under the federal Endangered Species Act of 1973 and/or the California Endangered Species Act; designated as rare under the California Native Plant Protection Act; and/or taxa that meet the criteria for listing as described in Section 15380 of the California Environmental Quality Act of 1970 Guidelines, including species listed on CDFW's *Special Vascular Plants, Bryophytes, and Lichens List* (CDFW 2022a), plants with a California Rare Plant Rank (CRPR) of 1, 2, 3, or 4, and/or plants that are considered a locally significant species (i.e., rare or uncommon in the county or region). Sensitive natural communities are defined as those natural community types (i.e., 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), or S3 (vulnerable) on CDFW's *California Sensitive Natural Communities List* (CDFW 2021) or in the CNDDB (CDFW 2022b). These survey results will inform the preliminary constraints and benefits associated with restoration conceptual design and assess avoidance and minimization measures for the restoration actions potential adverse impacts on sensitive resources in the planning area.

2.4.1 Desktop review

A list of special-status plants and sensitive natural communities that may occur in the planning area was developed by querying the following resources:

- The U.S. Fish and Wildlife Service (USFWS) online *Information for Planning and Consultation* (IPaC) (includes the official species list) (USFWS 2021),
- The California Native Plant Society's (CNPS) online *Inventory of Rare and Endangered Vascular Plants of California* (CNPS 2022a), and
- CDFW's CNDDB and Biogeographic Information and Observation System (BIOS) (CDFW 2022b), includes special-status plants and both legacy and sensitive natural communities.

The USFWS, CNPS, and CNDDB database queries were each based on a search of the USGS 7.5-minute quadrangles in which the Project is located (Fields Landing and Eureka), and the surrounding California quadrangles (Tyee City, Arcata North, Arcata South, McWhinney Creek, Hydesville, Fortuna, Ferndale, and Cannibal Island); hereinafter project vicinity. Appendix B lists special-status plant species, and sensitive natural communities identified from the sources described above.

The potential for special-status plant species or sensitive natural communities listed in Appendix A to occur in the Project area was determined by: (1) reviewing the current distribution of each species (i.e., whether it overlaps with the planning area); (2) reviewing the documented occurrence information from the CNDDB, Consortium of California Herbaria (CCH 2021), and CalFlora (2021); (3) comparing the habitat associations of each species with the habitat conditions documented in and adjacent to the planning area; and (5) using professional judgment to evaluate habitat quality and the relevance of occurrence data, or lack thereof.

This review and analysis resulted in the following categories of the likelihood for a special-status species to occur in the planning area:

- **None:** the planning area is outside the species' current distributional or elevation range and/or the species' required habitat is lacking from the planning area (e.g., cismontane woodland).
- **Low:** the species' known distribution or elevation range is within the vicinity of the Project, but not the planning area, and/or the species' required habitat is of very low quality or quantity in the planning area.
- **Moderate:** the species' known distribution or elevation range overlaps with the planning area and/or the species' required habitat occurs in the planning area.
- **High:** the species has been documented in the planning area and/or its required habitat occurs in the planning area and is of high quality.

A total of 56 special-status plant species were documented as occurring within the project vicinity (Appendix B). Based on habitat associations along with landform, soils, and known elevation range within the planning area, 11 special-status plants have low potential, three have moderate, and four have high potential to occur in the planning area (Table 2-19). The remaining 38 special-status plant species were considered not likely to occur (Appendix B). Four legacy natural communities were documented from the CNDDB query in the project vicinity (not specifically documented in the planning area); northern coastal salt marsh, Sitka spruce forest, northern foredune grassland, and coastal terrace prairie (Table 2-20). Northern coastal salt marsh occurs along the Elk River and Swain Slough banks in the planning area (Table 2-20). The vegetation classification and map results provide all sensitive natural communities in the planning area.

Table 2-10. Special-status plant species with potential to occur in the Elk River Planning Area 1.

Scientific name (common name)	Family	Lifeform	Status (Federal, State, CRPR)	Habitat association and blooming period	Potential to occur
Angelica lucida (sea-watch)	Apiaceae	perennial herb	None/None/4.2	Coastal bluff scrub, coastal dunes, coastal scrub, coastal salt marshes and swamps; 0–490 ft. Blooming period: May–September	High. Suitable habitat is present and documented occurrences known less than one mile from the planning area.
Astragalus pycnostachyus var. *pycnostachyus* (coastal marsh milk-vetch)	Fabaceae	perennial herb	None/None/1B.2	Mesic coastal dunes, coastal scrub, and coastal salt and streamside marshes and swamps; 0–100 ft. Blooming period: (April) June–October	Low. Suitable habitats are present in planning area however, nearest occurrence is greater than 10 miles from the Project.
Bryoria pseudocapillaris (false gray horsehair lichen)	Parmeliaceae	fruticose lichen (epiphytic)	None/None/3.2	Usually on conifers in coastal dunes (SLO Co.) and immediate coast in North Coast coniferous forest; 0–295 ft. Blooming period: N/A (lichen)	Low. A sparse quantity of mature conifers are located within the planning area.
Bryoria spiralifera (twisted horsehair lichen)	Parmeliaceae	fruticose lichen (epiphytic)	None/None/1B.1	Usually on conifers in North Coast coniferous forest along the immediate coast; 0–100 ft. Blooming period: N/A (lichen)	Low. A sparse quantity of mature conifers are located within the planning area.
Carex leptalea (bristle-stalked sedge)	Cyperaceae	perennial rhizomatous herb	None/None/2B.2	Bogs and fens, mesic meadows and seeps, and marshes and swamps; 0–2,295 ft. Blooming period: March–July	Low. Suitable habitat is present in the planning area however, nearest occurrence is known from a 1918 Tracy collection occurring in a mossy bog along a north slope (CDFW 2022b)
Carex lyngbyei (Lyngbye's sedge)	Cyperaceae	perennial rhizomatous herb	None/None/2B.2	Brackish or freshwater marshes and swamps; 0–35 ft. Blooming period: April–August	High. Suitable habitat is present and documented occurrences known along the Elk River and Swain Slough banks within the planning area.

Scientific name (common name)	Family	Lifeform	Status (Federal, State, CRPR)	Habitat association and blooming period	Potential to occur
Carex praticola (northern meadow sedge)	Cyperaceae	perennial herb	None/None/2B.2	Mesic meadows and seeps; 0–10,500 ft. Blooming period: May–July	Low. Suitable habitat is present in the planning area however nearest documented occurrence within 10 miles of the project is known from a 1914 and 1915 Tracy collection attributed to the Ryan Slough region.
Castilleja ambigua var. *humboldtiensis* (Humboldt Bay owl's-clover)	Orobanchaceae	annual herb (hemiparasitic)	None/None/1B.2	Coastal salt marshes and swamps; 0–10 ft. Blooming period: April–August	High. Suitable habitat is present and documented occurrences known less than one mile from the planning area.
Chloropyron maritimum subsp. *palustre* (Point Reyes bird's-beak)	Orobanchaceae	annual herb (hemiparasitic)	None/None/1B.2	Coastal salt marshes and swamps; 0–35 ft. Blooming period: June–October	High. Suitable habitat is present and documented occurrences known less than one mile from the planning area.
Chrysosplenium glechomifolium (Pacific golden saxifrage)	Saxifragaceae	perennial herb	None/None/4.3	Streambanks, sometimes seeps, sometimes roadsides in North Coast coniferous forest and riparian forest; 30–2,100 ft. Blooming period: February–June (July)	Low. Riparian habitat is present it in the planning area however the riparian structure and plant composition present do not appear suitable for this species.
Lathyrus palustris (marsh pea)	Fabaceae	perennial herb	None/None/2B.2	Mesic in bogs and fens, coastal prairie, coastal scrub, lower montane coniferous forest, marshes and swamps, and North Coast coniferous forest; 0–330 ft. Blooming period: March–August	Moderate. Suitable habitat is present and a single occurrence near the planning area was documented in a marsh north of Elk River Slough in 2003 (CDFW 2022b)
Pleuropogon refractus (nodding semaphore grass)	Poaceae	perennial rhizomatous herb	None/None/4.2	Mesic in lower montane coniferous forest, meadows and seeps, North Coast coniferous forest, and riparian forest; 0–5,250 ft. Blooming period: (March) April–August	Low. Suitable habitat is present in the planning area however no known occurrence within 10 miles of the Project.

Scientific name (common name)	Family	Lifeform	Status (Federal, State, CRPR)	Habitat association and blooming period	Potential to occur
Polemonium carneum (Oregon polemonium)	Polemoniaceae	perennial herb	None/None/2B.2	Coastal prairie, coastal scrub, and lower montane coniferous forest; 0–6,005 ft. Blooming period: April–September	Low. Suitable habitat is present in the planning area however no known occurrence within 10 miles of the Project.
Puccinellia pumila (dwarf alkali grass)	Poaceae	perennial herb	None/None/2B.2	Coastal salt marshes and swamps; 0–35 ft. Blooming period: July	Low. Suitable habitat is present in the planning area however only known occurrence within 10 miles of the Project is from a 1938 Tracy collection near the Eel River mouth.
Sidalcea malviflora subsp. *patula* (Siskiyou checkerbloom)	Malvaceae	perennial rhizomatous herb	None/None/1B.2	Often roadcuts in coastal bluff scrub, coastal prairie, and North Coast coniferous forest; 45–2,885 ft. Blooming period: (April) May–August	Low. Suitable habitat is present in the planning area however known occurrences within 10 miles of the Project are from a pre-1950 Tracy collections in Eureka and Table Bluff (CDFW 2022b).
Sidalcea oregana subsp. *eximia* (coast checkerbloom)	Malvaceae	perennial herb	None/None/1B.2	Lower montane coniferous forest, meadows and seeps, and North Coast coniferous forest; 15–4,395 ft. Blooming period: June–August	Moderate. Suitable habitat is present and a single occurrence within the planning area was documented from a 1907 Tracy collection along a ditch in the Elk River (CDFW 2022b).
Silene scouleri subsp. *scouleri* (Scouler's catchfly)	Caryophyllaceae	perennial herb	None/None/2B.2	Coastal bluff scrub, coastal prairie, and valley and foothill grassland; 0–1,970 ft. Blooming period: (March–May) June–August (September)	Low. Suitable habitat is present however single documented occurrence within 10 miles of the Project is known form a 1904 Tracy Collection near Bucksport (Eureka) (CDFW 2022b).

Scientific name (common name)	Family	Lifeform	Status (Federal, State, CRPR)	Habitat association and blooming period	Potential to occur
Spergularia canadensis var. *occidentalis* (western sand-spurrey)	Caryophyllaceae	annual herb	None/None/2B.1	Coastal salt marshes and swamps; 0–10 ft. Blooming period: June–August	Moderate. Suitable habitat is present in the planning area and several documented occurrences within 5 miles of the Project.

[1] Status:

Federal

None No federal status

State

None No state status

California Rare Plant Rank

List 1B Plants rare, threatened, or endangered in California and elsewhere

List 2B Plants rare, threatened, or endangered in California, but more common elsewhere

List 3 Plants about which more information is needed, a review list

List 4 Plants of limited distribution, a watch list

CNPS 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] Months in parentheses are uncommon; N/A = Not applicable

Table 2-11. CDFW sensitive natural communities with potential to occur in the Elk River Planning Area 1.

Sensitive natural community	State status[1]	Description	Suitable habitat present in Survey Area?
Northern coastal salt marsh	S3.2	Highly productive, herbaceous and suffrutescent, salt-tolerant hydrophytes forming moderate to dense cover and up to 1 meter tall. Usually segregated horizontally with *Spartina* nearer to open water, *Salicornia* at mid-littoral elevations and a richer mixture closer to high ground. Located within hydric soils subject to regular tidal inundation by salt water for at least part of each year (Holland 1986). It is distributed along the California coast from the Oregon border south to Point Conception in Santa Barbara County. This natural community is comprised of the *Salicornia pacifica*, *Distichlis spicata*, and *Spartina densiflora* Herbaceous Alliances (Sawyer and Keeler-Wolf 1995, Holland 1986, CNPS 2022b). This legacy natural community is associated with the *Sarcocornia pacifica* (*Salicornia depressa*) Herbaceous Alliance (S3) (CNPS 2022b). The CNDDB noted elements with excellent occurrence ranks contained *Salicornia pacifica*, *Distichlis spicata*, *Jaumea carnosa*, *Cordylanthus maritimus* ssp. *palustris*, *Castilleja ambigua* subsp. *humboldtiensis*, and *Triglochin maritimum*.	*Sarcocornia pacifica* stands were documented along the banks and tidal flats of Elk River and Swain Slough.
Sitka Spruce forest	S1.1	A mid-successional forest dominated by Sitka spruce, Oregon crabapple, *Baccharis pilularis*, *Salix* spp., *Lonicera involucrata*, *Sambucus racemosa*, *Rhamnus californica*, *Salix hookeriana*, *Morella californica*, *Rubus spectabilis*, *Polystichum munitum*, *Marah oregana*, *Maianthemum* spp. in understory (Holland 1986). This legacy natural community is associated with the *Picea sitchensis* Forest & Woodland Alliance (S2) (CNPS 2022b).	Small patches of *Picea sitchensis* were observed along the banks of Elk River.

Sensitive natural community	State status[1]	Description	Suitable habitat present in Survey Area?
Coastal Terrace Prairie	S2.1	A dense, tall grassland (up to one meter tall) dominanted by both sod and tussock forming perennial grasses. Most stands are quite patchy and variable in composition, reflecting local differences in available soil moisture capacity. Characteristic species include *Agrostis tenuis, Armeria maritima*, *Calamagrostis nutkaensis*, *Danthonia californica, Deschampsia cespitosa*, and *Festuca rubra*. Coastal terrace Prairie is comprised of Calamagrostis nutkaensis, Deschampsia cespitosa - Hordeum brachyantherum - Danthonia californica, Festuca idahoensis - *Danthonia californica*, *Holcus lanatus - Anthoxanthum odoratum*, *Phalaris aquatica - Phalaris arundinacea, and Poa pratensis - Agrostis gigantea - Agrostis stolonifera* herbaceous alliances (CNPS 2022). This legacy natural community is associated with the Calamagrostis nutkaensis (S2), Deschampsia cespitosa - Hordeum brachyantherum - Danthonia californica (S3), and Festuca idahoensis - Danthonia californica (S3) herbaceous alliances (CNPS 2022b).	*Deschampsia cespitosa* and *Hordeum brachyantherum* grassland stands were observed in the Planning area.
Northern Foredune Grassland	S1.1	A sparse grassland (10 to 50% total cover) of the upper strand and foredunes dominated by *Elymus mollis* and *Poa douglasii*, with *Ambrosia chamissonis*, *Abronia latifolia*, *Calystegia soldanella*, and *Cakile* spp. in varying proportions (Holland 1986). This legacy natural community is associated with the *Leymus mollis* Herbaceous Alliance (S2) (CNPS 2022b)	Not observed in the Planning area.

[1] State status

S1: Critically Imperiled – At very high risk of extirpation in the state due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors.

S2: Imperiled – At high risk of extirpation in the state due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.

S3: Vulnerable – At moderate risk of extirpation in the state due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.

A pre-field review was conducted in March 2021 to:

- Review key identifying characteristics and life history stages (e.g., bloom time) of the targeted special-status vascular and nonvascular plant species and sensitive natural communities with potential to occur in the planning area,
- Create maps of known locations for targeted special-status vascular and nonvascular plant species and sensitive natural communities within the planning area, and
- Prepare and plan for field surveys.

The timing of life history stages for each targeted species (Table 2-19) was reviewed to determine survey periods that would coincide with the phenological stage (e.g., flowering or fruiting) during which the special-status plant species were most easily identified in the field. A spring survey (i.e., May) and a summer survey (i.e., July) captured all pertinent blooming periods.

To familiarize surveyors with key characteristics and natural variation of those characteristics of each special-status vascular and nonvascular species, information was obtained through a review of: (1) CNPS (2022a) and CDFW (2022b) data; (2) photographs on CalPhotos (University of California Berkeley 2022); and (3) key characteristics using the online *Jepson eFlora* (Jepson Flora Project 2022).

Information on known occurrences of special-status vascular and nonvascular species and sensitive natural communities was compiled and plotted in Geographic Information System (GIS) and printed onto field maps.

2.4.2 Field surveys

The surveys for special-status plant species and sensitive natural communities were conducted on May 12–14, 2021 and July 12–14, 2021 by qualified botanists with: (1) experience conducting floristic surveys; (2) knowledge of plant taxonomy and plant community ecology and classification; (3) familiarity with the plant species of the area; (4) familiarity with appropriate state and federal statutes related to plants and plant collecting; and (5) experience with analyzing impacts of a project on native plant species and natural communities. The survey followed the methods of the *Guidelines for Conducting and Reporting Botanical Inventories for Federally Listed, Proposed and Candidate Plants* (USFWS 1996) and *Protocols for Surveying and Evaluating Impacts to Special-Status Native Plant Populations and Sensitive Natural Communities* (CDFW 2018). Specifically, surveys were comprehensive for vascular plants such that "every plant taxon that occurs in the project area is identified to the taxonomic level necessary to determine rarity and listing status" (CDFG 2018). If identification was not possible in the field, the plants were collected for identification in the laboratory (using the "1 in 20" rule, Wagner 1991) or, if potentially a special-status plant, according to the botanists' current CDFW plant voucher collection permit guidelines (e.g., not more than five individuals or two percent of the population, whichever is less, for one voucher sheet). All plant species were identified following the taxonomy of the *Jepson eFlora* (Jepson Flora Project 2022).

The location and population boundaries of any identified special-status species were recorded in the field using a handheld GPS unit and a CNDDB form was completed for each occurrence. Information collected for each special-status population included the following:

- numbers of individuals,
- phenology,

- habitat description (e.g., surrounding plant communities, dominant species, associated species, substrates/soils, aspects/slopes),
- relative condition of the population (i.e., a qualitative assessment of site quality and occurrence viability [excellent, good, fair, or poor]), and
- recognizable risk factors.

In addition, photographs were taken to document diagnostic floral characteristics, growth forms, and habitat characteristics of special-status species. The GPS data were post-processed and corrected, then incorporated into a GIS database.

A comprehensive list of all species observed in the Elk River Planning Area 1 is provided in Appendix B. Several special-status plant occurrences were observed throughout the planning area (see Section 2.4.1.3) as well as several nonnative invasive weeds with a Cal-IPC rating of high (i.e., species that have severe ecological impacts on physical processes, plant and animal communities and vegetation structure) or otherwise noted as invasive in the region. Three invasive weeds that occur with moderate frequency and form dense stands displacing native vegetation in the planning area include *Spartina densiflora* (dense-flowered cordgrass), *Phalaris arundinacea* (reed canary grass), and *Rubus armeniacus* (Himalayan blackberry). These three species formed semi-natural alliances and their stands were delineated during the vegetation classification and mapping efforts (see Section 2.4.4.2)

2.4.3 Special-status plants

Four special-status plant species were documented in the planning area: *Carex lyngbyei* (Lyngbye's sedge), *Angelica lucida* (sea-watch), *Spergularia canadensis* var. *occidentalis* (western sand-spurrey), and *Castellija ambigua* subsp. *humboldtiensis* (Humboldt Bay owl's-clover) (Figure 2-37). Occurrence data for all documented occurrences are provided in Table 2-21 and summarized in the following sections. Completed CNDDB forms for all 2021 documented occurrences are provided in Appendix B.

Table 2-12. Special-status plant occurrences in the Elk River Planning Area 1.

Species name	Status[1] (Federal/ State/CRPR)	Existing CNDDB occurrence?	Occurrence label	Population size
Carex lyngbyei (Lyngbye's sedge)	-/-/2B.2	Yes, Occurrence 9	CALYN 001	21 patches (0.42 ac)
			CALYN 002	35 patches (2.82 ac)
			CALYN 003	11 patches (2.31 ac)
			CALYN 004	6 patches (0.36 ac)
			CALYN 005	16 patches (0.04 ac)
Angelica lucida (sea-watch)	-/-/4.2	No	ANLUC 001	27 patches (0.53 ac)
			ANLUC 002	12 patches (0.02 ac)
			ANLUC 003	4 patches (0.06 ac)
Castilleja ambigua subsp. *humboldtiensis* (Humboldt Bay owl's-clover)	-/-/1B.2	Yes, Occurrence 13	CAAMB 001	4 patches (0.09 ac)
			CAAMB 002	2 patches (0.15 ac)
			CAAMB 003	4 patches (0.53 ac)
Spergularia canadensis var. *occidentalis* (western sand-spurrey)	-/-/1B.2	No	SPCAN 001	1 patch (0.02 ac)

[1] Status:

- No status

California Rare Plant Rank (CRPR)

List 1B Plants rare, threatened, or endangered in California and elsewhere
List 2B Plants rare, threatened, or endangered in California, but more common elsewhere
List 4 Plants of limited distribution, a watch list

CNPS Threat Ranks:

0.2 Fairly threatened in California (moderate degree/immediacy of threat)
0.3 Not very threatened in California (low degree/immediacy of threat or no current threats known)

Figure 2-37. Special-status plant occurrences in Elk River Planning Area 1.

Carex lyngbyei (Lyngbye's sedge)

Lyngbye's sedge is a perennial rhizomatous herb in the Cyperaceae family with a California Rare Plant Rank (CRPR) of 2B.2. It is limited to the North and Central Coast at 0–33 ft elevation (Jepson Flora Project 2022). In California, it is known to occur in Del Norte, Humboldt, Mendocino, Marin, and Napa counties where it occurs in brackish and freshwater marshes and swamps and blooms from April through August (CNPS 2022a).

In the planning area, Lyngbye's sedge frequently occurred in dense stands along the tidally influenced channels of Elk River and Swain Slough and their adjoining drainages (Figure 2-38). These populations were associated with the CNDDB occurrence 9 (Table 2-11). However, the full extent of this documented occurrence (including the Elk River population) was never captured in the planning area. Investigations throughout the planning area during the 2021 botanical surveys characterized five populations distinguished by geographic connectivity, habitat, unique threats and disturbances, and overall occurrence quality (Table 2-21). Two occurrences (CALYN 001 and 002) were observed along the lower intertidal banks of Elk River. The largest occurrence (CALYN 002, pictured above right) consists of intertidal, dense, monotypic bands of vegetation along both sides of the river. The upstream occurrence in Elk River (CALYN 001), was restricted to openings within the otherwise forested riparian corridor. Similarly, along Swain Slough, occurrence CALYN 004 was composed of several patches growing within openings of a partially forested riparian corridor. The upstream Swain Slough occurrence (CALYN 003) represented another healthy Lyngbye's sedge stand. This occurrence formed a dense, monotypic band growing in the intertidal zone along both banks of the slough. These four occurrences along Elk River and Swain Slough showed little signs of disturbance and appeared to be in excellent condition. Potential threats include competition by *Spartina densiflora* (dense-flowered cord grass), (along the upper elevation extent), bank erosion, and sea-level rise. Finally, a fifth occurrence (CALYN 005) was observed growing along the sides of shallow drainages within an actively grazed agricultural field east of Swain Slough. These drainages were subject to tidal influence from a leaky tidegate upstream of Martin Slough. This population was sparse and showed signs of grazing in areas where cattle had access.

Tens of thousands of individuals were observed within these five occurrences in 2021 (Table 2-21). In general, Lyngbye's sedge populations were immediately bordered by salt marsh communities including associations to the *Sarcocornia pacifica (Salicornia depressa)* Herbaceous Alliance. Additional herbaceous plants observed along the intertidal channel benches adjacent to Lyngbye's sedge populations included *Juncus lescurii* (San Francisco rush), *Symphyotrichum chilense* (Pacific aster), *Potentilla anserina* subsp. *pacifica* (Pacific silverweed), *Triglochin maritima* (common arrow-grass), dense-flowered cord grass, *Distichlis spicata* (salt grass), *Deschampsia cespitosa* (tufted hair grass), and *Salicornia pacifica* (pickleweed). Shrubs *Salix scouleriana* (Scouler's willow), *Salix hookeriana* (coastal willow), and *Sambucus racemosa* (red elderberry) were observed along the upper bank and adjacent to populations associated with openings within riparian forest/shrublands.

Spergularia canadensis var. occidentalis (western sand-spurrey)

Spergularia canadensis var. *occidentalis* (western sand-spurrey) is an annual herb in the Carophyllaceae family with a CRPR of 2B.1 (i.e., plants rare, threatened, or endangered in California, but more common elsewhere; seriously threatened in California) (CNPS 2022a). In California, this species is known to occur only in Humboldt County at 0–10 ft elevation within coastal salt marsh and swamp habitats.

One new occurrence of western sand-spurrey was noted in the planning area with over 200 individuals observed in an intertidal location in the Swain Slough. Like other Humboldt Bay occurrences, western sand-spurrey in the planning area had established along an open lower intertidal mudflat. This occurrence was documented on a small mudflat island in the slough channel exposed during low tide events (Figure 2-37). Sparse vegetative cover was noted at this location with western sand-spurrey providing the highest cover (~15% absolute cover). In addition, some dense-flowered cordgrass and *Cotula coronopsis* (common brass-buttons) were noted, each with less than 5% absolute cover. The high inundation times between low tide events in the Swain Slough seem to maintain control of both nonnative plant associates. Other potential threats to this occurrence include mudflat erosion and sea-level rise.

Castilleja ambigua subsp. humboldtiensis (Humboldt Bay owl's-clover)

Castilleja ambigua subsp. *humboldtiensis* (Humboldt Bay owl's clover) is a hemiparasitic annual herb in the Orobanchaceae family that has a CRPR of 1B.2 (i.e., plants rare, threatened, or endangered in California and elsewhere; fairly threatened in California). It is limited to the North and Central Coast specifically Humboldt, Mendocino, and Marin counties at 0–3 m (0–10 ft) elevation (Jepson Flora Project 2022). It occurs in coastal salt marshes and swamps and blooms from April through August (CNPS 2022a).

Three popultions of Humboldt Bay owl's-clover were observed within the planning area during the 2021 botanical surveys. Per CNDDB records, this species was documented along lower Elk River and Swain Slough at the downstream end of the planning area. Although the 2021 occurrences within the planning area were upstream of the CNDDB documented occurrence (occurence # 13), these sightings were attributed to this population (Table 2-21). Similar to Lyngbye's sedge characteriztion, the Humboldt Bay owl's clover occurrences in the planning area were grouped based on geographic connectivity, habitat, unique threats and disturbances, and overall occurrence quality. Two populations were attributed to salt marsh habitat on intertidal benches along Swain Slough (CAAMB 002 and CAAMB 003). The third population was located along interior tidelands (CAAMB 001). This location was historically converted to agricultural fields however over the last several decades, it has been re-exposed to tidal influence and is transitioning back to estuarine wetlands (Figure 2-37).

All three populations appeared to be in excellent condition with minimal disturbances or threats observed. Plant associates included pickleweed, *Jaumea carnosa* (marsh jaumea), salt grass, *Juncus lescurii* (soft rush), common arrow-grass, Pacific silverweed, common brass-buttons, and dense-flowered cord grass (Appendix B). Threats to populations of Humboldt Bay owl's-clover included encroachement by invasive plants, dense-flowered cord grass and common brass buttons, and potential ground disturbance from agriculture; yet these threats seemed of little impact to current populations.

Angelica lucida (sea-watch)

Angelica lucida (sea-watch) is a native perennial herb in the Apiaceae family that has a CRPR of 4.2 (CNPS 2020). It is limited to the North Coast specifically Humboldt, Mendocino, and Del Norte counties from 0 to 164 ft above sea level (Jepson Flora Project 2022). Sea-watch typically occurs in coastal bluff scrub, coastal dunes, coastal scrub, and coastal salt marshes and blooms from May to September (CNPS 2022a).

Three large populations of sea-watch were observed within the planning area mostly attributed to upland coastal scrub habitats along Elk River and Swain Slough levees and earthen berms (Figure 2-37, Table 2-21). One population was characterized by scrub habitats along Elk River (ANLUC 001) and another along Swain Slough uplands (ANLUC 002). The third more interior population was observed scattered in transitional tideland features and adjacent to roadsides along berms (ANLUC 003). Plant associates included woody shrubs and vines common to coastal scrublands *Lonicera involucrata* (coast twinberry), *Rubus ursinus* (California blackberry), *Baccharis pilularis* (coyote brush), and the invasive *Rubus armeniacus* (Himalayan blackberry). Associated herbaceous plants included San Francisco rush, Pacific aster, Pacific silverweed, common arrow-grass, tufted hair grass, *Achillea millefolium* (common yarrow), *Atriplex prostrata* (fat-hen), *Scrophularia californica* (California bee plant), *Conium maculatum* (poison hemlock), and *Lotus corniculatus* (bird's foot trefoil).

2.4.4 Vegetation classification

Vegetation community types are distinct plant assemblages with a characteristic appearance (size, shape, spacing) based on their interaction with the landscape (e.g., topography, soils, hydrology, geology, climate, slope, exposure, disturbance, substrate) (CNPS 2022b). These distinct patterns formed the basis for habitat classification and description. Vegetation types were defined to the alliance- or more fine-scale associate-level (i.e., floristically driven classification units defined by structure and dominant and/or characteristic species) as described in the online edition of *A Manual of California Vegetation* (CNPS 2022b). Alliances were assigned when there was no listed association, or the defined associations were not relevant to the community type. Stands that are characterized by nonnative plant species are designated under semi-natural alliances. This standardized vegetation classification follows established protocols that conform with the State of California standard vegetation classification system. Provisional associations were created for distinct species assemblages that were frequently observed in similar landform position within the planning area. Available regional vegetation datasets (i.e., CALVEG, FRAP) were reviewed to assess baseline conditions but were not used for the development of the vegetation map due to their coarse scale. A vegetation map was developed to document the vegetation community types classified within the planning area, to inform design opportunities and constraints, and provide baseline information for the regulatory review process.

Available aerial photography (i.e., high-resolution [1.5-in pixel] orthorectified aerial photography created for the City of Eureka collected on July 24, 2019 [Office of Coastal Management 2020] and UAS-flown imagery collected on October 13, 2021 by Stillwater Sciences) were used to develop the map of existing vegetation community types. Aerial photography captured both low and high tide stages in the planning area. As such, the full extent of vegetation polygons were captured within the regularly flooded intertidal zone. Vegetation community polygon boundaries were digitized using photo-interpretive techniques that included the delineation of distinct vegetation signatures and the review of the NOAA 2014 and 2019 LiDAR-derived Digital Elevation Model (DEM) to assess surface topography and the landform position of vegetation communities. Vegetation community verification points were collected during the spring floristic surveys using the ArcGIS Collector application on handheld tablets (Samsung Galaxy Tablet, Apple iPad). Data collected were used to support the interpretation of vegetation community signatures in aerial photos, verify dominant vegetation signatures, and refine vegetation type boundaries. Alliance boundaries were mapped to canopy extent therefore mapped vegetation alliance boundaries may include overstory canopy over open water or herbaceous communities.

The vegetation map includes four native and two nonnative forest associations, six native and one nonnative shrubland associations, and 18 native and 10 nonnative herbaceous alliances/associations (Figure 2-38, Table 2-23). An overview of these mapped vegetation communities is provided in Figure 2-38 with a set of larger scale maps provided in Appendix B. Other cover types included developed/disturbed and open waters (Figure 2-38, Table 2-23). Since vegetation was mapped based on areal extent of vegetative canopy, open waters in the vegetation map are associated with waterways that lacked an overstory canopy. Extent of waters within the planning area are provided in Section 2.5. Development and disturbed areas were associated with agricultural land use (e.g., barns, access roads), paved roadways, private residential, and utilities (i.e., substation).

Table 2-13. Vegetation communities within the Elk River Planning Area 1.

Association	Alliance and cover types	Area (ac)	State[1] rank
Forest associations			
Alnus rubra Alliance	*Alnus rubra Forest Alliance* Red alder forest	4.5	S4
Hesperocyparis macrocarpa Ruderal	*Hesperocyparis macrocarpa - Pinus radiata Forest & Woodland Semi-Natural Alliance* Monterey cypress - Monterey pine stands	0.3	SNA
Pinus radiata Association		0.1	SNA
Picea sitchensis Alliance	*Picea sitchensis Forest & Woodland Alliance* Sitka spruce forest and woodland	1.3	S2
Salix lucida ssp. *lasiandra / Urtica urens - Urtica dioica* Association	*Salix lucida ssp. lasiandra Forest & Woodland Alliance* Shining willow groves	2.0	S3
Salix lucida ssp. *lasiandra* Association		0.6	S3

Association	Alliance and cover types	Area (ac)	State[1] rank
Shrubland associations			
Baccharis pilularis Association	*Baccharis pilularis Shrubland Alliance* Coyote brush scrub	9.2	S5
*Rosa nutkana Provisional**	*No associated alliance*	3.1	N/A
Rubus ursinus Association	*Gaultheria shallon - Rubus (ursinus) Shrubland Alliance* Salal - berry brambles	17.3	S4
Rubus armeniacus Association	*Rubus armeniacus - Sesbania punicea - Ficus carica Shrubland Semi-Natural Alliance* Himalayan blackberry - rattlebox - edible fig riparian scrub	5.8	SNA
Salix hookeriana Association	*Salix hookeriana - Salix sitchensis - Spiraea douglasii Shrubland Alliance* Coastal dune willow – Sitka willow- Douglas spirea thickets	5.4	S3
*Salix sitchensis - Salix scouleriana Provisional**		23.6	N/A
Salix sitchensis Association		1.1	S3
Herbaceous associations			
Alopecurus geniculatus Alliance	*Alopecurus geniculatus Provisional Herbaceous Alliance* Water foxtail meadows	2.4	S3?
Argentina egedii - Eleocharis macrostachya Association	*Argentina egedii Herbaceous Alliance* Pacific silverweed marshes	3.6	S1
Argentina egedii Association		29.3	S1
Cotula coronopifolia Association *See also Sarcocornia pacifica - Distichlis spicata/Atriplex prostrata - Cotula coronopifolia Complex*	*Atriplex prostrata - Cotula coronopifolia Herbaceous Semi-Natural Alliance* Fields of fat hen and brass buttons	0.3	SNA
Carex lyngbyei Alliance	*Carex lyngbyei Provisional Herbaceous Alliance* Lyngbye's sedge swathes	5.8	S1
Deschampsia (cespitosa, holciformis) Association	*Deschampsia cespitosa - Hordeum brachyantherum - Danthonia californica Herbaceous Alliance* Coastal tufted hair grass - Meadow barley - California oatgrass meadow	0.8	S3
Hordeum brachyantherum Association		12.9	S3
Distichlis spicata - Parapholis strigosa Association	*Distichlis spicata Herbaceous Alliance* Salt grass flats	4.3	S4
Distichlis spicata - Sarcocornia pacifica Association		13.1	S4
Distichlis spicata Association		1.2	S4
Eleocharis macrostachya Association	*Eleocharis macrostachya Herbaceous Alliance* Pale spike rush marshes	0.8	S4
Juncus effusus Association	*Juncus effusus Herbaceous Alliance* Soft rush marshes	19.3	S4?

Association	Alliance and cover types	Area (ac)	State[1] rank
Juncus (lescurii) - Distichlis spicata Association	*Juncus lescurii Herbaceous Alliance* Salt rush swales	1.8	S2?
Juncus lescurii Association		5.2	S2?
*Glyceria declinata and/or Cyperus eragrostis Provisional**	*No associated alliance*	2.3	N/A
Phalaris arundinacea Association	*Phalaris aquatica - Phalaris arundinacea Herbaceous Semi-Natural Alliance* Harding grass - Reed Canary grass swards	5.8	SNA
Sarcocornia pacifica - Distichlis spicata Association	*Sarcocornia pacifica (Salicornia depressa) Herbaceous Alliance* Pickleweed mats	26.5	S3
Sarcocornia pacifica - Distichlis spicata/Atriplex prostrata - Cotula coronopifolia Complex	*Sarcocornia pacifica Alliance and Atriplex prostrata - Cotula coronopifolia Semi-Natural Alliance Mosaic*	24.5	S3 or SNA
Scirpus microcarpus Pacific Coast Association	*Scirpus microcarpus Pacific Coast* (new pending Alliance) Small-fruited bulrush marsh	5.9	S2
Spartina densiflora Association	*Spartina (alterniflora, densiflora) Herbaceous Semi-Natural Alliance* Smooth or Chilean cordgrass marshes	2.5	SNA
Typha (latifolia, angustifolia) Association	*Typha* (*angustifolia, domingensis, latifolia) Herbaceous Alliance* Cattail marshes	0.9	S5
Zostera marina Association	*Zostera (marina, pacifica) Pacific Aquatic Herbaceous Alliance* Eelgrass beds	0.5	S3
Agricultural grassland associations			
Agrostis (gigantea, stolonifera) Association[2]	*Poa pratensis - Agrostis gigantea - Agrostis stolonifera Herbaceous Semi-Natural Alliance* Kentucky bluegrass - Redtop - Creeping bentgrass meadows	21.4	SNA
Agrostis stolonifera - Festuca arundinacea Association		96.3	SNA
Poa pratensis Association		69.1	SNA
Holcus lanatus Association	*Holcus lanatus - Anthoxanthum odoratum Herbaceous Semi-Natural Alliance* Common velvet grass - sweet vernal grass meadow	58.2	SNA
Lolium perenne - Festuca arundinacea Association	*Lolium perenne Herbaceous Semi-Natural Alliance* Perennial rye grass fields	136.1	SNA
Lolium perenne Association		171.6	SNA

Association	Alliance and cover types	Area (ac)	State[1] rank
Other			
Developed/Disturbed	Developed/Disturbed	30.1	SNA
Open Water[3]	Open Water	23.4	N/A

[1] State Rank
SNA No rating was provided where the eponymous species of an alliance/association was classified by a nonnative species (semi-natural alliances).
S1 Critically Imperiled – At very high risk of extirpation in the state due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors
S2 Imperiled – At high risk of extirpation in the state due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
S3 Vulnerable – At moderate risk of extirpation in the state due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
S4 Apparently Secure – At a fairly low risk of extirpation in the state due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
(?) Denotes an inexact numeric rank because we know we have insufficient samples over the full expected range of the type, but existing information points to this rank.

[2] Grouped with Agricultural grassland association however, had mixed land use with only some stands in active pasture (see Figure 2-39).

[3] Open water defined in this section refers to waters without overstory canopy. Section 2.5 provides details on delineated waterways subject to USACE- and State-jurisdiction throughout the planning area.

* *Classified within Elk River planning area 1 only, not a published MCV2 association/alliance. A pending Salix scouleriana Provisional Alliance is in review (K. Sikes, CNPS, pers. comm., 26 October 2022).*

Covering a total of 553 ac (~62%) of the planning area, most of the Elk River valley bottom was occupied by nonnative grassland associations related to active agricultural land use, primarily grazing pasture for dairy cows and hay production (Figure 2-38, Table 2-23). Leaky tide gates and degraded earthen berms along Elk River and Swain Slough have returned tidal influence back onto historical tidelands in and adjacent to ERWA and some parcels along Swain Slough. These tidally influenced locations are no longer managed for agriculture land use and thereby contain most of the native and naturalized herbaceous vegetation types documented in the planning area. Tidal regimes in reclaimed tidelands of Elk River and Swain Slough formed intertidal coastal salt marsh and brackish marsh communities that totaled approximately 99 ac of the planning area (Figure 2-39). The Elk River riparian corridor was narrowed by land use throughout the planning area. It was composed mostly of willow species, although a small stand of intact evergreen conifers was observed near the ERWA. Overall riparian vegetation in the planning area totaled approximately 39 ac (Table 2-23). Lowland swales and drainages throughout the valley bottom were composed of hydrophytic herbaceous species. Vegetation composed of hydrophytic wetlands within the planning area totaled ~70 ac (Table 2-12). Levee crests and upland earthen berms were composed of species assemblages associated with coastal scrub habitat (~30 ac) (Figure 2-39). Sensitive natural communities observed in the planning area and semi-natural alliances characterized by nonnative invasives in the region are described in the following sections.

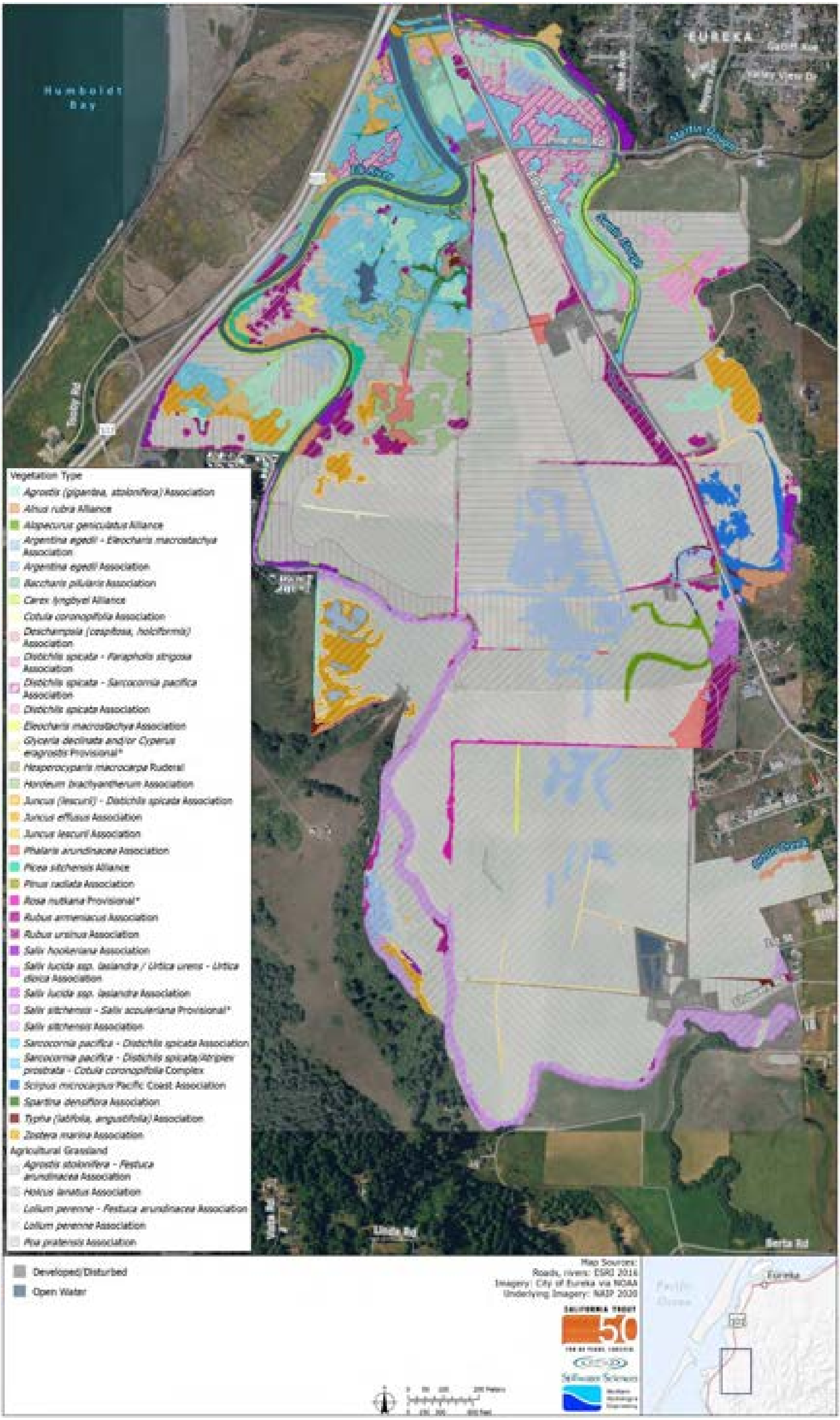


Figure 2-38. Vegetation cover types within the Elk River Planning Area 1.

2.4.4.1 Sensitive natural communities

Eighteen native vegetation associations in the planning area were listed sensitive natural communities with state ranks of 1, 2 and 3 (CDFW 2021) and totaled an approximate 129 ac (~16%) of the planning area, when excluding the mixed pickleweed, fat-hen and brass button complex (24.5 ac) (Table 2-22 and Table 2-23, Figure 2-38, Appendix B). These natural communities were primarily associated with reclaimed tidelands near the downstream end of the planning area and intact woody riparian vegetation. Table 2-13 provides a general description and condition of the observed sensitive natural communities in the planning area.

Table 2-14. Observed sensitive natural community descriptions within the Elk River Planning Area 1.

Sensitive natural community	General description
Picea sitchensis Alliance (Sitka spruce Forest, S2)	Small stand adjacent to Elk River along elevated gradient of earthen berm near Elk River Wildlife Area
Salix lucida subsp. *lasiandra / Urtica urens - Urtica dioica* Association *Salix lucida* subsp. *lasiandra* Association (Shining willow groves, S3)	Formed riparian cover along drainages near the perimeter of valley bottom. High cover stands with intact native understory including skunk cabbage, various ferns, and hydrophytic forbs. Often bordered by *Scirpus microcarpus* (small-fruited bulrush), *Urtica dioi*ca (stinging nettle), *Rosa nutkana* (Nookta rose), and *Rubus* spp.
Salix hookeriana Association *Salix sitchensis* Association *Salix sitchensis - Salix scouleriana Provisional* (Coastal dune willow – Sitka willow – Douglas spiraea thickets, S3)	Various willow stands formed most of the Elk River narrowed riparian corridor in the planning area. Land management activities have constrained woody shrubs and trees to the sloped channel banks and top of bank features. Very sparse overstory tree canopy with high clonal willow growth along/within channel. These associations had various levels of disturbance and the landward boundaries were grazed by livestock. Very dense canopy, multi-stemmed trunks, low to moderate herbaceous cover. A pending *Salix scouleriana* Provisional Alliance is in review. It is linked to post-fire disturbance areas and may be merged with another disturbance-related alliance (K. Sikes, CNPS, pers. comm., 26 October 2022).
Alopecurus geniculatus Alliance (Water foxtail meadow, S3?) *Argentina egedii* Association *Argentina egedii - Eleocharis macrostachya* Association (Pacific silverweed marshes, S1)	Stands formed in lowland swales within the valley bottom associated with historical flow pathways of Elk River, Swain Slough and other waterways and lowland features that have been reintroduced to tidal influence. Often located within agricultural pasture. Seasonally inundated with perennial saturated soils. Associated with freshwater and brackish wetlands within the planning area.
Carex lyngbyei Alliance (Lyngbye's sedge swathes, S1)	Stands are composed almost entirely of this special-status species that are occupying low regularly flooded intertidal channel banks. Very low disturbance by nonnatives (e.g., dense-flowered cordgrass) due to high densities. Overall, stands are of high quality and prevalent along most of the intertidal channels void of overstory vegetation.

Sensitive natural community	General description
Deschampsia (*cespitosa, holciformis*) Association (Coastal tufted hair grass meadow, S3) *Hordeum brachyantherum Lowland* Association (Meadow barley meadow, S3)	Composed of native coastal mesic grasses forming grassland communities along the elevated gradient surrounding estuarine wetlands in the planning area. Occurs along seasonally inundated features associated with high brackish marsh.
Sarcocornia pacifica - Distichlis spicata Association (Pickleweed mats, S3) *Juncus lescurii* Association (S2?) *Juncus (lescurii) - Distichlis spicata* Association (Salt rush swales, S2?)	This association, along with other native associations with state ranks of S4, comprise the intertidal coastal marsh (or estuarine wetlands) within the planning area. They are regularly or irregularly flooded by tidal waters of Elk River and Swain Slough depending on proximity to open water tidal drainages. Per regional intertidal coastal marsh classification (Schlosser and Eicher 2012), these associations had moderate to high cover and included emergent low salt marsh, emergent high salt marsh and emergent brackish marsh types based on salinities, plant composition, and site elevations within the planning area. *Spartina densiflora* (dense-flowered cordgrass) was documented throughout these types with low cover. However, dense patches throughout the coastal marsh were delineated and presented in Figure 2-39.
Sarcocornia pacifica - Distichlis spicata/Atriplex prostrata - Cotula coronopifolia Complex (Pickleweed mats, S3/Fields of fat hen and brass buttons, SNA)	This complex is composed of an emergent high salt marsh type and a semi-natural alliance that often occurs in seasonally flooded saline mudflats (CNPS 2022b) and described as an emergent brackish marsh type in the region (Schlosser and Eicher 2012). This complex occurred in the Elk River Wildlife Area in features that had longer seasonal inundation by brackish waters and varied salinity from fluctuating tidal waters. This complex was grouped to capture mudflat areas with sparse patchy cover by these two cover types. Within this complex, small patches of *Bolboschoenus maritimus* subsp. *paludosus* (saltmarsh bulrush) were noted in features that had longer inundation times.
Scirpus microcarpus Pacific Coast Association (Small-fruited bulrush marsh, S2)	This association occurred in areas subject to frequent inundation including roadside inboard ditches and lowland features adjacent to drainages. It often formed high cover (>80% relative cover) in delineated features and often was a transition between drainages and mesic grasslands in the planning area.
Zostera marina Association (Eelgrass beds, S3)	Patchy distribution of eelgrass was detected on sediment within the Swain Slough channel bed from the confluence with Elk River near HWY 101 bridge to around 620 ft upstream of the Elk River Road crossing in the planning area. Eelgrass density and percent cover were not evaluated within these patches. See Appendix C for photographs.

2.4.4.2 Invasive vegetation types

Semi-natural alliances in the planning area that were characterized by a species with a California Invasive Plant Council (Cal-IPC) rating of high (i.e., a species that has severe ecological impacts on physical processes, plant and animal communities, and vegetation structure) or were known to the region as having invasive tendencies, were defined as invasive vegetation types within the planning area. These stands can have detrimental impacts on the existing native species assemblages within planning area due to their widespread seed production and ease of dispersal, aggressive growth form, and ability to further establish and displace native vegetation. Understanding their habits and general distribution throughout the planning area is an important element to evaluating potential restoration and control measures for these species during the early development of the design.

Invasive vegetation types include *Rubus armeniacus* (Himalayan blackberry riparian scrub), *Phalaris arundinacea* (reed canarygrass swards) and *Spartina densiflora* (dense-flowered cordgrass marshes) semi-natural alliances. All are known to have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. When present, these invasive weeds often displace native species, reducing native species recruitment and overall species richness. These species each occupy different habitats within the planning area including estuarine, freshwater wetland and riparian features. As such, design concepts will include management and control of these species depending on the location and habitat in review.

***Rubus armeniacus* (Himalayan blackberry)**

Himalayan blackberry is a European native introduced to North America in 1800s and was naturalized along much of the west coast by the 1940s. It is a common invasive along California coastal habitats where it forms dense thickets in pastures, disturbed riparian corridors, roadsides, fencelines and right of way corridors. Once established in riparian corridors it can persist regardless of periodic inundation by fresh or brackish water (Randall and Hoshovsky 1996). It is a strong competitor that rapidly displaces native plant species by producing a dense canopy limiting access to light for understory native vegetation. When established in wildlife corridors it can inhibit passage by medium to large mammals as the dense thickets are comprised of thick vining stems with stout prickles that can become impenetrable. Dense thickets that surround infrastructure including farm buildings and fence lines are considered a fire hazard if not managed (Randall and Hoshovsky 1996). Himalayan blackberry is a large seed producer (up to 13,000 seeds per square meter) with a moderate seed life (Amor 1974). The most effective removal and control methods include mechanical removal and/or burning followed by herbicide treatment. Since Himalayan blackberry readily resprouts from roots and root crowns that can grow up to 8 inches in diameter, successful control will require the full removal of roots and root crowns (DiTomaso et al. 2013).

In the planning area, this species was documented from 39 stands that ranged in size from 2 ft^2 to just under 1 ac (0.97 ac) (Figure 2-39, Table 2-2, Appendix B).

Phalaris arundinacea (reed canarygrass)

Phalaris arundinacea (reed canarygrass) is a perennial, cool-season, rhizomatous grass in the family Poaceae. It is an aggressive invader of wetland areas, where once established, will outcompete and diminish native herbaceous communities with its spreading rhizomatous habit that forms a thick sod layer up to approximately 1.5 ft thick (Tu 2004). It forms dense, monotypic stands that clog waterways and displace herbaceous native and naturalized vegetation communities. Reed canarygrass thrives in saturated low-elevation wetlands and can tolerate prolonged periods of drought but does not survive in dry upland habitats (Tu 2004). Experiments conducted on reed canarygrass salinity tolerance indicate reduced biomass and growth rate (shoot growth) after exposure to brackish salinities (Dahlkamp et al. 2021) as well as decreased seed germination (Boyles 1985). Reintroduction or expansion of the tidal regime into tidally protected areas with reed canary grass has shown dieback of the species in the region. Although reed canarygrass thrives in freshwater wetlands, prolonged occurrence by high-water levels of at least 18 in upward to 24 in of water depth, and for a minimum time period of approximately eight months (e.g., November through June) is documented to prevent seed germination and kill rhizomes during the growing season (Annen et al. 2009, Gedik Biological Associates 2006). Tilling and solarization is an effective management strategy however, these control methods may be impractical to apply across large-scale infestations. Practitioners at multiple restoration sites noted herbicide application had a limited short-term effect on reed canarygrass control (Sikes et al. 2021). A common tool in restoration of reed canarygrass-infested wetlands along riparian corridors in the Pacific Northwest includes revegetation with native species to control above-ground and below-ground biomass through shade (overstory) and competition for nutrient availability (herbaceous emergent).

Eleven stands ranging from 0.2 to 2.2 ac were documented in the planning area. These were located along the southern extent of the ERWA, in patches within agricultural fields and near some infrastructure, as well as in patches of historic flow paths of Swain Slough and Orton Creek in the valley bottom (Figure 2-39, Table 2-22, Appendix B).

Spartina densiflora **(dense-flowered cordgrass)**

Spartina densiflora (dense-flowered cordgrass) is a perennial rhizomatous grass in the family Poaceae. Tolerant of high salinity environments, it can become established in higher tidal marshes where it has a negative effect on native plant populations and native wildlife and invertebrate communities. Dense-flowered cordgrass spreads by rhizomatous growth and water dispersal of seeds and rhizome fragments (DiTomaso et al. 2013). A recognized priority weed in Humboldt Bay, dense-flowered cordgrass is the target of several active eradication efforts associated with restoration projects throughout estuaries in the North Coast and Humboldt Bay. One currently underway and led by the City of Eureka, is taking place downstream of the planning area along the lower Elk River and its confluence with Humboldt Bay.

Eleven stands were documented within the planning area that ranged from 54 ft^2 to 1.4 ac. These were located along tidal drainages throughout the lower Elk River and Swain Slough in the planning area (Figure 2-39, Table 2-22, Appendix B).

2.5 Preliminary Delineation of Waters and Wetlands

A delineation of potential jurisdictional waters and wetlands and their transition to upland condition was conducted on October 18, November 30, and December 1, 2021, in accordance with the *Corps of Engineers Wetlands Delineation Manual* (1987 Manual, USACE 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0)* (USACE 2010). The delineation included any feature that could potentially meet the definition of a water protected under the Clean Water Act (and thus be subject to USACE-jurisdiction), Rivers and Harbors Act (USACE-jurisdiction), the Porter Cologne Act (SWRCB [State]-jurisdiction), Section 1602 of Streambed Alteration Agreement (CDFW-jurisdiction) and the California Coastal Act (CC-jurisdiction). USACE has jurisdiction over Waters of the U.S., including wetlands, pursuant to Section 404 of the CWA. Section 404 of the CWA applies to all Waters of the U.S., including wetlands, which are defined in the U.S. Code of Federal Regulations (33 CFR 328.3 and 40 CFR 120.2). Additionally, per Section 10 of the Rivers and Harbors Act, the USACE has jurisdiction over all waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide (i.e., navigable waters of the United States [U.S.]) as defined in 33 CFR 328.3 and 40 CFR 120.2.

The preliminary wetland delineation report for the Elk River planning area is provided in Appendix C. This report presents the field delineation methods and protocols, historical and existing conditions associated with wetland hydrology, soils, and climate, and detailed descriptions of the delineated jurisdictional waters and wetlands in the planning area. This section summarizes the results of the field and desktop investigations of jurisdictional waters and wetlands within the planning area. Appendix C should be referred to for protocol-level discussion on these features. All results are considered preliminary until verified by the San Francisco Regulatory Branch of the USACE. The USACE determines CWA jurisdiction of the wetland features in the planning area.

2.5.1 Preliminary navigable waters and other waters of the U.S.

The Elk River PA-1 contains 13.1 ac of USACE-jurisdictional tidal navigable waters subject to Section 10 of the Rivers and Harbors Act and Section 404 of the CWA, an additional 23.2 ac of Other Waters of the U.S. and 627.3 ac of potentially USACE-jurisdictional wetlands adjacent to these waters, both subject to Section 404 of the CWA (Table 2-24 and Figure 2-39, Appendix C). The potentially jurisdictional waters of the U.S. are also considered to be waters of the State under State- and CC-jurisdiction. In addition, there are 46.9 ac of wetlands and waters that are only subject to State- and/or CC-jurisdiction (Table 2-24 and Figure 2-39, Appendix C). Figure 2-40 presents an overview of the wetland delineation results, detailed large-scale figures are provided in Appendix C.

Table 2-15. Preliminary USACE-jurisdictional **features** in the Elk River Planning Area 1.

Description	Acreage
Navigable Waters of the U.S. (Section 10 and Section 404)	**13.1**
Elk River (tidal navigable waters) (W-1)	13.1
Other Waters of the U.S. (Section 404)	**23.2**
Elk River (estuarine tidal, excluding tidal navigable waters) (We1)	1.9
Swain Slough (estuarine tidal waters) (We2–We3)	3.9
Drainage (estuarine tidal waters) (We4–We8)	4.6
Elk River (riverine tidal) (Wr1)	5.8
Elk River (non-tidal waters) (Wn1)	2.5
Elk River Vegetated (woody riparian rooted within OHWM/HTL in estuarine/riverine tidal or non-tidal waters) (Wv1–Wv5)	4.4
Adjacent Wetlands (Section 404)	**627.3**
Estuarine Regularly/Irregularly Flooded Persistent Emergent (EF1–EF8)	83.9
Estuarine Aquatic Eelgrass Beds (EB1–EB2)[1]	0.5
Palustrine Seasonally Flooded-Saturated Persistent Emergent (SS1–SS7)	48.0
Palustrine Semipermanently Persistent Emergent (SP1–SP10)	26.3
Palustrine Seasonally Flooded Persistent Emergent (SF1–SF7)	443.0
Intermittently Flooded Broadleaved Deciduous Scrub-Shrub (BS1–BS8)	17.4
Intermittently Flooded Broadleaved Deciduous Forested (BD1–BD5)	8.4
Additional Waters of the State[2]	**46.9**
One-parameter wetlands within the Local Coastal Zone (OP1–OP6)[3]	45.3
Agricultural water treatment ponds (AG1)	1.6

1 Defined as vegetated shallows and protected under the Section 404(b)(1) of the CWA as “special aquatic sites” (40 C.F.R. § 230.43)

2 In addition to all listed USACE-jurisdictional features. These features are considered jurisdictional by the State based on definitions provided in Section 2.2

3 Most of the planning area is located within Coastal Zone Categorical Exclusion areas associated with Categorical Exclusion E-86-4.

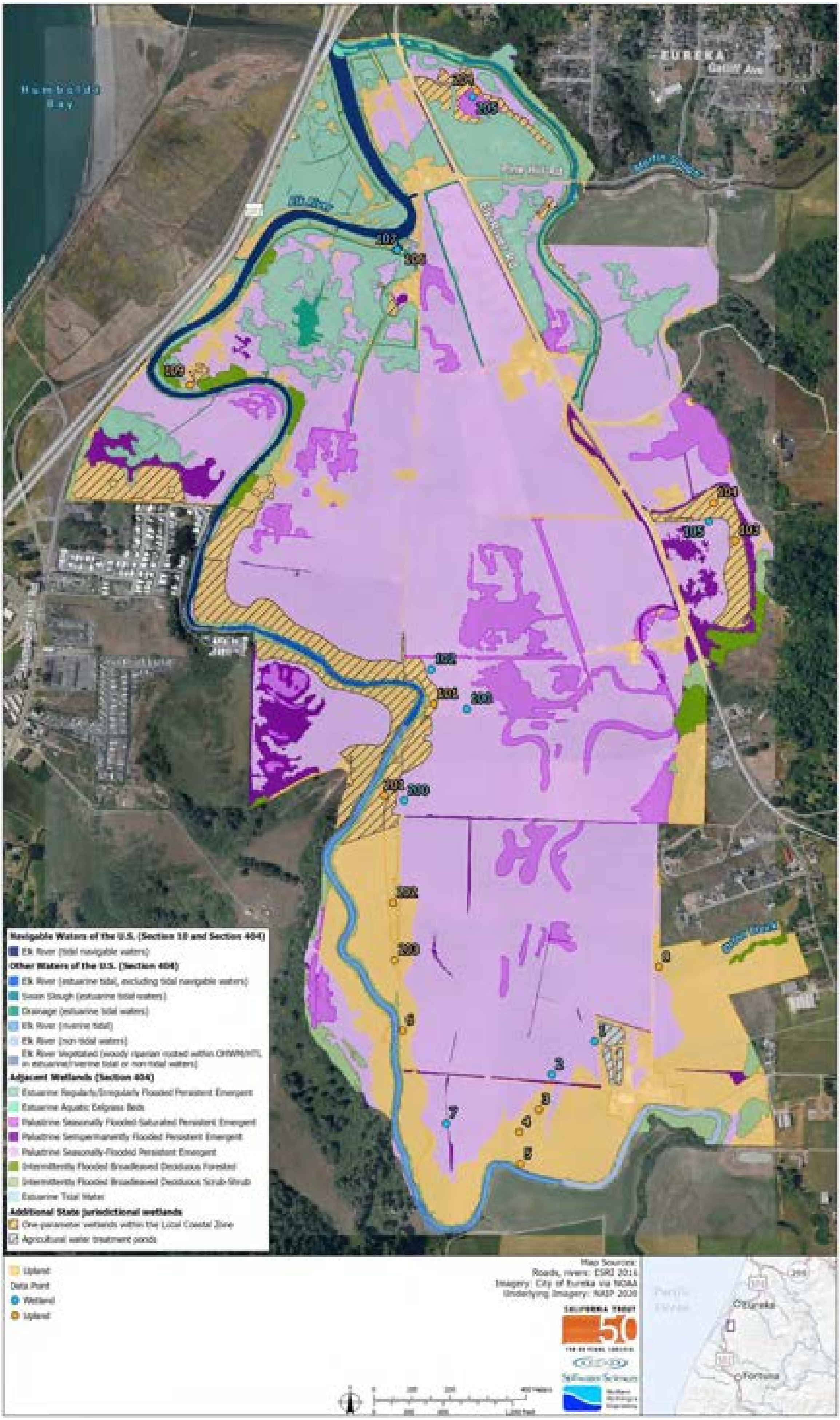


Figure 2-39. Preliminary jurisdictional waters and wetlands in Elk River Planning Area 1.

2.5.1.1 Waters of the U.S.

Per the *Navigable Waterways List* (USACE 1971), Elk River is a tidal navigable water of the U.S. subject to Section 10 jurisdiction. Its documented navigable length is 1.6 miles upstream from the Humboldt Bay confluence to the head of navigation landmark referred to as "Elk River Corners" (USACE 1971). This portion of the Elk River is subject to USACE jurisdiction under both Section 10 (jurisdictional navigable waters) and Section 404 (tidal waters of the U.S.) and was delineated by the MHW defined by the unconsolidated bottom and unconsolidated shore of Elk River main channel for the entire 1.6-mile documented navigable length (Appendix C). Based on the topography derived from LiDAR at this location (NOAA 2014), the Elk River estimated MHW contour elevation occurred at or below the MHW elevation reported at the tidal water level station Humboldt Bay North Spit, CA (Station ID 9418767) of 5.8 ft, NAVD88 reported for the 1983–2001 Epoch. Navigable waters of the U.S. totaled 13.1 ac in the planning area and excluded subtidal and intertidal vegetation that appeared below the MHW elevation (Table 2-14, Figure 2-40). These vegetated habitats were delineated separately and included *Zostera marina* (eelgrass, OBL) along the channel bed near the Swain Slough confluence and the lower border of the intertidal *Carex lyngbyei* (Lyngbye's sedge, OBL) population along Elk River. Eelgrass habitat is defined as vegetated shallows and is protected under the Section 404(b)(1) of the CWA as "special aquatic sites" (40 C.F.R. § 230.43). The intertidal sedge population was characterized as adjacent estuarine persistent emergent wetlands (Section 3.3.2)

Other Waters of the U.S. subject to Section 404 jurisdiction were associated with tidal (estuarine and riverine) and non-tidal waters and totaled 23.2 ac in the planning area (Table 2-24, Figure 2-39). Estuarine tidal waters in PA-1 totaled 10.4 ac and included Swain Slough (4.6 ac), portions of Elk River–excluding waters already captured as tidal navigable waters (1.9 ac), and adjacent drainages with direct surface water connections (including leaky tide gates) to Elk River and Swain Slough (4.6 ac) (Table 2-24, Figure 2-39, Appendix C). These tidal estuarine waters in PA-1 measured monthly average daily salinity values of 10 to 31 throughout the year. The HTL in delineated estuarine tidal waters in PA-1, often included coastal intertidal marsh habitat. These estuarine tidal wetlands were classified separately and as such, the transition to these intertidal wetlands defined the upper extent of estuarine tidal waters in the planning area.

In Elk River, estuarine tidal waters transitioned to riverine tidal approximately two miles upstream from the HWY 101 bridge at MSR2. The continuous monitoring measurements recorded in 2021 just upstream of this location (ES-3) measured monthly mean daily salinities of less than 0.5 ppt except from June–October that measured less than 3 ppt. Riverine tidal waters totaled 5.8 ac and were delineated by the OHWM using LiDAR-derived topography to assess break in slope of the channel bed and the top of bank locations along with site characterization. Often narrowed riparian corridors had woody vegetation rooted along the sloped channel banks that occurred within the OWHM/HTL of Elk River. In the planning area, those features were characterized as "Elk River Vegetated" waters (4.4 ac) in order to capture the waters extent as well as delineate the channel and riparian condition in the planning area (Table 2-24, Figure 2-39, Appendix C). Tidal waters of the U.S. in the Elk River transitioned to non-tidal waters upstream of station 25,000 where the bed elevation of the channel was equal to the highest tide on record and totaled 2.5 ac in the planning area (Wn1, Table 2-24).

2.5.1.2 Wetlands

Wetland types within PA-1 include both non-tidal (i.e., palustrine seasonally flooded, seasonally flooded-saturated persistent, and semipermanently flooded emergent wetlands and palustrine intermittently flooded broadleaved deciduous scrub-shrub or forested wetlands), and tidal (i.e., estuarine regularly/irregularly flooded persistent emergent wetlands).

Palustrine seasonally flooded emergent wetlands

Palustrine seasonally flooded emergent wetlands were the most prevalent wetland type in the planning area totaling 443 ac, just over half of the planning area (Table 2-24). These wetlands were primarily coastal mesic grasslands actively used for cattle and dairy ranching and hay production. The grassland species assemblages had low plant diversity and were composed primarily by facultative pasture grasses and forbs, indicative of decades of controlled vegetation management in this region. Landforms were mostly flat with a gradual rise towards Elk River embankments or other surrounding infrastructure (Figure 2-39).

Uplands adjacent to palustrine seasonally flooded emergent wetlands were defined by landscape position (height above the valley floor) and adjacent infrastructure associated with development such as roads, highways, and roadside berms (Figure 2-39). In general, constructed features in the planning area (e.g., paved roadways, agricultural dirt or gravel access roads, barns, homes, water treatment ponds, substation) were delineated as uplands. Vegetated uplands were defined by the elevated raised berm surrounding the right bank of Elk River through much of the valley bottom (Figure 2-39). Forage grasses and forbs commonly found within North Coast pasture lands have facultative (FAC) wetland ratings. As such, dominant vegetation at data points sampled within pasture will often pass the dominance test for hydrophytic vegetation. When hydric soils and/or wetland hydrology indicators are lacking, the species assemblage was considered an artifact of decades of continuous agricultural management to maintain cover by these species, rather than these species growing as hydrophytes on the landscape. When dominant vegetation was not indicative of the wetland upland transition in the planning area, uplands were delineated based on topography (i.e., the height above the valley floor or elevation contour where data points lacked one or more wetland parameters). In the Coastal Zone, any vegetated feature with one or more observed wetland indicators were categorized as CC-jurisdictional wetlands (Table 2-24, Figure 2-39) (Appendix C).

Palustrine seasonally flooded-saturated/semi-permanently flooded emergent wetlands

Seasonally flooded-saturated emergent wetlands totaled 48 ac in the planning area and were characteristic of lowland areas within the palustrine seasonally flooded emergent wetlands (Table 2-24, Figure 2-39). They were characterized by a mosaic of undulations and shallow swales along the valley floor formed by the historical flow pathways of Elk River, Swain Slough, Orton Creek, and other waters (Figure 2-39). Along the lower extent of the planning area, these lowland features have formed over the last few decades from the reintroduction of daily tide cycles (Figure 2-40). Vegetation in these wetlands were typically composed of hydrophytic forbs and graminoids common in freshwater to brackish conditions with varying cover.

Semi-permanently flooded wetlands were in swale and roadside drainages often near infrastructure (roadways, berms), toe slopes (where the valley floor met hillsides or development), and agricultural ditches and composed 26 ac of the planning area (Table 2-24). These sites often contained stout hydrophytic perennial graminoids like *Scirpus microcarpus*, *Carex obnupta*, *Juncus effusus, Typha latifolia*, along with *Oenanthe sarmentosa* (water parsley, OBL) (Figure 2-39).

Both wetland types were in lowland features and drainages within the planning area and therefore were bound by palustrine seasonally flooded emergent wetlands. Exceptions occurred where these features abutted infrastructure associated with development. At these locations the upland boundary was delineated by the edge of development (Figure 2-39).

Palustrine intermittently flooded broadleaved deciduous scrub-shrub and forested wetlands
Palustrine scrub-shrub and forested wetlands formed most of the riparian corridor along Elk River in PA-1 and totaled 17 and 8 ac, respectively. Due to agricultural land practices the riparian corridor has been narrowed and woody vegetation was restricted to immediate channel banks along Elk River. Willows were most often rooted on the sloped channel banks of the Elk River channel, primarily below the top of bank or OHWM/HTL (Table 2-24). Acreage associated with vegetation rooted below top of bank was not included in these wetland categories but rather characterized as Vegetated-Other Waters of the U.S. (Table 2-24). Broadleaved deciduous scrub-shrub wetlands were primarily composed of *Salix hookeriana* (coastal willow, FACW), *Salix sitchensis* (Sitka willow, FACW), and *Salix scouleriana* (Scouler's willow, FAC). Herbaceous understory species included creeping buttercup, *Holcus lanatus* (velvet grass, FAC), rye grass, *Carex lyngbyei* (Lyngbye's sedge, OBL), *Dryopteris expansa* (expanding wood fern, FACW), and patches of *Rubus armeniacus* (Himalayan blackberry, FAC). Although the upper extent of jurisdictional waters may have included the root crown for individuals within these woody stands, the outer extent of these palustrine scrub-shrub and forested wetlands were captured by the edge of riparian canopy that typically extended beyond the top of bank.

Palustrine broadleaved deciduous forested wetlands included mostly a patchwork of *Salix lasiandra* (Pacific willow, FACW) and *Alnus rubra* (red alder, FAC) but also a small *Picea sitchensis* (Sitka spruce, FAC) stand (Figure 2-39). Stands to the east occurred along toeslopes adjacent to Elk River Road and along the historic channel network of the valley floor. Other stands were immediately adjacent to Elk River bordering the estuarine wetlands just above benches composed of intertidal estuarine wetlands (Figure 2-39).

The upland border to scrub-shrub and forested wetland types in the planning area were defined by a distinct change in vegetation to pasture grassland or to coastal scrub habitat. The upland delineation in the pasture was characterized at the height above the valley floor where data points lacked hydric soils and/or wetland hydrology. Coastal scrub uplands were documented along raised berms and road prisms throughout the planning area. These features defined the typical upland boundary to palustrine forested/scrub-shrub wetlands in the vicinity of the ERWA (Figure 2-39). Dominant vegetative cover was composed of California blackberry or coyote brush along with herbaceous species *Achillea millefoliata* (common yarrow, FACU) and nonnative *Raphanus sativus* (cultivated radish, NL/UPL). Both hydric soils and primary wetland hydrology indicators were at sampled locations in these uplands.

Estuarine persistent emergent wetlands
Estuarine persistent emergent wetlands were the second most prevalent wetland type documented in the planning area with 84 ac, or 10% (Table 2-24). The vegetation classification described in Section 2.4.4 of the intertidal coastal marsh and brackish marsh communities in the planning area was used to characterize the boundaries of regularly and irregularly flooded estuarine persistent emergent wetlands. Estuarine persistent emergent wetlands in the planning area ranged in ground surface elevation from 6.5 to 8.5 ft (NAVD88). This elevation range correlated with the 2022 estimated HTL/MHHW extent for Elk River and Swain Slough tidelands (7–8.6 ft). As such, tidal waters of the U.S. were adjusted to the lower extent of these estuarine wetlands so as to only include open waters and unvegetated mudflats and channels. These wetlands were classified based on vegetation community types characterized by dominant halophytes including S*alicornia pacifica* (pickleweed, OBL), *Spartina densiflora* (dense-flowered cordgrass, OBL), *Distichlis spicata* (salt grass, FACW), *Juncus lescurii* (salt rush, FACW), *Atriplex prostrata* (fat-hen, FAC), *Cotula coronopifolia* (common brass buttons, OBL), and *Carex lyngbyei* (Lyngbye's sedge, OBL). Tidal flood regime (regular/irregular) was based on the wetlands proximity to open tidal

channels and rise in elevation. Regularly flooded estuarine wetlands included emergent low salt marsh benches adjacent to Elk River and Swain Slough and adjacent drainages. Irregularly flooded features were often muted by leaky tidegates or by their distance from a tidal channel. These typically included emergent high salt marsh and brackish marsh communities.

Uplands surrounding estuarine habitats in the planning area were delineated along the elevated features associated with relic earthen berms and existing levees. Dominant vegetation at these locations included upland coastal scrub species and data points confirmed no hydric soils or wetland hydrology indicators were present (Appendix C). Uplands associated with levees and earthen berms along Elk River and Swain Slough were delineated using LiDAR-derived topography alongside the mapped coastal scrub vegetation polygons (e.g., coyote brush and California blackberry stands) and as such, excluded eroded or scoured areas transitioning towards wetland conditions (Figure 2-39).

Additional state-jurisdictional wetlands

In addition to all potential USACE-jurisdictional waters and adjacent wetlands described in above, an additional 45 ac of potential CC-jurisdictional wetlands and just under two acres of additional waters of the state (agricultural water treatment ponds) were identified in the planning area (Table 2-24, Figure 2-39). Boundaries for these wetlands were delineated from data points with at least one positive primary wetland parameter located within the Coastal Zone.

One-parameter wetlands within the Coastal Zone of Planning Area 1 included features in the former tidelands that were in transition from agricultural grassland to estuarine wetland habitat due to increased tidal influence from malfunctioning tide gates and failure of earthen berms surrounding lower Swain Slough. Hydric soils were confirmed but both wetland hydrology and dominant hydrophytic vegetation were absent (Appendix C). The sampled one-parameter wetland characteristic of USACE upland grasslands in the downstream areas of the planning area, was documented along an elevated band without hardscaped protection and surrounded by estuarine wetlands. The adjacent wetlands had converted from agricultural land use to salt marsh and brackish marsh communities from continued tidal influence over the last few decades.

Coastal scrub habitat along the levees lacked all three wetland parameters and were not considered state jurisdictional features in the Coastal Zone (Figure 2-39). Coastal scrub habitat composed most of the uplands along the elevated features along Elk River and some portions of the Swain Slough. Features attributed to agricultural pasture were included as one-parameter wetlands although their facultative grass/forb species composition was considered a product of land management rather than natural occupation by hydrophytic vegetation. No additional one or two parameter wetlands were identified in the Coastal Zone as the other upland habitats delineated within the Coastal Zone were associated with development (Figure 2-39).

2.6 Land Use and Infrastructure

2.6.1 Land use

Planning Area 1 is composed of 35 parcels, owned by 8 landowners. The parcels are zoned as AE (agricultural exclusive) and AG (agricultural general). Land uses include ranching (cattle), rural residential homesteads, and public lands (Elk River Wildlife area). Land use and zoning for the Project Area, as well as those parcels currently enrolled in the Williamson Act, are shown in Appendix B of California Trout et al. (2022).

2.6.2 Infrastructure

A wide variety of infrastructure relevant to enhancement design and planning is found within Planning Area 1, including bridges, utility lines (water, gas, electricity, fiber optic cables), levees, culverts, tide gates, drainage ditches, private residences, commercial dairy infrastructure (barns and treatment ponds), and private and county roads, and Hwy 101 (Figure 2-40).

There are two road crossings on Elk River in the PA-1 and three road crossings on Swain Slough. The HWY 101 Bridge crosses the Elk River at the downstream project boundary and private bridge crosses Elk River at STA 20,930. Elk River Road crosses Swain Slough 520 ft and 4,850 upstream of the confluence. Pine Hill Road crosses Swain Slough 2,660 ft upstream of the confluence.

Fiber optic cables are owned by AT&T and are located above ground on poles along Elk River Road and Pine Hill Road. AT&T poles and lines in the ERWA and along Pine Hill Road west of Elk River Road are in the process of being removed.

Constructed levees are concentrated in the northern portion of PA-1 (Figure 2-40). Breaches, or eroded areas of levees were identified by field surveys; however, dense vegetation on the levees limited identification of all eroded areas. Levee length, stationing, number of breaches and locations are summarized in Table 2-25.

Constructed levees occur along the river left side of Elk River (looking downstream) from Hwy 101 (STA 7,800) to STA 10,900. This levee was intentionally breached at two locations to allow full tidal exchange to the northern portion of the ERWA. The highway acts as a levee upstream to STA 12,300. A portion of this levee appears to be a remnant of Pine Hill Road that extended across Elk River.

Constructed levees occur on river right of Elk River from the confluence with Swain Slough to about STA 12,800. These constructed levees are breached in several locations due to erosion and the aging of infrastructure. A broad section of levee appears to be missing/eroded between the just downstream of tide gate at Sta 9,650 (T22 Appendix A Figure A-1) and the road at the downstream end of the levee on ERWA. The constructed levees on ERWA appear to grade into natural sediment levees upstream of STA 12,800. Low constructed levees may occur upstream, but they are difficult to distinguish from the natural sediment levees and dense vegetation prohibits accurate mapping of constructed levees. In addition, the elevated areas along the channel margins that appear to be constructed levees upstream of STA 12,800 appear to consist of the native soil that was redistributed when drainage ditches are cleaned out, rather than formal levee construction with engineered and/or compacted materials. In the southern portion of the project area, a levee occurs along Showers Road is actively managed and extends downstream to about STA 25,500. A short, elevated segment along the channel margin that may be a constructed levee occurs near STA 24,400.

Swain Slough is constrained by levees of variable height and integrity. On river left (looking downstream) a fairly continuous levee occurs from the confluence with Elk River to the tide gate at Elk River Road. The levee has several low areas that are vulnerable to overtopping and the levee has been breached in several locations, allowing frequent tidal inundation of the parcel (Figure 2-40). A tide gate near Elk River Road bridge has failed. On river right a section of levee occurs from the confluence with Elk River to Elk River Road bridge crossing, and between Pine Hill Road and the tide gate at Elk River Road. The levee section between Pine Hill Road and Elk River Road on river right was upgraded recently.

Constructed levees occur within the ERWA along a primary drainage channel that extends upstream from the failed tide gate at Sta 9,660 (T22 Appendix A Figure A-1). The levee is generally intact though there may be unmapped breaches.

Culverts and tide gates were inventoried in the project area. Coordinates, material type, and dimensions for each structure and maps with culvert IDs are provided in Appendix A. Fifty-four culverts and 18 tide gates were identified in the project area. The majority of culverts are less than 2 ft in diameter and less than 75 ft in length and associated with crossings of the drainage ditches. There are five long culverts from 320 to 1400 ft in length. Four of the long culverts occur in the southern portion of PA-1 (Appendix A, Figure A-2). One culvert (C-250E) is 1,100 ft long and drains a substantial section of agricultural fields and the second is approximately 1,400 ft in length (C-105) and routes Orton Creek to the Elk River near the dairy barn at the southern boundary of PA-1 (STA 26,200). A 320 ft culvert drains from a ditch east of the dairy barn and connects to C-105 at an unknown location. The culvert does not have a tide gate, so it allows Elk River flow to drain through the culvert into the ditch at high flows. A 350 ft culvert (C-102) drains a large drainage ditch that runs perpendicular to the valley and enters the Elk River at near STA 19,150. The outlet of the culvert was not found, but it assumed not to have an attached gate as the landowner reports that Elk River floods through the culvert at high flows/tides into the drainage ditch. The only long culvert (440 ft) in the norther portion of PA-1 (C-8) is near the intersection of Pine Hill and Elk River Roads. This culvert delivers water from the roadside drainage ditch to the Elk River through the culvert and a tide gate (Appendix A, Figure A-1).

A network of drainage channels and swales occurs in PA-1 which generally routes water to Elk River and Swain Slough. Approximately 91 drainage channels were identified from air photography, LiDAR data and ground surveys (Figure 2-40). The surveyed thalweg and typical dimensions of the channels were used to improve the representation of these features in the existing topography. Additional historic swales occur throughout PA-1 that influence flow paths, but these features tend to be considerably shallower than the primary drainage system that is maintained by the landowners.

Water service is provided by Humboldt County Services District along Elk River Road to 6562 Elk River Road. The HCSD water line runs from Severt Lane to Pine Hill Road, through the ERWA. The top of the water line is buried approximately 3 ft below ground, except where it crosses a slough channel and Elk River. At these locations, the water line is elevated above the adjacent marsh plain/river. The buried lines are two 8-in pipes that are 5 ft apart. One of the pipes is polyvinyl chloride (PVC) and the other is asbestos-cement (AC). These pipes converge to a single 16-in ductile iron pipe to cross the Elk River, then split back into two 8-in pipes. There is a valve box located on the existing levee and a metering station in the paved portion of the Pine Hill Road extension. The water line has had two failures in recent years.

There is no public sewer service in PA-1. All residences are on septic systems. Public sewer ends near Walnut/Ridgewood, just east of Eggert Road.

Pacific Gas & Electric (PG&E) related infrastructure includes a substation, located on the west side of Elk River Road, power lines and gas lines. PG&E plans to abandon the northern most gas line (L-126B) in 2025. The southern gas lines (L-126A/177) will remain active (Figure 2-40).

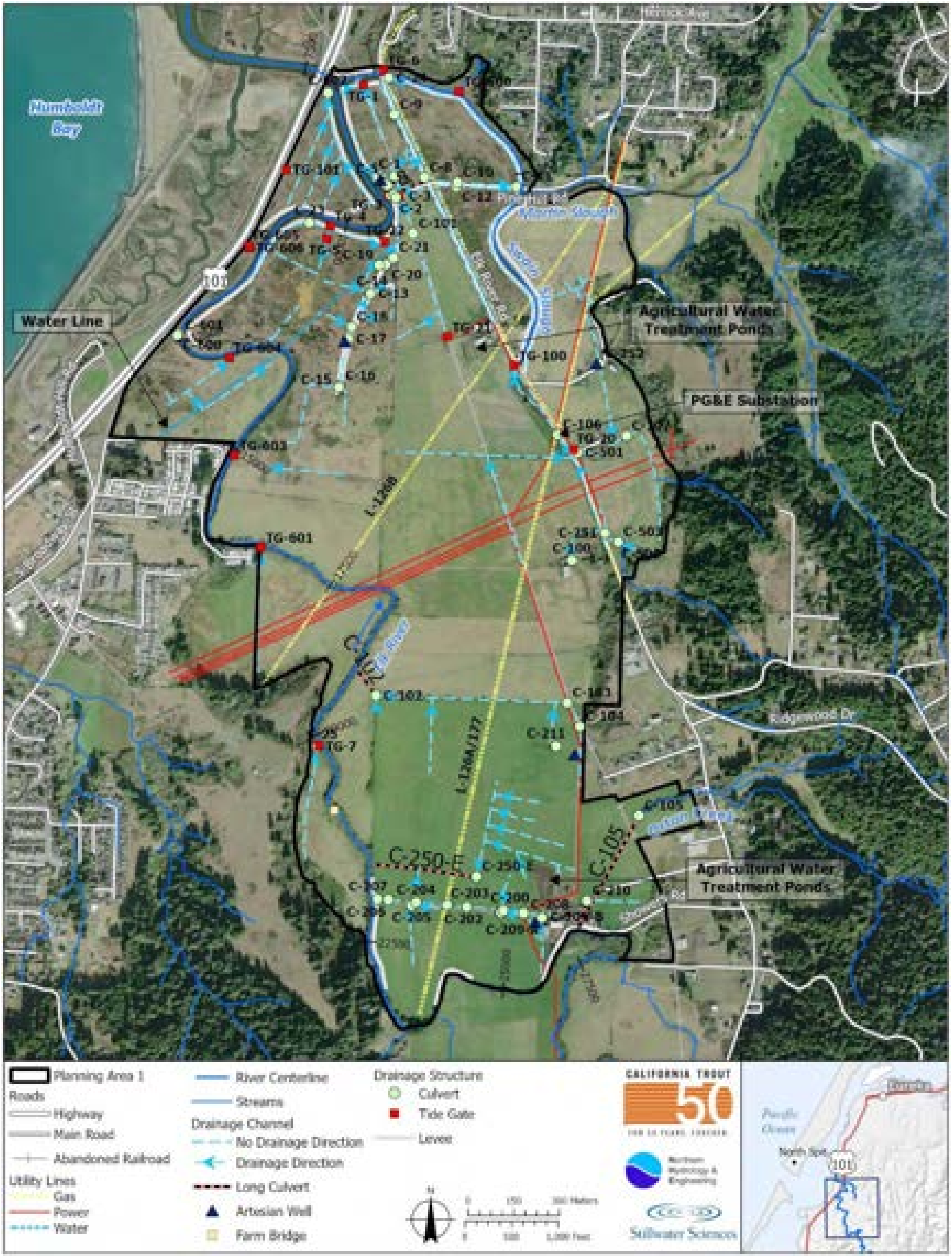


Figure 2-40. Existing infrastructure map of Planning Area 1.

Table 2-16. Summary of constructed levees.

Location	River Station	Length (ft)	Number of breaches	Location of breaches
River left of Elk River	7,800–10,900	3,100	2	8,370 and 9,160
River right of Elk River from confluence with Swain Slough to Pine Hill Road	7,920–9,230	1,275	1	8,430
River left of Elk River, upstream of Pine Hill Road	9,300–12,800	3,500	2	9,590 and 12,340
Internal Elk River Wildlife Area	9,640	3,125 (2 levees)	Not mapped	Not mapped
River right of Elk River near Showers Road	25,522-26,432	910	0	-
River right side of Swain Slough from confluence to Elk River Road	20–420-	400	0	-
River right side of Swain Slough from confluence to Elk River Road	70-230 and 300–450	310	4	240, 350, 450, 480
River left side of Swain Slough from Pine Hill Road to tide gate at Elk River Road	600–2,640	1,970	2	600, 1,350-1,620
River right side of Swain Slough from Pine Hill Rd to tide gate at Elk River Road	2,720–4,850	2,250	0	-
East side of Swain Slough from Pine Hill Road to tide gate at Elk River Road	2,700–4,850	2,010	1	2,960

3 10% DESIGNS

The Lower Valley and Tidal Estuary (Planning Area 1) of Elk River present an enormous opportunity for ecological uplift, increased productivity of working lands, and improved public access. In the Estuary, hundreds of acres of former tidal marsh and riparian habitat on both public and private lands are degraded and in need of restoration. Aquatic habitat in the Elk River mainstem, slough channels, and along the stream-estuary ecotone—critical zones for juvenile salmonids and other estuarine-dependent fish species, crustaceans, amphibians, and other aquatic life—requires intervention to regain some of its former value. Drainage infrastructure requires repair and modernization to recreate flow patterns benefitting natural resources and agricultural land uses. These improvements, along with a managed sea-level rise retreat strategy, set the stage for expanded public access that will be planned and designed in future phases of work.

The lower Elk River valley is now being rapidly altered by sea level rise. Mean tide elevations in Humboldt Bay have already risen an estimated 19 in over the last century (NOAA 2022) and sea levels at the North Spit gage in Humboldt Bay are expected to rise 3.1 to 10.9 ft by the end of the century, increasing 4.8 to 23 ft by 2150 (OPC 2018). The most effective response to sea level rise in the lower Elk River is a managed retreat strategy (Laird 2014, 2015), in which unproductive are actively restored to tidal marsh habitat and retreatment strategies are developed for at-risk agricultural lands. Restoration of tidal marsh will reinvigorate and accelerate sediment accretion processes, which enable natural habitats to adapt and persist, and increase resilience of sensitive species to other stressors.

The primary restoration approach in the tidal reaches is to restore natural tidal and fluvial drainage patterns in the lower Elk River valley, by:

1. altering the type and configuration of drainage infrastructure (drainage ditches, culverts, tide gates, pasture bridges);
2. restoring slough and tidal channel connectivity to the mainstem Elk River by reducing or removing constructed levees;
3. reconnecting freshwater springs, seepages, and tributaries; and
4. recontouring portions of the floodplain through strategic placement of excavated sediment material to help direct winter flood-flows down the valley through floodplain channels that connect into appropriately sized tidal channel networks.

Once more natural drainage patterns have been established, natural habitats can be enhanced or restored at appropriate locations to benefit threatened fish, wildlife, and plant species.

The following sections describe our conceptual restoration and enhancement designs. These proposed actions are based on recommendations first presented in the Elk River Recovery Assessment (CalTrout et al. 2019). Actions were then evaluated in close collaboration with landowners, land managers, and resource agency scientists as part of the Elk River Stewardship Program. Actions vetted by this group were further refined based on more detailed site-specific studies of existing conditions.

The following design sections in this chapter are ordered as follows:

- **Section 3.1 Design guidelines and constraints**: provides the overarching guidelines for the design of features for Elk River, including PA-1. These guidelines were initially developed for South Fork Elk River and expanded to include PA-1. Constraints are specific to PA-1 and include infrastructure, landowner, fisheries, vegetation, and flooding.
- **Section 3.2 Design concepts**: provides a description of the types of restoration concepts and their benefits.
- **Section 3.3 Enhancement sites**: identifies the specific sites where the design concepts are applied and provide site specific information, including proposed alignments, footprint (area), site specific constraints, and benefits.
- **Section 3.4 Hydraulic model results**: summarizes the existing and design frequency and duration of flooding, and changes to flow depths, and velocities over a range of stream flows and tides. Refer to Appendix F for more detailed information on model development and findings.
- **Section 3.5 Climate Change:** summarizes key climate change vulnerabilities and next steps for a climate change analysis.
- **Section 3.6 Summary of Project Benefits and Regulatory Assessments:** description of project benefits and regulatory strategy.

An idealized design process has a series of design steps that have an increasing amount of refinement and analysis. However, at any design step, analyses may indicate necessary design adjustments or revisions. Similarly, a new or unforeseen constraint or opportunity may arise that requires a major shift in the design. There are some design components or sites in PA-1 that have a higher level of certainty that designs, as shown and analyzed, will move through the next design phases as a series of refinements and could, as individual sites, be at a more advanced design level than 10%. Other sites have potential opportunities (e.g., through land acquisitions) that will create substantially different opportunities than were considered in this design phase. Other sites will affect agricultural operations, and design dimensions may need to be further adjusted to accommodate those changes in the next design phase. Where these uncertainties are known, they are described in the Enhancement Site section. The design level described in this report (10%) is meant to convey the status of the overall design.

3.1 Design Guidelines and Constraints

Preliminary design guidelines were developed based on geomorphic, aquatic, and vegetation assessments in Elk River PA-1; recommendations from the technical advisory committee for the Elk River Estuary; and literature values. These guidelines are currently at the 10% conceptual design level and are expected to be refined as the project progresses in later phases.

Table 3-1. Preliminary design recommendations and supporting information for Elk River PA-1 10% designs.

Feature/Issue	Guideline	Notes/References
Aquatic habitat		
Alcove, side channel, pools, riffles	Enhance features where they currently exist, or a forcing feature (e.g., large wood) is installed to maintain the feature.	Recommendation from TAC and professional judgement.
Target flow range for habitat restoration	Low flow—~1-year Full tidal range.	Habitat enhancement actions should be designed to function optimally at these flow ranges.
Pool-to-pool spacing	1–5 channel widths	Carroll and Robison (2007), Keller et al. (1985), Montgomery et al. (1995), Buffington and Montgomery (2002).
Residual pool depth for salmonid summer rearing	2–6 ft	General guidelines based on Beecher et al. (2002) habitat preferences for juvenile Coho Salmon and NMFS (2012) habitat complexity indicators for salmonid rearing, and channel size in the Project reach. Deeper pools particularly important for age 1 and older juvenile steelhead.
Depth of alcoves at summer base flow	1–4 ft	Beecher et al. 2002
Side channel entrance inundation design flow	≤ 10% exceedance	Habitat assessment in SF Elk River.

Feature/Issue	Guideline	Notes/References
Side slopes of excavated habitat features	Use low slopes to create gradual transitions (e.g., 10H:1V) where possible.	Professional judgement to maximize edge habitats, with consideration for site-specific factors (e.g., bank stratigraphy and existing vegetation).
Water velocity for Coho Salmon rearing habitat	0–0.6 ft/s	Beecher et al. (2002) showed that juvenile Coho Salmon preferred water velocities < ~ 0.6 ft/s. Laboratory flume studies indicate that they will often select velocities approaching zero when given the choice (Katzman et al. 2010).
Escape cover	> 30% of wetted channel area obscured by cover.	Based on professional judgement and NMFS (2012) habitat complexity indicators. Primarily due to water depth, large wood, small woody debris, undercut banks, and overhanging vegetation.
Winter refugia habitat	Provide high quality low-velocity (<0.6 ft/sec) habitat that is accessible/connected over the range of design flows—especially winter flows.	Beecher et al. (2002), Katzman et al. (2010)
Turbidity	Create off-channel seasonal or perennial ponds near springs and provide access to lower turbidity tributaries to create lower turbidity winter habitat with more favorable growth conditions for juvenile salmonids.	Turbidity is expected to increase as a result of climate change (Curtis et al. 2021). See Martin et al. (2019) for turbidity effects on salmonids
Large wood debris		
Minimum large wood size	<u>Key Piece</u> >75 ft long and >1 ft DBH, or >50 ft long and >2 ft DBH, or >25 ft long and >3 ft DBH.	Fitzgerald (2004) and professional judgement based on field assessment of sizes of wood that would be stable and trap other debris in the Project reach, with consideration for site-specific risks (e.g., related to potential bank erosion, infrastructure, and flood inundation).
Large wood frequency (pieces/100ft)	5–19	Fitzgerald (2004), Carroll and Robison (2007), HRC (2015).
Large wood volume (ft^3/100ft)	420–1,340	Fitzgerald (2004), Carroll and Robison (2007), HRC (2015).
Large wood key piece frequency (pieces/100ft)	1	Fitzgerald (2004), HRC (2015).
Large wood mobility	Variable, similar to natural systems.	Address risk of wood to infrastructure
Large wood decay	15–25-year period	Typical decay rates for coniferous species.

Feature/Issue	Guideline	Notes/References
Planform stability		
Avulsion across residential property	No increase in risk of avulsion across residential properties.	Address risk of avulsion through design overbank roughness created with large wood and vegetation mgmt. where possible.
Stream boundary construction techniques	Employ techniques that also provide margin shelter and riparian habitat.	Employ biotechnical techniques where possible.
Riparian vegetation		
Riparian forest enhancement – Nonnative weed management	Reduce and control expansion of invasive nonnative species in the riparian understory. Reduce future nonnative plant establishment in design features with upland weed removal.	Requires development of a nonnative weed management strategy and implementation plan.
Riparian forest enhancement – Interplanting	In the riparian corridor, establish a more diverse habitat structure and varied native species assemblage by interplanting in the mesic frequently, infrequently, and rarely flooded planting zones.	Implement with removal of nonnatives, restore native understory, and increase tree and shrub species richness.
Riparian revegetation and restoration	Expand riparian corridor into adjacent grasslands where possible.	
Water Quality		
Salinity	Create spatial and seasonally diverse fresh and brackish water areas within restored tidal areas by reducing mixing of stratified waters and creating multiple locations for fresh and tide waters to enter marshes.	Assumption: Removing rather than breaching levees may reduce mixing of stratified water.
Suspended sediment	Increase suspended sediment deposition in tidal marshes by restoring full tidal prism, where possible, and removing levees rather than breeching levees.	Removing rather than breaching levees will increase sediment deposition in the marsh plain.
Infrastructure		
Tide Gate	Improve fish access by (1) removing tide gates where possible, or (2) retrofitting top hinge tide gate flaps with side hinge tide gate flaps to improve fish access during ebb tides, and (3) adding an adjustable opening to the tide gate to improve fish access during the flood tides. Use adjustable tide gate flaps to protect agricultural uses	Adjustable tide gate opening provides flexibility to regulate the volume of tide water that moves upstream of the tide gate, enabling the project to adapt to sea level rise or future changes in upstream constraints.

Feature/Issue	Guideline	Notes/References
Levee	Remove levees where possible to restore full tidal prism, reduce mixing of stratified waters and increased sediment deposition. Install eco-levees to limit tidal inundation into agricultural areas	Eco-levees or horizontal levees provide protection against sea level rise. The gradual slopes on the bay side of the eco-levee and tidal marsh vegetation slow storm surges, attenuate wave action, and absorb floodwater. The eco-levee builds over time through sediment deposition (Gregg and Braddock, 2021).
Fencing	Install exclusion fencing around restored features and along perennial water courses.	
Drainage Ditches	Create connected flow paths that deliver water to high quality habitats to reduce potential fish mortality; create areas of natural treatment.	
Culverts	Reduce the frequency and length of culverts; convert culverted drainages to open channels.	

Design constraints were developed through landowner interviews and field assessments. Identified constraints include:

- Infrastructure: The Project actions shall protect all infrastructure in the current state, unless specifically identified for removal or upgrade. Specific infrastructure constraints and approaches to address or remove the constraint are discussed in the enhancement site section. Infrastructure constraints that span multiple enhancement sites include:
    - PG&E gas lines, which will be avoided and protected. Currently, the northern most gas line shown in Figure 2-40 is scheduled for abandonment in 2025. Following abandonment of the line, the design team will coordinate with PG&E to remove segments of the line that overlap with enhancement sites.
- Health and Safety: The primary health and safety constraint within the Project area is flood risk to agricultural buildings and residences. The project will not increase flooding from fluvial or coastal sources outside the boundaries of the enhancement sites.
- Landowner: Landowners in the planning reach utilize their property for a variety of purposes. Existing and future land uses preferred by landowners will be retained. In many cases, the current land use drives the types of enhancements proposed at the enhancement site.
- Water quality: The Project shall not increase the amount of saline/brackish water that inundates agricultural lands outside the boundaries of the enhancement sites.
- Cultural Resources: Sensitive cultural resources that occur within the project boundary will be protected.

3.2 Design Concepts

The following sections describe techniques used to enhance habitat and reduce flooding in productive agricultural land, restoring and promoting healthy geomorphic, hydraulic, and biological processes. These techniques are applied to specific sites in Section 3.4, and a hydraulic analysis of these sites is presented in section 3.5.

3.2.1 Sediment remediation

The Elk River Recovery Assessment (CalTrout et al. 2019) concluded that dramatic increases in sediment supply during the 1988–2000 period resulted in severe channel aggradation along the entire Elk River mainstem and downstream into the tidal estuary through MSR2. The report recommended consideration of mechanical sediment remediation to remove excessive stored sediment, with the modified channel geometry and slope in MSR2 transitioning to existing conditions in MSR1. However, the Recovery Assessment HST modeling (CalTrout et al. 2019, Section 6) also demonstrated that even with sediment remediation, suspended sediment concentrations would not improve, and the enlarged channel capacity would facilitate increased transport of sediment through MSRs 1-2 and into Humboldt Bay.[4]

Based on these conclusions from our modeling analysis of physical processes, and along with regulatory and socio-economic considerations, channel modification in the MSR1-MSR2 tidally influenced reaches was removed from the list of actions recommended by the Stewardship Program. Tidal estuaries are natural depositional and aggradational zones, and while our analyses acknowledge continued water quality impairments resulting from elevated suspended sediment concentrations, the preferred outcome in the tidal estuary is to enable deposition, marsh accretion, and trapping of sediment on restored tidal marsh surfaces, reducing the export of this material to Humboldt Bay. As discussed in the next section, sediment accretion rates in unmuted tidal systems in Humboldt Bay may keep pace with sea level rise, at least in the near term. With restoration of a full tidal inundation, sediment accretion rates will likely be high in the Elk River estuary over the next few decades as watershed processes recover and sediment supply remains elevated.

The mainstem of Elk River through MSR1 is expected to widen and deepen over time in response to increased tidal exchange from several estuary restoration projects in the watershed. These include the Martin Slough Enhancement Project implemented by the RCAA in 2018–2019, the Elk River Tidal Wetland Restoration Project implemented by the City of Eureka in 2022, and by the estuary enhancements and riparian vegetation management actions proposed herein. Our project will add to the sediment trapping benefits provided by with City of Eureka and Coastal Conservancy's Elk River tidal wetland restoration project, which is located just downstream of our project footprint to the west of HWY 101. Together, these projects should significantly reduce the delivery of suspended sediment to Humboldt Bay.

During the forthcoming engineering design phase in Planning Area 1, specific, small-scale sediment excavation actions may be proposed in the mainstem Elk River and Swain Slough. However, these actions would target fish and aquatic habitat objectives, including laying back streambanks, deepening pools, or creating alcoves, and would not result in significant remediation of stored sediment, or changes in sediment transport and depositional processes.

[4] The Recovery Assessment stated (Section 6.3.3): "The Existing Condition and Reduced SSC scenarios result in transport of 73–95% of the sediment that enters a geomorphic reach to the next downstream reach. The Modified Channel scenario results in transport of 92–100% of the sediment that enters a geomorphic reach to the next downstream reach."

3.2.2 Tidal marsh enhancement

3.2.2.1 Levee modification/removal; slough channel, tidal creek channel, and pond excavation

As discussed in Section 2 above, the lower tidal reaches of the Elk River were diked and drained to accommodate agriculture, principally cattle and dairy ranching. These reaches are now mostly disconnected from the tides, which previously inundated extensive salt and brackish marsh plains.

Lacking a full daily tidal prism, salt and brackish marsh habitat areas have diminished and tidal marsh morphology has become degraded (Figure 3-1A). The former dendritic network of tidal channels and sloughs is barely visible in our relative elevation model (Figure 2-1), LiDAR topography, and historical aerial photographs (Figure 2-3); the natural topographic relief from high marsh plain (~6–8 ft MSL) to the bottom of tidal creek channels (~ 1–3 ft) is lost. Former channels are aggraded, and marsh plains have subsided.

Ditches, earthen dikes, and tide gates constructed to protect agricultural lands have also fallen into disrepair. Slough-facing portions of dikes have eroded away in many locations (Laird 2015), and lack of maintenance has allowed dikes to breach and tidal water to leak onto pasture surfaces. Because of these dike breaches and tide gate failures, uncontrolled tidal inundation is extensive in some agricultural lands within the Elk River estuary. In recent years, pasture grasses have begun to die back and more salt-tolerant plant species like salt grass (*Distichlis spicata),* fat-hen (*Atriplex prostrata*), hairy sickle grass (*Parapholis strigosa*), brass-buttons (*Cotula coronopifolia*), and pickleweed *(Salicornia pacifica)* have gained cover. Unmanaged agricultural lands that revert to tidal wetlands tend to be very unproductive, prone to invasive plant infestations, and typically provide poor habitat for juvenile salmonids and other estuarine-dependent species. With advancing sea level rise, this trend toward tidal marsh reversion is accelerating and irreversible.

Possible tidal marsh enhancement options range from an entirely passive "wait and see" approach to active mechanical excavation to aid in reconstructing a more natural topographic condition. A passive, hands-off approach might propose mechanical breaching of levees to allow full tidal inundation but would otherwise allow tidal action to reform a natural marsh morphology, which requires suitable, low, ground elevations that do not occur in PA1, and would likely require many decades or longer to fully recover a natural slough channel network and marsh plain. Such long recovery periods are particularly likely where former tidal marsh has been diked and farmed, which leads to soil compaction that hinders tidal drainage system formation via natural scour processes (PWA 2004).

Wallace et al. (2005) observed that excavated first and second-order tidal creek channels jump-started the development of a natural channel drainage density, and that the tidal prism rapidly evolved to match reference sites. We have adopted this this design approach. Our objective, borrowed from PWA (2004) is to "*create a succession of biologically rich and diverse tidal wetland habitats, including transitional wetlands and adjacent uplands, as part of a sustainable estuary system that requires minimal long-term intervention*." Our proposed design involves mechanical removal of all earthen dike materials where feasible (i.e., where dikes are not essential to protect surrounding agricultural lands) and placement of this sediment in suitable locations (i.e., sediment re-use areas, discussed below). Modifying or removing degraded levees will restore a full tidal prism, reconnect Elk River to extensive salt and brackish marsh plains during high tides, and re-initiate sediment deposition and marsh plain vertical accretion processes (Figure 3-1B). Then, in combination with the removal or modification of existing levees, we propose to reconstruct a network of variably sized subtidal and intertidal channels and intertidal pools roughly following the footprint of former tidal channels (e.g., Figure 2-3) where feasible. Following earthworks construction, salt and brackish marsh vegetation will be planted at appropriate surface elevations to jumpstart revegetation of restored marsh plains, channel edges, and transitional areas.

For example, as detailed in Section 3.3.1, preliminary design for the larger ERWA- site proposes a complex tidal channel system with one fourth-order subtidal channel connected to the mainstem Elk River, feeding a dendritic network of smaller intertidal channels. This design is proposed to facilitate juvenile fish access deep into the marsh area, maximize forage habitat along tidal channel edges, and allow some tidal channels to retain water depth throughout the entire tidal cycle (Figure 3-2). Downstream of the ERWA, Elk River has a hydraulic control (sill) at approximately 1 ft MSL elevation, which will enable our tidal channel system to retain water at most low tides. Smaller drainage channel networks (i.e., localized tidal marsh “watersheds”) are also proposed at the southern (upstream) end of the ERWA and other locations, that may encourage more freshwater inputs, especially during high winter stream flows.

A key challenge to restoring tidal wetlands is compensating for marsh surface subsidence and sea level rise. Recent modeling in Humboldt Bay by NHE (2014, 2015) and Cascadia Geosciences (CG) (2013) has demonstrated that Humboldt Bay has the highest *relative* rate of sea level rise (SLR) in California (~47 cm [centimeters]/century or 18.5 in/century). This high relative rate of SLR is due to the simultaneous effects of compaction and tectonic subsidence of former tidelands and pastures, combined with ongoing sea level rise (CG 2013; Laird 2013, 2015; Sullivan et al. 2022).

Marsh accretion through sediment deposition can compensate for the rapid rate of relative SLR observed in Humboldt Bay. Recent estimates of short-term marsh accretion rates average 2.19 ± 1.36 mm/year (~22 cm/century or 8.66 in/century) (Curtis et al. 2019). While these rates may represent the most recent local estimates of sediment accretion, the short sampling duration may not provide the full picture of inter-annual variability in sediment deposition, or variability in tributaries to Humboldt Bay.

Elk River has the highest suspended sediment concentrations of any Humboldt Bay tributary (Klein et al. 2011). Our empirical observations in numerous tidal marsh settings in Humboldt Bay suggest that undisturbed (i.e., unmuted) marshes in Humboldt Bay currently appear to be keeping pace with relative SLR, with average sediment accretion rates up to 4 to 5 mm/year, and that restored tidal marshes in Elk River would respond similarly, by increasing accretion rates and by shifting vegetation patterns. In contrast, restored tidal marsh systems with muted tidal prisms may not receive adequate sediment supplies to keep pace with SLR. For this reason, restoration of full tidal prism will be prioritized where possible.

Our design concepts also incorporate an appropriate density of subtidal and intertidal channels, utilizing design criteria developed in San Francisco Bay by Pacific Watershed Associates (PWA 2004). PWA recommends first and second-order tidal creek drainage densities ranging between 0.01 to 0.02 ft/ft^2 or about 436 to 871 ft of channel per acre of marsh.

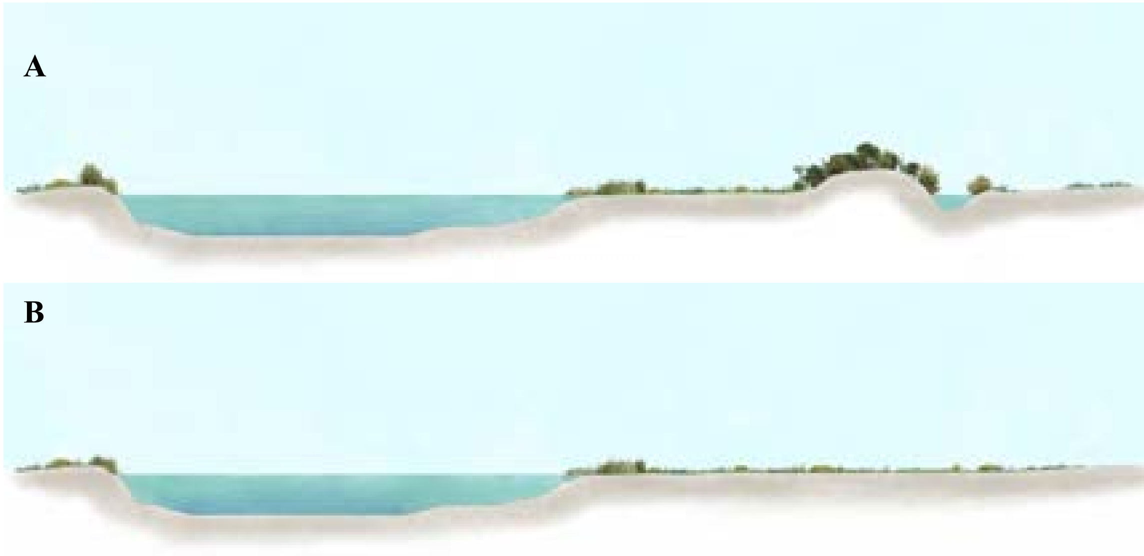


Figure 3-1. Elk River salt and brackish marshes. Existing conditions – with a narrow strip of marsh plain disconnected from larger tidal wetlands by existing levees (A). Proposed conditions resulting from removing and modifying levees to reconnect Elk River to extensive salt and brackish marsh plains during high tides, and from enhancing slough channel networks (B). Example is from ERWA- South in PA1.

3.2.2.2 Fill placement for topographic diversity (natural levees, hummocks)

To the greatest extent feasible, sediment excavated from earthen levees, slough channels, and ponds would be placed as close as is feasible to excavation sites, such as along tidal channel banks to form natural levees, and in hummocks in inter-marsh areas. Natural levees constructed with excavated material would be highest at the top of bank and slope gradually away from the channel. Hummocks would be most suitable for creating or facilitating drainage divides between restored tidal channel networks. Off-hauling of sediment is not proposed. The enhanced topographic relief within the inner marsh areas formed by natural levees and hummocks will enable a greater diversity of marsh vegetation types, including low salt marsh and mixed high salt marsh, brackish wetlands, and transitional areas to riparian and upland ecotones, and upland areas on constructed eco-levees or on surrounding upland hillsides (Figure 3-1 and Figure 3-2).

Figure 3-2. Tidal marsh enhancement including enhancement of slough channels, intertidal ponds, salt marsh, brackish wetlands, wetland-to-riparian and wetland-to-upland ecotones, riparian, coastal grasslands, and uplands. Example is from ERWA-South in PA1.

3.2.2.3 Salt and Brackish Coastal Marsh and Riparian Revegetation within enhanced marsh areas

It is estimated that as much as 11,000 ac of salt marsh and intertidal channels have been diked, drained, and converted from tideland into agricultural use (Humboldt Bay Harbor, Recreation and

Conservation District [HBHRCD] 2007). As mentioned previously, the historic conversion of Elk River and Swain Slough tidelands to agricultural land use has altered the natural vegetation, hydrology, geomorphology, and soils in the planning area. Over a century has occurred since the initial tideland disturbance and many former tidelands remain in agricultural pasture behind intact earthen dikes. At locations where dikes and tide gates have started to degrade, estuarine wetland habitats including emergent salt marsh and brackish marsh plant communities (i.e., northern coastal salt marsh) have formed alongside remnant agricultural vegetation that remained disconnected from the tidal prism (e.g., elevated earthen berms, nonnative naturalized grasslands).

The creation of an enhanced tidal channel network will alter site hydrology and increase saline and brackish water extents. This in turn will promote the continued expansion and creation of estuarine wetlands including intertidal coastal marsh communities. Vegetation planting will accelerate the establishment of high native plant cover that will discourage nonnative weed invasion and promote the formation of a contiguous northern coastal salt marsh along the larger tidal gradient. These enhancements are in line with both the *Humboldt Bay Management Plan* and the *Humboldt Bay Area Plan Local Coastal Program*, which emphasize the importance of restoring and enhancing salt marsh communities within their historic footprint due to their benefit to fish and wildlife, stabilizing sediment, and protecting shoreline structures (HBHRCD 2007, Humboldt County Planning Department 1983).

Northern coastal salt marsh forms highly productive plant communities characterized by dominant herbaceous, suffrutescent, halophytic plant species (Holland 1986). It provides habitat for rare plants including Point Reyes bird's beak, Humboldt Bay owl's-clover, western sand-spurrey, and Lyngbye's sedge and forms multiple sensitive natural communities with state rarity ranks of S2 (imperiled) and S3 (vulnerable) (e.g., pickleweed mats, salt marsh bulrush marsh, salt grass flat associations, tufted hairgrass - red fescue brackish salt marsh). Although some of these communities are present within the planning area (Section 2.4.4.1), much of the existing tidal estuarine wetlands have sparse vegetative cover and share moderate to high cover with nonnative plant species (i.e., mixed stands of pickleweed, salt grass, fat hen, brass buttons and creeping bent grass associations) or are characterized by the invasive weed dense-flowered cordgrass (Figure 2-38). The vegetation design approach within estuarine habitats in the planning area is to maintain, enhance, and expand sensitive natural communities while protecting rare plants and restoring their habitats to conserve current populations and promote their expansion. Nonnative weed management, including strategies for the management and control of dense-flowered cord grass, is discussed in Section 3.3.6.

Tidal inundation duration and frequency along with other factors like soil and water salinity are key factors influencing plant distribution within coastal marsh communities (Barnhart et al. 1999). Elevation within coastal marsh communities is a well-documented environmental gradient for which tidal influence can be measured (Barnhart et al. 1999, Schlosser and Eicher 2012). Planting zone selection will be informed by the relative elevation above MHHW and water salinity measurements collected within the planning area. Studies of northern coastal salt marsh communities throughout Humboldt Bay and Eel River estuary indicate brackish marsh communities exist within a salinity gradient range from 0.5 ppt to 30 ppt and salt marsh communities from 30 ppt or greater (Schlosser and Eicher 2012). Typical salinities throughout the Elk River and Swain Slough estuarine wetlands in the planning area generally measured 14 to 34 ppt throughout the growing season (Section 2.2.2.2). Combined with findings from the vegetation characterization, the estuarine enhancement sites are anticipated to support both coastal salt marsh and brackish marsh communities. The intent of the low elevation gradient adjacent to the intertidal channels and ponds is to allow the formation of emergent low salt marsh, intertidal brackish marsh (based on Elk River's extant Lyngbye's sedge population), mixed high salt marsh, and high brackish marsh as shown in Figure 3-2 to Figure 3-4. Further along the elevation gradient tidal influence will decrease, and the formation of native riparian scrub, shrub, and forested communities will be enhanced and created (Figure 3-5). These design features will also serve as an area for potential marsh migration.

Figure 3-3. Salt marsh enhancement including an enlarged slough channel network, intertidal pools, brackish vegetation along channel edges and mixed high marsh. Water elevation shown is approximately mean higher high water (MHHW). Example is from ERWA-Sough in PA1.

Figure 3-4. Mixed high salt marsh is located at an elevation near MHHW.

Figure 3-5. Emergent brackish marsh is located at an elevation above MHHW.

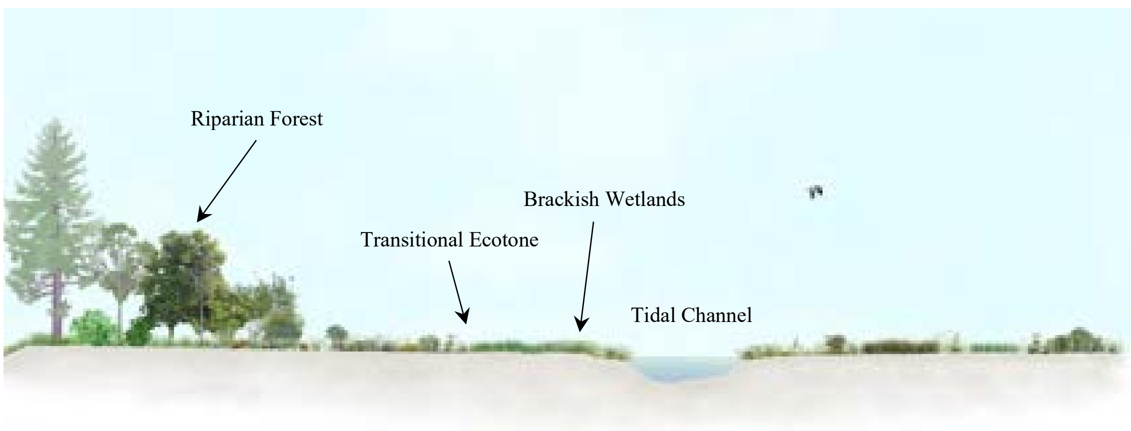


Figure 3-6. Brackish wetlands enhancement including off-channel habitat with tidal channels fringed with brackish marsh vegetation. Brackish wetlands transition through a wetland-to-riparian ecotone, grading to riparian forest and uplands.

3.2.3 Stream-estuary ecotone habitat restoration

Estuaries are highly productive ecosystems, providing habitat for a rich assemblage of aquatic and terrestrial species and acting as a critical transition zone between riverine and marine environments. As described in Section 2.3, the importance of the estuary to salmonid populations is well established. Fisheries ecologists define this highly productive rearing zone as the "stream-estuary ecotone", the area extending from the upper limit of tidal influence downstream to where channels become surrounded by mudflats, *and* the downstream-most freshwater reach. This definition of the ecotone, adopted from Merrell and Koski (1978) and Miller and Sadro (2003), includes mainstem channels, slough channels, and adjacent marsh habitats that are accessible to fish for at least some portion of the tidal cycle.

Stream-estuary ecotones support three important elements of salmonid ecology: habitat capacity, productivity, and life history diversity. Capacity refers to habitat quantity or area, productivity refers to habitat quality, food resource abundance, and other factors that promote high growth rates and survival, and life history diversity encompasses the different pathways or "tactics" individual organisms or cohorts utilize in completing their life cycle. Some basic restoration objectives are thus to:

1. increase capacity by restoring access to critical habitats (e.g., restored slough channels and tidal marshes) or by increasing pool frequency and habitat complexity;
2. increase juvenile growth rates and condition factor by prioritizing habitat areas with more favorable bioenergetics (food and temperature conditions that increase metabolic scope for growth), which translates into a larger size-class distribution of rearing juveniles; and
3. increased life history diversity by providing alternative rearing pathways (e.g., in headwater tributary, mainstem, or estuarine habitats).

Each of these elements of salmonid ecology improve salmonid population resilience to external stresses and threats. Furthermore, the lower-gradient freshwater stream reaches connected to the stream-estuary ecotone can also be as productive as the tidal marsh and estuarine habitats, if hydraulic and habitat conditions are optimal. High juvenile rearing capacity, productivity, and life history diversity in lower valley mainstems and the stream-estuary ecotone leading to high ocean survival of salmonids is therefore an important justification for focus on tidal marsh and estuarine restoration in Elk River. The restoration design concepts that address these objectives are described in the sub-sections that follow.

In addition to salmonids, as described in Section 2.3, the Elk River tidal estuary is habitat for numerous other native fish and amphibian species whose habitats have been diminished and populations impacted by alterations in the Elk River, and which could benefit from habitat restoration and enhancement.

3.2.3.1 Off-channel habitat enhancement

The Elk River tidal estuary contains two main channels—Elk River and Swain Slough—draining a broad, flat tidal wetland area (see sections 2.1 and 2.2). As such, there is considerable opportunity for creating and/or enhancing off-channel habitat spanning saline, brackish, and freshwater dominated ecotone areas. Off-channel habitat design concepts include:

1. a large tidal marsh area proposed within the Elk River Wildlife Area (ERWA, described in Section 3.3.2);
2. large tidal marsh areas in several other surrounding low-elevation properties along Elk River and Swain Slough;
3. a small 0.25-ac off-channel pond and channel connected to lower Swain Slough and fed by ephemeral suburban runoff from surrounding hillsides (see section 3.3.1.5);
4. an abandoned portion of Swain Slough surrounded by grazed pastures that will be reconnected to Swain Slough and provide freshwater habitat behind a tide gate; and
5. two transitional tidal wetland features with brackish-to-freshwater channels that capture freshwater spring seepage from surrounding hills and terminate in freshwater ponds.

Collectively, these features provide an exceptional opportunity to create high quality aquatic habitat for a diversity of fish, bird, amphibian, and wetland plant species, protected from surrounding agricultural lands, and fed by daily tidal cycles and seasonal freshwater runoff. Notably, projected climate-driven increases in the frequency and magnitude of high flow and turbidity events (Grantham 2018, Persad 2020, Curtis 2021) amplifies the need for proposed off-channel features to provide turbidity refugia and enhance ecosystem resilience. The proposed tidal marsh habitats provide the largest area of off-channel habitat, with more than 167 acres of area slated for restoration to full tidal habitat Figure 3-4 and Table E-1). This area includes subtidal slough channels and a dendritic network of intertidal channels, tidal pools, salt and brackish wetlands, wetland-to-riparian and wetland-to-upland ecotones, riparian habitat, coastal grasslands, and uplands. These tidal wetland areas would provide aquatic habitat for a large assemblage of native fish species, several of which are state or federally listed as threatened or endangered (Section 3.3.3). Combined with the tidal marsh restoration project on the west side of HWY 101, Elk River would contain over 281 ac of newly restored salt marsh, a considerable achievement within the context of Humboldt Bay. The freshwater backwater area connected to Swain Slough and the two backwater brackish/freshwater channels connected to Elk River will provide up to 5.4 ac of high-quality winter and spring non-natal rearing habitat for juvenile salmonids. These backwater channels and ponds will resemble recently constructed habitat features in Martin Slough, but are generally larger and have more abundant freshwater inputs. These freshwater inputs, along with riparian and wetland plant community enhancements will help to maintain suitable water quality and minimize potential deleterious impacts from surrounding agricultural land uses (e.g., cattle grazing).

Figure 3-7. Seasonal wetland off-channel from the Elk River.

Figure 3-8. Seasonal wetlands are dominated by emergent vegetation that flood during high flows.

Figure 3-9. Perennial wetland off-channel from the Elk River.

3.2.3.2 Mainstem Elk River and Swain Slough habitat enhancement

In Planning Area 1, the lower mainstem of Elk River and Swain Slough provide extensive open-water habitat that benefits the focal fish species described above and in Section 2.3. Proposed actions that directly or indirectly benefit main channel aquatic habitats include:

1. removal of earthen dikes confining the channel,
2. expansion of surrounding tidal marsh habitat connected to the mainstems via enhanced or restored intertidal channels,
3. removal or thinning of vegetation (mainly Hooker's willow) rooted unnaturally in the bed of the channel,
4. reconnection of freshwater sources from tributaries and ephemeral seeps along the base of hillsides,
5. large wood augmentation, and
6. construction of alcove habitats.

Proposed restoration actions will directly benefit anadromous salmonid and estuarine-dependent species and their habitats. First, as described in Section 3.3.2, expansion of tidal marsh will result in an increased tidal prism in Planning Area 1, which will extend the mainstem tidal prism further upstream, increase the length of brackish water mixing zone, increase the duration of inundation of higher tides. Second, the proposed removal of earthen levees along the Elk River mainstem (Section 3.3.2, Figure 3-2) will enable more tidal inundation of salt and brackish marsh plains, flushing nutrients and invertebrate food resources back into mainstem channels and providing a more productive rearing environment for estuarine fish species. Third, vegetation management proposed for segments of MSR-2 (see Section 3.3.6) will provide more open-channel habitat in reaches expected to be utilized by Longfin Smelt for spawning. Fourth, reconnection of wet season ephemeral and perennial sources of fresh water to the mainstem Elk River and Swain Slough will provide more fresh and brackish water, especially at the upper boundaries of the stream-estuary ecotone, which is particularly beneficial to Tidewater Goby, Lyngbye's sedge, and juvenile salmonids. Moreover, as described in Section 3.3.5, extension of Swain Slough, with a muted tidal prism past the Elk River Road culvert, will expand this type open-water brackish and tidally influenced freshwater habitat and facilitate fish movement into Orton Creek. Finally, strategic addition of large wood structures and development of alcove habitats along the mainstem of lower Elk River and Swain Slough will provide deeper pools, more complex escape cover, and velocity refugia, creating better fish habitat during low tide and improving connectivity between low tide, high tide, and off-channel habitats. Alcoves are enlarged mainstem channel areas that provide low velocity slackwater habitat directly connected to the main channel. These areas provide refuge from high velocities and suspended sediment concentrations during winter high flows and are productive rearing areas.

Historical land management practices have significantly altered the composition of channel and floodplain vegetation and have constrained the remaining Elk River riparian corridor to a narrowed feature composed primarily of woody midstory tree and shrub species. Willow vegetation types are the predominate riparian vegetation community in the planning area, often forming clonal, even-aged stands with low species richness. Land management throughout the planning area has contributed to the sparse and patchy distribution of riparian overstory trees (e.g., Sitka spruce, red alder, Pacific willow). The fast growing and disturbance-adapted willow stands that form the constrained Elk River riparian corridor have further diminished riparian overstory establishment by limiting natural regeneration by preserved trees. To improve the function of the riparian ecosystem in the planning reach, the riparian corridor will be treated in select locations to:

1. remove nonnative invasive plants (see Section 3.3.6),
2. thin and manage disturbed willow stands including in-channel live woody vegetation,
3. release high-value trees to retain existing vertical structure and species richness,
4. interplant thinned riparian stands with native riparian overstory tree species native to the region, and
5. expand the riparian corridor into the adjacent floodplain.

We can encourage growth of a diverse and resilient native plant assemblage by thinning the existing dense willow stands, interplanting thinned areas with other species, and expanding the riparian corridor by planting native trees and shrubs. A key objective of the riparian enhancement treatments is to develop a multi-tiered riparian structure typical of intact native riparian forest. The restored riparian corridor along Elk River will produce additional aquatic resources (e.g., diverse tree plant material, terrestrial arthropods) associated with macroinvertebrates typical of salmonid diet (Miller et al. 2008). It will also enhance wildlife habitat with the potential to provide a greater quantity of insects for foraging bats, create additional vertical structure for nesting migratory birds, expand dispersal and foraging habitat for amphibians and reptiles (e.g., northern red-legged frogs and western pond turtles), and increase cover habitat for small mammals (i.e., create more interstitial spaces from live wood and detritus) that in turn will enhance foraging habitat for large mammals and birds of prey.

Riparian vegetation enhancement will include interplanting with shade-tolerant natives in areas with low overstory cover, along disturbed banks, and where the understory has been disturbed by invasive weed management actions. Overstory canopy development will include revegetation with predominantly tall single-stem deciduous hardwood trees to maintain organic input into the system and increase stand resiliency. Incorporating a patchwork of evergreen conifers will increase species richness and provide year-round cover, dense shade, long-term nutrition, and stream cover, as well as a future source of large wood. The riparian enhancement associated with increasing native conifer and hardwood trees and native understory species within the riparian corridor will not only increase aquatic and terrestrial resource value but also act as a long-term vegetation management strategy. The establishment of mature riparian and overstory trees will increase understory shade and thus aid in nonnative plant control and promote in-channel large wood recruitment.

As described in Sections 3.3.3.1 and 3.3.3.4, future stages of design will include plans for installation of instream large wood pieces or jams. These wood structures would be installed in tandem with riparian vegetation enhancement along the mainstem corridor, and they would provide velocity refugia and promote access to floodplain or adjacent off-channel features for juvenile fish in the channelized lower mainstem Elk River. Where possible, these features will be installed where existing bank slopes are less steep or can be graded to shallower slopes. Depending on site constraints, small alcoves may be added along the bank in conjunction with large wood features to facilitate connectivity between low flow (main channel) and high flow (floodplain) fish rearing habitats.

Figure 3-10. Existing of existing riparian vegetation along sections of Elk River (ER-10 and ER-12) that are dominated by fine stem clonal willow growth that cover the banks.

Figure 3-11. Example of riparian enhancement in mainstem Elk River.

3.2.3.3 Large wood augmentation

Density of instream large wood is a primary factor that determines the overall quantity and quality of salmon and steelhead habitats in coastal Northern California streams. McMahon and Reeves (1989) postulated that large wood could be considered a keystone habitat feature for salmonids because of its overwhelming influence on channel morphology (e.g., pool formation, bank condition), sediment and organic matter sorting and retention, water velocity, and availability of escape cover. Large wood density has been linked to overall salmonid production in streams and correlated with salmonid abundance, distribution, and survival (Sharma and Hilborn 2001). In particular, the high rates of wood loading associated with old growth forests with intact riparian areas generally leads to increased salmonid abundance and improved habitat quality (Lestelle and Cederholm 1984, Dolloff 1986, McMahon and Reeves 1989, Fausch and Northcote 1992).

Abundant large wood increases the frequency, depth, and complexity of pool habitats used by rearing juveniles and results in overall increases in reach-scale habitat diversity (e.g., pool-riffle sequences; Everest and Meehan 1981, Bisson and Sedell 1984, Flannery et al. 2017). High densities of large wood markedly increase the carrying capacity for older age classes of juvenile salmonids, which typically prefer deeper habitats (Bisson et al. 1988). Winter carrying capacity and smolt production of coho salmon have been increased by adding large woody debris or creating off-channel habitat to provide refuge from high flows (Cederholm et al. 1997, Solazzi et al. 2000). Stream channels tend to be more complex and more stable with increasing volumes of large wood, and the structural complexity that provides substrate diversity, low velocity refugia during high flows, and cover from predation is also improved as compared with those conditions lacking abundant large wood (McMahon and Reeves 1989). Complex log jams with large logs and intact rootwads are particularly important for creating and maintaining stream ecosystem processes and function (Flannery et al. 2017). For these reasons, determining the locations where instream and off-channel habitats enhancements can be created by adding large wood pieces or engineered jams is fundamental for improving fish habitat in the Planning Area.

Because of the shortage and limited overall function of existing wood in Planning Area 1, large wood augmentation is an important aquatic habitat restoration action. The addition of large wood to stream channels generally involves the installation of log structures to enhance aquatic habitat and restore critical in-channel geomorphic processes and habitat functions.

Proposed in-channel large wood augmentation will take on several different forms and will be used to accomplish several different restoration objectives depending on characteristics of the site. One of the primary objectives for wood structures in the planning reach is to create low-velocity winter rearing habitat for Coho Salmon and other salmonids, with designs intended to achieve one or more of the following:

1. create complex, low-velocity pool and bank margin habitats in areas currently lacking low velocity refugia;
2. maintain alcove inlets via flow deflection and scour and/or backwatering; or
3. facilitate juvenile fish access to adjacent low-velocity floodplain habitats.

Within the homogeneous tidally influenced channels of lower mainstem Elk River and Swain Slough, another key objective of large wood augmentation is to improve the quantity and quality of rearing habitat for juvenile salmonids and other species during lower tides. As described in Section 2.3.2, high quality low-tide habitat is generally limited in MSR1 and Swain Slough. Since available habitat during low tides likely limits fish carrying capacity in tidal channels

(Tschaplinski 1987), providing rearing habitat and cover at lower tides and improving connectivity between low tide, high tide, and off-channel habitats are important components of fish habitat restoration in the planning area.

3.2.4 Floodplain connectivity and recontouring

The lower valley and tidal estuary of Elk River is dominated by large areas of floodplain that transition down-valley to tidal marsh plains. Floodplains have been heavily altered by drainage infrastructure—primarily a network of ditches, culverts, and tide gates, regularly intersected by ranching roads and cattle fencing. The flat topography in the lower valley further compounds water drainage challenges. Drainage infrastructure in this reach was designed primarily to serve ranching and dairy operations and does not accommodate fish rearing habitat or migration patterns.

Reconnecting and maintaining stream and tidal inundation onto floodplains and marsh plains is a central feature of our restoration designs. However, our objective is to restore more natural patterns of inundation and flow direction and replace the dysfunctional system created over the past many decades. In the lower end of MSR-3 andMSR-2, floodplain modification is proposed through the strategic placement of thin layers of sediment (~0.5–1.0 ft fill depths) to gently recontour existing floodplain and pasture surfaces to create intentional flow pathways, abandon and fill non-functional drainage ditches, remove culverts, and route flood flows into "receiving" tidal channels and marshes. These intentional flood-flow pathways are broad, shallow swales that are inundated infrequently during moderate and larger winter floods but provide pasture for grazing during the low-flow season. This improved flood-flow routing will reduce the risk of stranding of juvenile salmonids during winter by conveying flow (and any entrained salmonids) toward high-quality winter rearing habitat further down the valley in the ERWA and in Swain Slough.

Figure 3-12. Floodplain channel through agricultural grasslands during flood flows in the Elk River. The low flow channel, set within a broad shallow floodplain channel, provides deeper flow paths with cover for fish to pass through agricultural grasslands to reach higher quality habitats as high water recedes. During dry periods, the floodplain channel is grazed.

Marsh plains along the stream-estuary ecotone will be connected to mainstem channels through removal of earthen dikes along the mainstem Elk River and Swain Slough and replacement of old top-hinged tide gates with fish friendly side-hinged tide gates. These actions are described in more detail in Section 3.3.2 above.

3.2.5 Tributary restoration

Tributary restoration within the Elk River valley bottom includes identifying intermittent and perennial tributaries that are disconnected from the mainstem and tidal slough network (e.g., routed through long culverts). Reconnecting and daylighting these tributaries and re-establishing surface flow and a riparian corridor through pasture lands will substantially improve habitat for wildlife and juvenile fish rearing during the wet season. Reconnecting freshwater flows from tributaries to a restored tidal slough network would lower salinities and help to maintain water quality for longer periods, providing high quality juvenile rearing habitat in the winter and spring. Additionally, providing fish passage into restored tributary channels can provide refugia for salmonids during flood events and larger tributaries may provide spawning habitat for Coastal Cutthroat trout and potentially other salmonids.

Expansion and/or enhancement of the riparian corridor along tributaries can occur in multiple ways. Tributaries with an existing riparian corridor may be enhanced by increasing riparian corridor width, increasing species diversity within the existing footprint, and conducting nonnative weed management. In addition, portions of the riparian area can be designed to be flash grazed. Flash grazed areas are referred to as riparian paddocks (Haan 2015); these paddocks are fenced to keep livestock away except during short period grazing events. Long-term grazing management and strategic riparian planting is anticipated to successfully expand riparian vegetation within the Elk River valley bottom.

Figure 3-13. Tributary restoration may include daylighting tributaries that flow through long culverts, riparian enhancement, improving channel complexity wood, alcoves, inset benches, and exclusion fencing. Some riparian areas may be suitable for flash grazing as shown. Example is from Orton Creek in PA1.

3.2.6 Nonnative weed management

Beyond the actively grazed agricultural pasture, the planning area is characterized by a mosaic of native and nonnative vegetation communities. Nonnative communities classified by an invasive species (i.e., listed with a weed rating of high or moderate by Cal-IPC) or known regionally as a problematic species, can impair stream recovery and riparian ecosystem function (Fierke and Kauffman 2016) and will require significant effort to control and manage. High intensity control and management measures are required for invasive nonnative weeds due to their high biomass concentration, density, extent, growth habit, reproductive biology, and/or ability to rapidly establish after disturbance. These efforts will require large-scale treatment and long-term management strategies to suppress weed reinvasion. Other stands that are typed by less aggressive naturalized nonnative weeds (including species listed with a limited rating on the Cal-IPC inventory) will require less intense (low to moderate) control and management treatments. Some native vegetation alliances in the planning area are included in this category as they may contain patches of invasive species. Low to moderate intensity control and management treatments will consist of small-scale efforts, single or short-term treatments, and/or will require minimal repeat management. Nonnative weed treatments will occur in conjunction with vegetation enhancement and revegetation activities to prevent nonnative weed reinvasion and promote the creation of self-sustainable native natural communities.

Nonnative weed management will follow an integrated pest management approach involving the use of multiple management methods in various combinations (specific to the targeted species) to suppress nonnative weeds and encourage the successful establishment and return to native riparian, marsh, and grassland communities. Management strategies will implement manual, mechanical, cultural, and when necessary, chemical control treatments. Manual control treatments may apply to smaller nonnative weed patches and areas where large machinery is prohibited. Hand tools may include digging tools (e.g., Weed Wrenches™), mattocks, clippers, loppers, and machetes. Mechanical control treatments include the use of heavy equipment (e.g., excavators, grubbers, mowers) and power tools (e.g., chain saws, power trimmers, brush cutters, power pruners). Cultural control methods include mulching (e.g., ground cover application with organic mulch or cardboard), solarization, thermal control (e.g., flaming), water level manipulation, and prescribed grazing. Herbicide application can complement mechanical treatments and increase efficiency of initial treatments (Manning and Miller 2011). Treatments may involve foliar, cut stem, and basal bark applications. Herbicide selection and treatment would be guided by various land manager resources (e.g., *Best Management Practices for Wildland Stewardship: Protecting Wildlife When Using Herbicides for Invasive Plant Management* [Cal-IPC 2015]) and will follow state and local regulations. Herbicide use will only occur with support from landowners and other interested parties. Furthermore, herbicide use may require a licensed applicator.

An invasive weed management plan will be developed in future stages of the design planning. This plan would outline invasive weed management objectives within the planning area, detail the integrated pest management approach for targeted nonnative weed occurrences, and summarize the best management practices to avoid spread of invasives plants and reduce non-target effects (e.g., damage to native plants) during enhancement activities.

3.2.7 Sediment re-use

A central component of restoration actions throughout Planning Area 1 is earthworks excavation (e.g., dikes, sloughs and tidal channels, ponds). This action produces sediment, which is a valuable resource that may be useable on-site to achieve other project objectives. Suitable uses of sediment within our project area include placement on floodplains for improved flood routing, filling of abandoned pasture drainage ditches, placement as natural levees and hummocks for marsh plain topographic enhancement, or formation of an eco-levee to protect existing agricultural lands from tidal inundation. New fill will be revegetated to support existing or planned land uses.

Excavation of sediment, transport, and placement of sediment are among the costliest of construction actions. Sediment excavation will likely rely on the use of heavy equipment (excavators and dump trucks) to remove sediment from the channel or floodplain and transport it to nearby sediment re-use sites. Dewatering and fish relocation would be required if excavation is from in-channel locations accessible to fish. Transport of sediment to off-site locations is even more costly and is even, in some cases, cost prohibitive. Thus, it's preferable to find suitable uses of sediment within the project area and as close as is feasible to the excavation site.

In addition, not all sediment is the same, so different sediment types must be treated appropriately. For example, excavated sediment placed on the surface of pastures to enhance floodplain morphology must be good soil. This soil should be free of woody debris, bay mud, and bay-mud, or a significant invasive weed seedbank. Soil that initially contains invasive seeds can be treated to reduce the amount of invasive seed. In subsequent phases of engineering design, a materials management plan will be developed to specify proper treatment and placement of excavated sediment.

3.2.8 Infrastructure replacement and removal

The Elk River Planning Area 1 is a unique location in the watershed, where floodwaters from winter rainstorms interact with tidal waters that move into the project reaches from Humboldt Bay with each tidal cycle. Drainage of this landscape is an historically important objective in this area; a well-developed network of drainage and flood conveyance infrastructure has thus been installed and refined over the decades. This drainage system primarily consists of ditches, culverts, tide gates, and bridges. In some locations, roadways influence drainage by acting as a large levee; for example, Elk River Road along Swain Slough, and US Highway 101 at the bottom of the valley. These roadways are not proposed as part of infrastructure modification.

A key objective of this project is to re-engineer and modernize the drainage infrastructure to maintain and/or improve winter flood conveyance while protecting agricultural lands from tidal inundation. This objective must also be realized in a way that restores and maintains ecological processes, fish and vegetation habitat, and that can evolve and adapt with sea level rise. Future design phases will address the potential impacts of localized erosion on design structures from both project actions (increased tidal prism) and sea level rise. Each piece of this network of drainage infrastructure is important to the system, and collectively must work together to meet our project objective. The hydraulic modeling described in Section 3.5 is specifically developed to evaluate the performance of this drainage objective.

3.3 Enhancement Sites

PA 1 is divided into Areas of Interest (AOI) labeled A–H (Figure 3-14). The areas of interest cover the entire planning area and are used within the report to summarize benefits or impacts that extend beyond the enhancement sites.

Enhancement sites are locations where actions are proposed and are categorized as tidal marsh enhancements, tributary restoration, off-channel habitat enhancement, main channel corridor, and sediment re-use sites. These enhancement sites often include riparian restoration actions, large wood augmentations, infrastructure modifications (Figure 3-15, Figure 3-16), and earthwork that are collectively responsible for the intended enhancement.

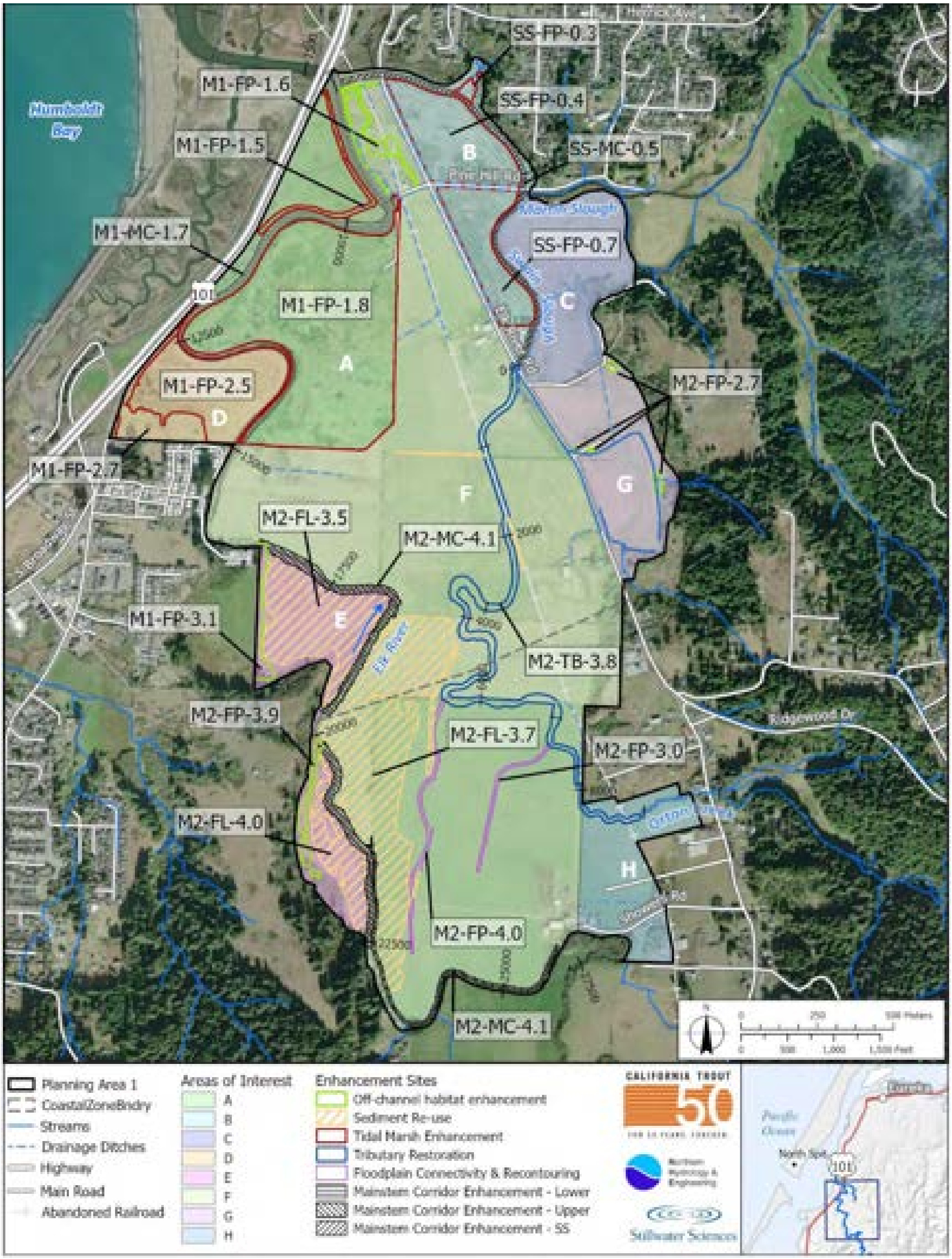


Figure 3-14. Enhancement Sites and Areas of Interest in Planning Area 1.

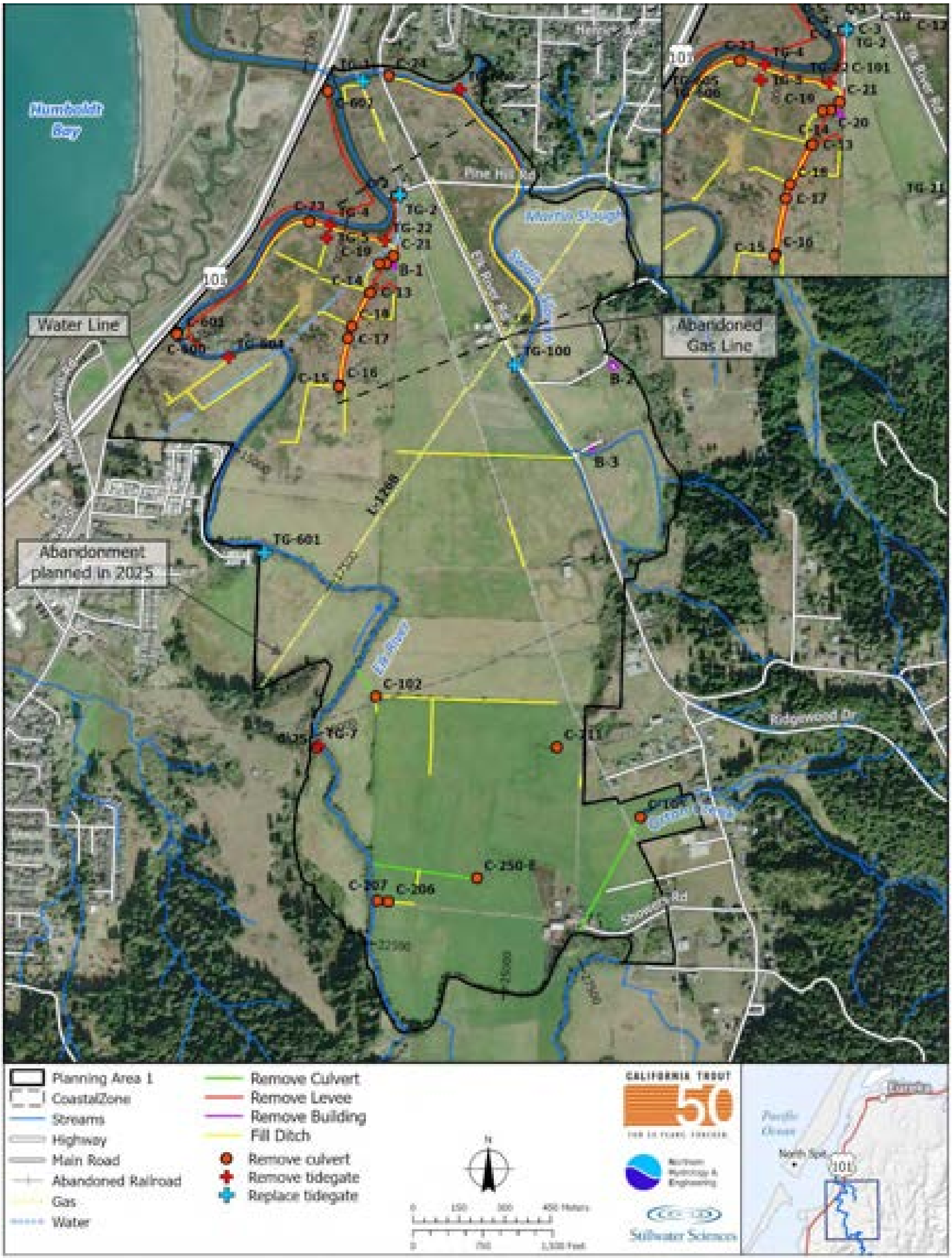


Figure 3-15. Infrastructure proposed for removal. These actions focus on routing overbank flow down valley, removing cross-valley drainage, retrofitting tide gates with fish friendly flap gates, and removing tide gates and levees at tidal march enhancement sites.

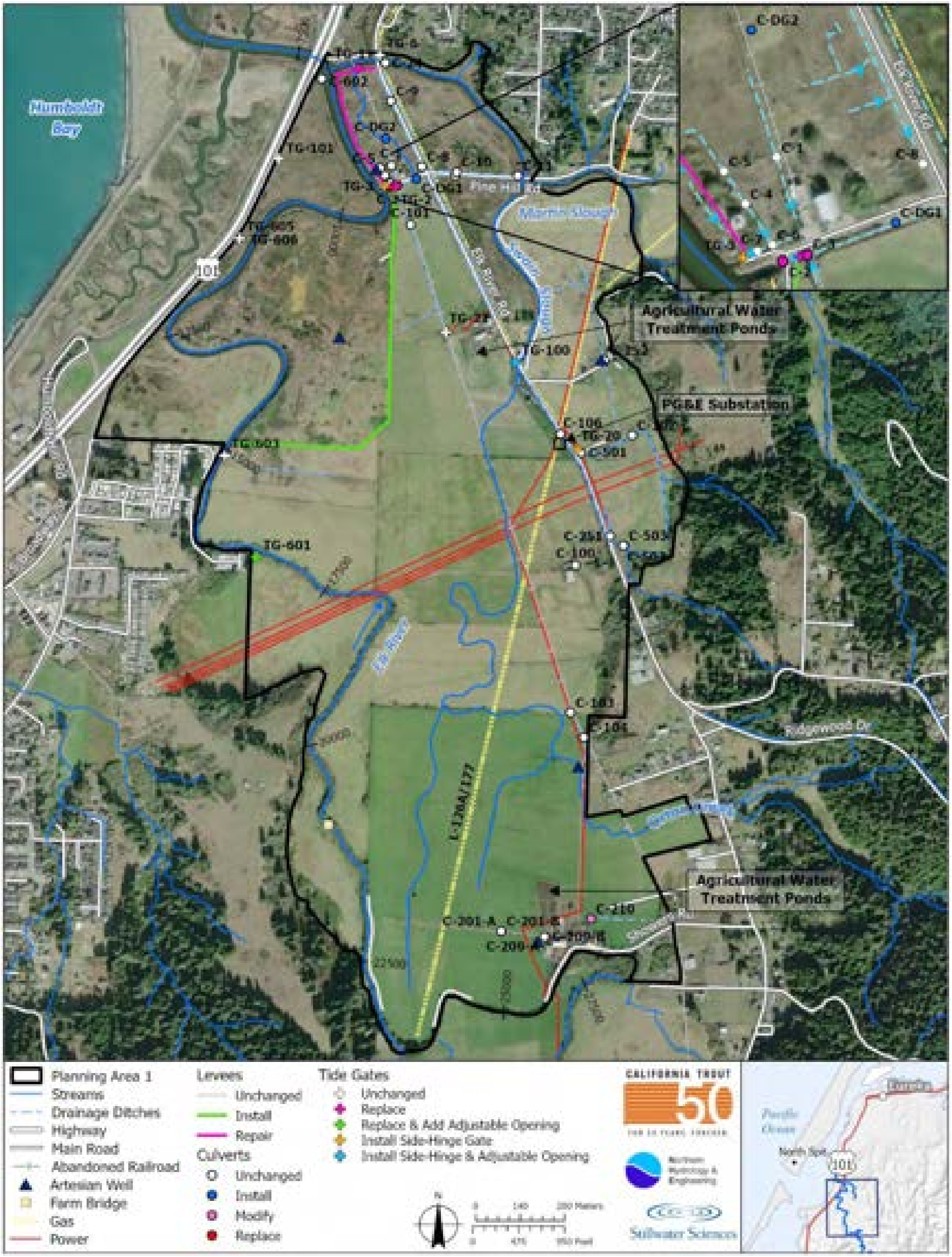


Figure 3-16. Proposed new infrastructure includes installing larger tide gates (side-hinge with optional ability to allow a muted tide at select sites), culvert through Pine Hill Road to improve drainage, increase existing levee height to protect freshwater off-channel enhancement site, eco-berm to protect agricultural lands while allowing full tidal restoration.

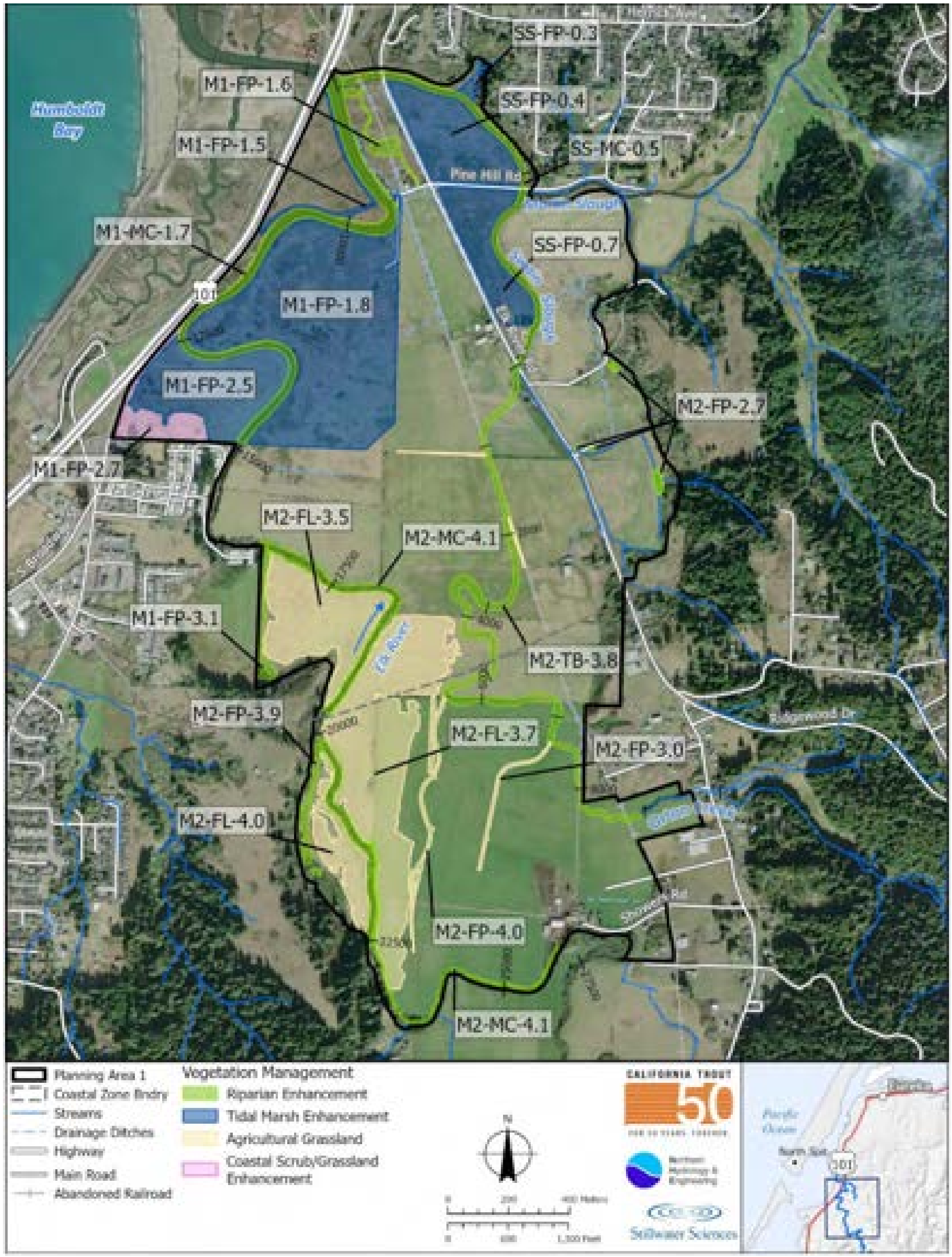


Figure 3-17. Vegetation actions in the enhancement sites include post-disturbance revegetation of sediment reuse areas to re-establish grasslands for grazing and excavated floodplain swales, conversion of agricultural grasslands to riparian forests along mainstem Elk River and the new alignment of Orton Creek, thinning and interplanting of vegetation along mainstem Elk River to improve diversity and wildlife habitat, and conversion of agricultural grasslands to tidal marsh at tidal marsh enhancement sites.

3.3.1 Tidal marsh enhancement

PA-1 has six tidal marsh enhancement sites, three on Elk River and three on Swain Slough. The overarching enhancement approach for all sites is to remove infrastructure that inhibits tidal exchange, restore a full tidal prism, and create spatially complex topography and spatially and temporally complex water quality conditions. These conditions, in turn, would create a range of habitats supporting a diverse range of species, including focal species (Coho Salmon, Chinook Salmon, steelhead, Coastal Cutthroat Trout, Tidewater Goby, and Longfin Smelt).

All sites have ground elevations that are too high for a tidal slough channel network to develop by tidal action alone, and mechanical excavation would be required to create the complex network depicted in Figure 3-2.

3.3.1.1 M1-FP-1.8 – ERWA south

This enhancement site occupies the southern parcel of the ERWA and is 84.7 ac. The primary objectives of the enhancement are to restore the tidal marsh, slough channel network, and associated habitats. The proposed design includes a complex tidal channel system with two primary channels connected to the mainstem Elk River that feed a dendritic network of smaller intertidal channels and ponds (Figure 3-2). Both proposed primary channels occupy historic slough channel locations (Figure 2-3). The tidal slough channel entrances will have widened inlets that function as alcoves extending into the tidal marsh. This design is proposed to facilitate juvenile fish access deep into the marsh area, maximize forage habitat along tidal channel edges, and allow some tidal channels to retain water depth throughout the entire tidal cycle (Figure 2-3). Downstream of the ERWA, Elk River has a hydraulic control (sill) at approximately 1 ft MSL elevation (Figure 2-9), which will retain water in the channel network at most low tides. The second primary channel is located at the southern end of the ERWA. The Elk River channel is often vertically stratified in this location with freshwater at the top of the water column and brackish water underneath. The position of this second channel will create more variable water quality conditions and encourage more freshwater inputs, especially during high winter flows.

Shallow water lines (Figure 2-40) runs through the central portion of the project site. These water lines will be replaced, in coordination with Humboldt Community Services District (HCSD). This action removes a significant constraint to restoration of the project site, improves the reliability of the water supply and reduces the vulnerability of the line to future sea level rise.

Additional infrastructure that will be removed from the site includes: (1) levee adjacent to Elk River, (2) two interior levees, (3) three tide gates, (4) ten culverts, (5) drainage ditches, and (6) milk barn structure and artificial fill. In addition, tide gate TG-2, which is immediately adjacent to the ERWA, will be replaced with a side-hinged double-barrel tide gate to facilitate fish passage and drainage of the floodplain corridor on the landward side of the proposed eco-levee.

Agricultural lands to the south and east of the ERWA are currently protected by the exterior levee along Elk River and the two interior levees. Although the largest tide gate (TG-22) in the exterior levee has failed and allows significant tidal inundation of the site, the size of the opening is relatively small and the amount of water that inundates the area does not negatively impact the adjacent agricultural lands. Following levee removal, Agricultural fields will be protected by a new earthen eco-levee running along the southern and eastern property boundaries (Figure 3-18). This eco-levee will provide the same level of protection to adjacent agricultural lands as existing conditions.

The eco-levee has a proposed elevation of 10 ft, NAVD88, which is roughly 3 ft above the adjacent ground elevation (Appendix G). The levee cannot be raised above 10 ft, NAVD88 without potentially increasing upstream flooding. The width of the crest of the eco-levee is proposed at 8 ft wide while the base of the eco-levee will vary substantially in width. Some portions of the eco-levee, such as those along the east property boundary, may have steeper slopes to maximize the tidal marsh footprint, while other areas (e.g., southern boundary) will have lower slopes to lengthen the transition from tidal marsh to riparian forests. New eco-levees double as sediment re-use sites. Elements such as soil composition, elevations, and low side-slope profiles will be incorporated into final designs to accommodate a natural transition from brackish marsh vegetation (e.g., San Francisco rush, alkali bulrush, Lyngbye's sedge) to riparian ecotone, and then to higher riparian and upland forest vegetation types. Proposed eco-levee elevations are critical elevational zones that support several special-status plant species, such as *Angelica lucida* (sea-watch). Importantly, the proposed eco-levee represents an innovative nature-based adaptation strategy that provides upland transition zone habitat, high tide refugia, and migration space for flora and fauna as sea level rise. Additionally, the gradual outboard slopes and tidal marsh vegetation helps to slow storm surges, attenuate wave action, and create conditions conducive to sediment deposition—allowing the eco-levee to naturally keep pace with SLR (Gregg and Braddock 2021).

Figure 3-18. Constructed eco-levees provide a low-gradient transition between inundated channels and wetlands to riparian forests, coastal grasslands, and uplands.

The planting design objective will focus on the development of a dynamic and resilient estuarine coastal marsh complex and the expansion of coastal riparian habitat. Coastal salt marsh and brackish marsh communities will be established alongside the designed tidal channel network. Established native vegetation will be salvaged and replanted along with supplemental native plantings to establish a mosaic of salt marsh and brackish marsh communities. Planting palettes will be guided by native plant assemblages of regional coastal vegetation communities. Planting zone delineation will be guided by the modeled hydrology, ground elevation/tidal influence, and landscape conditions within the site. Special-status plant occurrences will be preserved and when possible propagated and planted in suitable restored habitats to expand rare plant population extents throughout the planning area.

Invasive dense-flowered cordgrass and Himalayan blackberry are prevalent throughout this enhancement site, occupying existing tidal channel margins and upland levees. A dense stand of reed canary grass in the southern portion of the parcel receives seasonal freshwater input and is disconnected from tidal waters. Recommended treatments to control and manage these invasive species are provided in Section 3.4.5. The long-term control of reed canary grass in this enhancement site will be supported by the designed channel network that will introduce long duration inundation and tidal brackish waters into the southern upstream region of ERWA and the perennial deep shade provided by evergreen conifer planting along the eco-levee. A long-term management program will be required at this enhancement site since tidal waters will continually deliver dense-flowered cordgrass seeds and propagules that can quickly establish and spread if not monitored and managed regularly. Estuarine wetland recovery within this enhancement site includes the conversion of nonnative naturalized vegetation communities (i.e., creeping bentgrass, mixed fat-hen and brass button saltmarsh) to more resilient coastal native plant assemblages. Vegetation communities classified by invasive and nonnative naturalized communities are illustrated in Figure 3-20 in Section 3.4.5.

The benefits of a restored ERWA site to focal fish species and other aquatic organisms will be manifold. Restoring the full tidal prism and associated salt marsh and slough channel restoration will provide a mosaic of juvenile rearing habitats that can be accessed across the tidal cycle and utilized throughout much of the year by focal species. In addition to providing extensive low-velocity off-channel refuge habitat during high flow events, the restored salt marsh is expected provide high-quality feeding habitats in the winter and spring as juvenile salmonids transition between freshwater portions of Elk River and Humboldt Bay. Because access to low-velocity brackish habitats by larval Longfin Smelt in the stream-estuary ecotone is a key factor limiting their population in Elk River (Section 2.3.1.2), this site is expected to be particularly high value for the species. Additionally, the mosaic of tidal slough channels and large amount of functional wetland habitat created at the site is expected to provide ideal habitat for Tidewater Goby, increasing their ability to persist and locate preferred depth and salinity ranges as conditions changes.

3.3.1.2 M1-FP-1.5 – ERWA north

The northern parcel of the ERWA is 17.3 ac. The existing network of channels at the site are a series of relatively straight ditches. Hwy 101 forms the northwestern boundary of the site and a levee separates the marsh plain from Elk River on the eastern and southern borders. The levee is breached in two locations on the eastern side of the site, allowing substantial tidal exchange. However, access to the marsh plain habitat is limited to these two breach points. The vegetation community at the site is unique in the lower Elk River, in that it is an intact native vegetation community with a limited amount of *Spartina densiflora* in some of the channels.

The primary site enhancement proposed is to improve connectivity of the existing marsh plain and channel network to the mainstem Elk River by removing the levee. The tidal channel network could be improved, however, modifying the network would cause significant disturbance to the intact estuarine wetland complex composed of a mosaic of natural vegetation communities. Therefore, no modification to the planform of the channel network is proposed.

Dense-flowered cordgrass forms narrow linear patches along intertidal channels within this enhancement site and will be targeted for removal. Recommended treatments to control and manage this species is provided in Section 3.4.5. Long-term management along with revegetation efforts within the treatment footprint will promote the recovery of native coastal salt marsh habitat and reduce re-establishment and further spread of this invasive species. Earthen levee removal will convert upland coastal scrub (primarily coyote brush) to estuarine wetland habitat and extend the existing coastal salt marsh. This newly exposed tidally influenced area will be revegetated with coastal salt marsh species that form sensitive natural communities and enhance the adjacent salt marsh.

The primary benefits of levee removal to focal fish species include providing more gradually sloped, low velocity, and complex edge habitat along lower mainstem Elk River - facilitating access to high flow refugia and feeding habitats in the existing slough channels and salt marsh across a wider range of tides and flows.

3.3.1.3 M1-FP-2.5 and M1-FP-2.7 west

These enhancement sites are in AOI D and are bound by Hwy 101 to the west, residential properties to the south and Elk River to the north and east (Figure 3-14). These sites occupy a single parcel that is part of a possible land acquisition, and the conceptual design was developed under the assumption that the acquisition will be successful. Subsequent design phases will incorporate any additional opportunities/constraints identified in coordination with the new landowner.

Since there are no levees currently limiting tidal inundation of the site, no specific constraints have been identified due to the proximity of Hwy 101. A tide gate (TG-604) and culvert (C-600) will be removed to restore natural tidal and sediment regimes.

At present, a shallow water line runs from Severt Lane to Pine Hill Road, through the ERWA South (see section 3.4.1.4), and through agricultural lands on the southern and western borders of the enhancement site that have similar ground elevations (Figure 2-40). Enhancement actions at this site will coordinate with the Humboldt Community Services District (HCSD) to replace the water line at a depth that will not limit restoration of the site. If the water line remains in its current configuration, it will preclude restoration of full tidal inundation to the site and significantly decrease the effectiveness of the design, hindering our ability to create habitat and leaving the marsh plain and the line itself vulnerable to the effects of sea level rise. The conceptual design relies on the assumption that the water line will be replaced as proposed, which will benefit the project and ensure reliable, climate resilient drinking water delivery to surrounding communities.

The primary proposed enhancement to site M1-FP-2.5 is to restore the tidal slough channel network and corresponding tidal marsh habitats. As in the ERWA, several sensitive vegetation communities and rare plantsare associated within these tidally dynamic habitats. M1-FP-2.7 is in the higher elevation portions of the property (10–36 ft NAVD88, Appendix G), where various native upland habitats can be established. Currently, this enhancement site is covered by actively grazed agricultural pasture interspersed with reclaimed tidal coastal marsh. Nonnative naturalized grassland communities can be removed and revegetated with a mosaic of coastal marsh and riparian shrubland/forest vegetation communities, expanding sensitive and limited estuarine wetland habitat along Elk River. Revegetation efforts will increase special-status plant populations and sensitive natural communities in the enhancement area through direct planting and by reducing competition by nonnative weeds.

Invasive dense-flowered cordgrass forms mixed stands within the coastal brackish marsh communities lining the Elk River mainstem channel margins and drainage channels in the agriculture pasture of M1-FP-2.5, and dense thickets of Himalayan blackberry grow along the western and southern borders of M1-FP-2.7 West. Recommended treatments to control and manage these invasive species are provided in Section 3.4.5. A long-term management program is recommended at this enhancement site since tidal waters will continually deliver dense-flowered cordgrass seeds and propagules that can quickly establish and spread if not monitored and managed regularly. Estuarine wetland recovery within this enhancement site includes the conversion of nonnative naturalized vegetation communities (i.e., creeping bentgrass, mixed fat-hen and brass button saltmarsh) to more resilient coastal native plant assemblages. Vegetation communities classified by invasive and nonnative naturalized communities are illustrated in Figure 3-20 in Section 3.4.5.

Tidal channel and tidal marsh habitats are rare in this part of the watershed, so restoration of at this site will aid focal fish species. Depending on details of final site designs and levels of achieved tidal inundation and freshwater input, benefits to focal fish are expected to be similar to those described in section 3.4.1.4 for the adjacent Site M1-FP-1.8 (ERWA South).

3.3.1.4 SS-FP-0.4 and SS-FP-0.7 lower Swain Slough west

Enhancement site SS-FP-0.4 is 21 ac and is bordered by Elk River Road to the west, Swain Slough to the north and east (Sta 520 – 2,660), and Pine Hill Road to the south. Martin Slough enters Swain Slough at the southern end of the site. SS-FP-0.7 site is the 16 ac is immediately upstream of site SS-FP-0.4 and is separated by Pine Hill Road (northern end of site). This site is also bordered by Elk River Road to the west, Swain Slough to the east (Sta 2,660 to 4,400). Martin Slough enters Swain Slough at the northern end of the site.

A possible land acquisition of both properties is in progress, and the development of this conceptual design relied on the assumption that the acquisition would be successful. Later design phases will incorporate any additional opportunities/constraints identified in coordination with the new landowner.

The primary objective of the conceptual design at both sites is to restore the tidal marsh and slough channel network and all associated habitats. Infrastructure that limits the full tidal prism is proposed for removal; this includes the levee along Swain Slough the failing culvert (C-24). Site specific designs of a tidal slough network, intertidal ponds, and a variety of marsh types similar to Figure 3-1 to Figure 3-5 will be included in future design phases, following completion of the land acquisition.

The primary constraints to restoring the full tidal prism at both sites is the elevation of Pine Hill Road, which is roughly 8.5 ft (NAVD88) (Appendix G) and is only a few tenths of a foot higher than the Mean Monthly Maximum Water (8.33 ft, NAVD88; **Table 2-3**). Elk River Road may also need additional protections to reduce erosion potential along the road from increased tidal exchange. Alternatives, such as raising Pine Hill Road and adding a levee around the outer perimeter of the enhancement site, will be explored in future design phases.

The water quality conditions at Site SS-FP-0.4 and SS-FP-0.7 are expected to be slightly less brackish than Swain Slough at SS-1 and SS-2, respectively (Section 2.2.2.2). The proposed connection of Orton Creek to Swain Slough will provide additional freshwater flows to Swain Slough, and the proximity of the sites to the confluence with Martin Slough could offer some opportunities to create a gradient of salt/brackish wetlands of varying salinity.

The planting design objective at these enhancement sites is intended to expand estuarine wetland and sensitive natural community footprints and recover native vegetation communities that were historically present. Planting palettes will be guided by native species assemblages of regional coastal vegetation communities and the planting zone delineation will be guided by the modeled hydrology and landscape conditions within the site. Special-status plant occurrences will be preserved and, when possible, propagated and planted in suitable restored habitats, expanding population extents throughout the planning area.

Estuarine wetland recovery within this enhancement site includes the conversion of nonnative naturalized vegetation communities to more resilient coastal native plant assemblages. Removal of nonnatives and revegetation will focus within the creeping bent grass association and interplanting will occur within the existing sparse native coastal marsh and grassland communities. Vegetation communities classified by invasive and nonnative naturalized communities are illustrated in Figure 3-20 in Section 3.4.5

Restoration of a fully connected tidal marsh and a natural slough channel network at these sites would provide several benefits to focal fish species. First, it would create extensive low-velocity off-channel habitat during high flow events when juvenile salmonids and other native species may be entrained into the lower reaches of Swain Slough. The restored salt marsh would also provide high-quality feeding habitats during winter and spring as juvenile salmonids transition between fresh water and Humboldt Bay. Additionally, depending on achieved salinities, the tidal slough channels and wetland habitat created at the sites could provide suitable habitat for Tidewater Goby. Notably, the proximity of these sites to more persistent freshwater sources in Martin Slough and a restored Swain Slough drainage network (SS-FP-0.3, M2-TB-3.8, and M2-FP-2.7) would allow for fish to seamlessly move between different portions of the stream-estuary ecotone in response to change water quality conditions and food resources.

3.3.1.5 SS-FP-0.3 lower Swain Slough east

As described in Section 2.3.2.3 (under Winter Habitat), the enhancement site is an approximately 0.75-ac marsh that is fed by a small drainage originating in the adjacent wooded hillslopes that provides significant freshwater inputs to the site during the wet season. The marsh and a small existing brackish pond are currently disconnected from natural tidal patterns and fish access due to the presence of a levee and defunct tide gate (TG-600). Hydraulic model results indicate the marsh and pond remain disconnected at 10% exceedance flows (467 cfs, Elk River), but likely floods during 1-year events (655 cfs) and at tidal elevations greater than approximately 7.5 ft. The primary constraint to construction at the site is accessibility.

Earthwork proposed at SS-FP-0.3 includes removal of the levee and defunct tide gate, filling of the existing ditch, and excavation of a natural slough channel, which would connect with freshwater sources draining adjacent hillslopes and provide access to existing brackish pond. An additional small pond (~65 ft x 35 ft; 0.05 ac) will be excavated at the base of the hillslope that is fed by freshwater drainage and connects to the slough channel and existing brackish pond. This pond will be sited at approximately 8.2 ft elevation, just above the mean higher high water (MHHW) tide elevation (7.05 ft) and will be designed to support a persistent freshwater-dominant habitat. These actions will restore tidal connectivity, increase tidal prism, and create a gradient of freshwater to brackish conditions in the restored marsh complex.

Vegetation planting within recontoured surfaces will include native brackish and freshwater emergent marsh species. Revegetation will immediately precede project implementation to accelerate the formation of native plant-dominant estuarine and palustrine wetlands and suppress nonnative weed establishment. The design footprint along the intertidal Swain Slough channels will be reduced to the greatest extent possible to avoid and minimize impacts on nearby Lyngbye's sedge. If avoidance is not possible during project activities, individuals will be salvaged and transplanted to suitable locations within the planning area. Nearby invasive dense-flowered cordgrass patches observed along the tidally influenced Swain Slough channel bank will be removed and best management practices implemented to decrease invasive weed spread into the enhancement site. Recommended treatments to control and manage this species is provided in Section 3.4.5. A long-term management program for dense-flowered cordgrass may be required at this location if the designed conditions create suitable habitat for this species.

The proposed design is intended to provide low-velocity refugia habitat for focal species during flood events and persistent, freshwater and brackish off-channel rearing habitat throughout the winter and spring. This site provides particularly high value to focal fish species due to its location in lower Swain Slough, where persistent sources of fresh water are otherwise rare. The range of freshwater and brackish off-channel rearing habitats at this site would allow juvenile salmonids, larval Longfin Smelt, and Tidewater Goby to escape increasing salinities during high tides and on the receding hydrograph of winter storm events when large numbers of fish may have entered the estuary. The restored tidal marsh, existing brackish pond, and constructed freshwater-dominated pond will offer a mosaic of fish rearing habitats, providing abundant food resources and favorable growth conditions for juvenile salmonids and other species.

3.3.2 Stream-estuary ecotone habitat restoration

3.3.2.1 Off-channel habitat enhancement

A total of 4 Enhancement Sites within PA-1 are focused on off-channel habitat improvement including: M1-FP-1.6, M1-FP-3.1, M2-FP-2.7, and M2-FP-3.9. Collectively, these sites occupy ~7 ac of PA-1 with approximately 13,608 CY of excavation (Table E-1).

M2-FP-3.9 western off-channel habitat (upper site)
This 1.8 ac enhancement site is located within the southern parcel of AOI E along the western edge of PA-1 near river station 20,000 (Figure 3-14). Proposed enhancement measures within site M2-FP-3.9 include three main actions:

i) expansion of an alcove where the design channel meets the mainstem Elk River Sta 20,000),
ii) re-grading of an existing ~1,100 ft drainage ditch to increase sinuosity and enhance channel bed and bank complexity (e.g., inset benches, pools, bank scallops),
iii) creation or deepening of floodplain ponds that are fed by freshwater springs at the base of nearby hillslopes (Figure 3-9), and
iv) removal of a tide gate to enhance fish passage and restore a natural hydrologic/tidal regime.

In addition, minor floodplain recontouring associated with M2-FL-4.0 will serve to concentrate overbank flows into the proposed high-quality habitat features and minimize fish stranding. The 0.14- and 0.56-ac floodplain ponds will be sited approximately 1,150 ft upstream of the alcove feature in an area with pre-existing topographical depressions and will be graded to create a variety of depth zones to support a diverse native wetland plant community and create a mosaic of salmonid habitats. Whether the proposed pond features will support perennial or seasonal wetland habitat will be determined based on future site-specific hydrological data collection of the groundwater, springs and intermittent tributary. Consideration will be given to the prevention of colonization by undesirable plant and animal species (e.g., *Typha latifolia, Lithobates catesbeianus*) during future design phases.

Additional infrastructure that will be added to the site includes a crossing over the constructed channel and cattle exclusion fencing around the enhancement site. It is anticipated that the presence of upstream springs and restoration of healthy riparian and wetland plant communities will reduce potential water quality issues (e.g., eutrophication) arising from adjacent cattle grazing.

The existing tide gate (TG-7) and associated fill will be completely removed, and a large alcove feature (~120 x 35 ft) will be installed at an elevation roughly equivalent to the adjacent Elk River thalweg elevation (3.7 ft). This translates to depths of ~1–5 ft during typical tides and ensures hydraulic connectivity and the creation of high-quality habitat across a range of tides and freshwater flows. The design channel will be meandered so that it has a geometry similar to a tidal slough, and it will include pool and small alcove features, as well as complex banks, inset benches, and wood structures providing a diversity of habitats. Current design channel invert elevations allow for modest backwatering of the channel, but the magnitude of backwater/tidal effects and accompanying brackish influence declines considerably in the upstream direction. The gradient of salinities, temporally variable backwater effects, and range of water depths will help support a complex mosaic of habitats at this site. At the current 10% design phase, floodplain ponds are 4–8 ft deep with gently sloped banks, and they are connected to upstream springs and seeps through a small channel. The downstream sill elevation of these ponds is at an elevation of approximately 11.2 ft, NAVD88, which should, at least in the near term, keep the ponds above the influence of brackish or saline water. Final design specifications regarding channel and pond geometry will depend on the results of future hydraulic modeling as well as on-site hydrologic data collection (surface and groundwater).

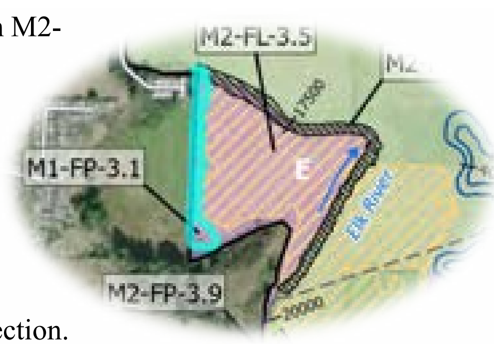
The alcove and channel will predominantly be planted with herbaceous native brackish and freshwater emergent hydrophytic species to form a diverse marsh complex. The intact riparian forest adjacent to the hillslope forms a unique riparian structure with a robust understory composed of yellow skunk cabbage and slough sedge and a sparse midstory shrub canopy; This riparian habitat can be enhanced through selective tree thinning and interplanting by additional native understory herbaceous species. Salvaged native plant material from riparian thinning efforts will be used for riparian revegetation throughout the planning area. Livestock exclusion fencing will reduce soil compaction and understory disturbance.

As with site M1-FP-3.1, this site will provide a diversity of high-quality fish habitats that support focal species across the tidal cycle and throughout the year and fill an important hole in the network of diverse rearing habitats proposed for the planning area. This site will create a large area of sustained freshwater rearing habitat during the winter and spring, supporting large numbers of salmonid fry and pre-smolts during the period before their salinity tolerance increases and they can inhabit the more saline water downstream. The large alcove will attract fish and facilitate access to the channel and upstream pond features, as it provides high-quality, low-velocity rearing habitat directly connected to the mainstem across a range of flows. The restored floodplain channel and ponds will provide a large amount of connected low-velocity refuge habitat for fish throughout the winter and spring. These velocity refuges will also help addresses a key habitat limitation to the Longfin Smelt, whose larval stage are vulnerable to higher salinities (Section 2.3.1.2). Depending on salinities, the alcove and tidally influenced lower portions of the restored channel may also provide suitable habitat for Tidewater Goby. Finally, these protected off-channel features are expected to provide highly productive feeding habitats in the winter and spring as juvenile salmonids transition between fresh and salt water. Because of their distance from the main channel and substantial freshwater inputs, the pond and slough channel are expected to remain clear relative to the mainstem Elk River, which suffers from chronic turbidities that can restrict fish feeding and growth.

M1-FP-3.1 western off-channel habitat (lower site)

This 2.1 ac enhancement site is located within the northern parcel of AOI E along the western edge of PA-1 near river station 16,750 (Figure 3-14). Proposed enhancement measures within site M1-FP-3.1 are focused on three main actions:

i) re-grading of an existing ~1,400-ft drainage ditch to increase sinuosity and enhance channel bed and bank complexity (e.g., inset benches, pools, bank scallops),
ii) creation or deepening of a ~0.63-ac seasonal or perennial brackish pond fed by freshwater springs at the base of nearby hillslopes (Figure 3-6), and
iii) excavation of an alcove where the design channel meets the mainstem Elk River (Sta 16,000).



In addition, minor floodplain recontouring associated with M2-FL-3.5 will help to concentrate overbank flows into the proposed high-quality habitat features and minimize fish stranding. The floodplain pond will be located in an area with pre-existing topographical depressions and will be graded to create a variety of depths to support a diverse native wetland plant community and create a mosaic of salmonid habitat. Whether the proposed pond feature will support perennial or seasonal wetland habitat will be determined based on future hydrological data collection. Consideration will be given to the prevention of colonization by undesirable plant and animal species (e.g., *Typha latifolia, Lithobates catesbeianus*) during future design phases.

The principal constraint to construction of the southern portion of the channel and pond on this site include the presence of a gas line that intersects the proposed channel (Figure 3-16). PG&E plans to abandon the gas line in 2025, and some sections of the gas line may need to be removed to achieve target design elevations.

Physical impacts from cattle (trampling and grazing) will be addressed by constructing exclusion fencing around the enhancement site. It is anticipated that the presence of upstream springs and restoration of healthy riparian and wetland plant communities will mitigate any potential water quality issues (e.g., eutrophication) arising from adjacent cattle grazing.

The existing tide gate and culvert (TG-601) will be replaced, moved to a location upstream of the proposed alcove feature, and installed at an elevation of 2 ft, which is1.5 ft lower than the existing culvert and roughly 1 ft above the low tide elevation of the Elk River. The tide gate will include a side-hinge flap and an adjustable opening to support fish passage, allow a muted tidal prism through the new gate that can be modified to facilitate adaptation to sea level rise and/or future changes in upstream constraints. The alcove is approximately 64 x 44 ft with an invert elevation roughly equal to the adjacent Elk River mainstem channel bottom (-2 ft), which translates to a depth of ~3 ft at low tide. As previously mentioned, the low tide elevation is controlled by a sill downstream of the ERWA (Enhancement Site M1-FP-1.6). A roughly 4–6 ft deep, 230 x 115 ft pond will be constructed at the head of the design channel (~ 1,275 ft upstream of TG-601) with a downstream sill elevation of 7.2 ft. The design channel will be meandered with a geometry similar to that of a tidal slough and include pool features, as well as complex banks (e.g., scallops), inset benches, and wood structures providing diverse habitats. Current design channel invert elevations and tide gate specifications allow for modest backwatering of the channel and upstream pond during moderate tides. The magnitude of backwater/tidal effects and accompanying brackish influence attenuate considerably in the upstream direction and will likely be predominately fresh during wet periods. The gradient of salinities, temporally variable backwater effects and range of water depths will help support a complex stream-estuary ecotone in this enhancement site. Final design specifications regarding channel and pond geometry will depend on the results of future hydraulic modeling as well as on-site groundwater stage data collection.

Planting will include a diverse palette of native brackish and freshwater emergent hydrophytic species to form a heterogenous marsh community that is currently limited within the Elk River floodplain. A *Typha latifolia (*broad-leaved cattail) stand will be removed to promote the early establishment of plantings; reducing competition by this fast-growing and disturbance adapted species will support the formation of open water habitat within the pond. The nonnative naturalized creeping bentgrass community that lines the existing drainage (Figure 3-20 in Section 3.4.5) will be removed and revegetated with native herbaceous marsh plantings and riparian shrubs and trees, and installation of a livestock exclusion fence will reduce soil compaction and vegetation disturbance in these enhanced wetlands. Lyngbye's sedge patches within the design footprint will be retained or replanted at suitable locations in the channel.

The design proposed for this site will provide habitat for focal species across the tidal cycle and throughout the year. Because of its location in lower Elk River (i.e., near the boundary of fresh and salt water and in a reach where frequently inundated off-channel habitat is lacking), this site provides very high value for fish populations in the watershed, filling an important hole in the network of diverse, high-quality rearing habitats proposed for the planning area. By providing high-quality, low-velocity rearing habitat directly connected to the mainstem across a range of tides and freshwater flows, the alcove will attract fish and facilitate access to the enhanced tidal channel and upstream pond features with rising flows and tides. The restored floodplain channel and pond will provide a large area of low-velocity refuge habitat for fish during moderate and high flow events in a part of the watershed where it is rare. In addition to greatly increasing winter rearing habitat for juvenile salmonids, this velocity refugia will addresses a key habitat limitation to the Longfin Smelt, whose larval stage requires access to low-velocity brackish habitats to prevent entrainment into the Bay where salinity levels are too high for larval survival. The tidal slough channel and persistent protected habitat provided by the pond also have potential to provide ideal habitat for Tidewater Goby. Finally, these protected off-channel features are expected to provide highly productive feeding habitats in the winter and spring as juvenile salmonids transition between fresh and salt water. Because of their distance from the main channel and substantial freshwater inputs, the pond and slough channel are expected to remain clear relative to the mainstem Elk River, which suffers from chronic turbidities that can restrict fish feeding and growth.

M1-FP-1.6 northern pond complex

This ~2.8 ac enhancement site occupies the very northern portion of the Central Floodplain Corridor (AOI F) near the Hwy 101 bridge and confluence of Elk River and Swain Slough (Figure 3-14). The principle focus of the conceptual design in the Northern Pond Complex is to expand off-channel freshwater habitat through the excavation of channels and ponds, improve drainage to mitigate upstream flooding by installing or modifying culverts and tide gates, and protect agricultural land from tidal inundation through the modification of an existing levee.

The proposed constructed channel and ponds will be connected during high flows via a new crossing (C-DG1; Figure 3-16) at Pine Hill Road (M1-I-1.76) that will route floodwaters to constructed features. This culvert may require a downstream float mechanism to limit the amount of freshwater during significant overbank flows. A culvert will be added to the railroad prism to connect the eastern and western side of the larger pond feature (C-DG2; Figure 3-16). An existing tide gate (TG-1) will be removed; instead, a new, fish-friendly tide gate will provide drainage through the enhanced levee, providing fish passage to Swain Slough. Also, a side-hinge tide gate will be added to TG-3 to facilitate fish passage to and from the Elk River, and the existing levee around the site will be raised from ~8.5 ft (Appendix G), NAVD88 to 10 ft, NAVD88 to protect the freshwater off-channel enhancement site from tidal inundation.

Two new ponds, with areas of roughly 0.25 and 1.2 ac, will be connected to upstream sources of fresh water during higher flow events via a ~1,300 ft floodplain channel (Figure 3-7 to Figure 3-9). The diameter and invert elevation of the upstream culvert through Pine Hill Rd will need to be properly designed to ensure adequate supply of freshwater to the site while minimizing excessive flooding of the property. The design channel will incorporate pool features, as well as complex banks, inset benches, and wood structures to create varied flow fields and provide a diversity of habitats. Final design specifications regarding channel and pond geometry will depend on the results of future hydraulic modeling as well as on-site groundwater data collection. It is anticipated that proposed levee modifications, together with the installation of the Pine Hill Rd culvert (C-DG1) will precipitate a conversion from a salt/brackish marsh to freshwater habitat/communities. Consideration will be given to the maintenance of adequate water quality (e.g., dissolved oxygen, nutrients, and salinity) in the proposed features given the lack of a perennial freshwater source and the fact that much of the upstream water supply derives from overland runoff from adjacent agricultural pastures.

Vegetation communities may shift from estuarine to palustrine in response to increased freshwater input. The existing brackish marsh adjacent to the proposed freshwater ponds will require supplemental planting to support the plant community shift towards freshwater marsh establishment. Vegetation planting along pond bank gradients will include a diverse palette of freshwater species to promote the establishment of one or more regionally sensitive natural communities. Several brackish marsh species range from fresh to brackish water tolerance and may be retained for interplanting in the enhancement site. Native vegetation within the pond footprint will be salvaged and used throughout the planning area, and any special-status plants that may be impacted by freshwater flows will be salvaged and replanted in suitable locations in the planning area.

The ponds at this site will provide connected freshwater rearing habitat for juvenile salmonids during the wet season when sufficient inflow is present to maintain water quality. By providing unique freshwater habitats near the confluence of lower Elk River and Swain Slough where salinities are otherwise high, this site offers habitat for juvenile salmonids that may have entered the estuary during winter storm events to escape increasing salinities as flows recede. By providing connectivity between the floodplain south of Pine Hill Rd., constructed freshwater pond habitats, Elk River, and Swain Slough, this site has the potential to support significant numbers of fish that may have otherwise become stranded on the floodplain. Fish that reach the ponds will experience protected winter rearing habitat that provides favorable growth conditions away from the high and turbid flows of lower Elk River.

The primary uncertainty to enhancing freshwater habitat on this site is the supply of fresh water to the site. Since freshwater would only enter the site when the Elk River floods, there will be a more limited window for habitat use than other sites. There is also a higher potential for fish to become isolated in ponds because they are not fed by an intermittent tributary or springs. Groundwater depth and salinity are unknown. Groundwater characteristics will be explored at a later design phase.

M2-FP-2.7 eastern off-channel habitat

This 0.4-ac site is located within AOI G on the eastern side of the PA-1 between Elk River Rd and the Elk River valley eastern valley floor (Figure 3-14). The central focus of design in this area is to:

i) improve fish passage to off-channel freshwater habitat through modification of an existing tide gate (TG-20),
ii) expand freshwater habitat through excavation of a seasonal or perennial pond (), and
iii) restore native wetlands following the removal of two building structures.

The site would connect to the restored Swain Slough channel (site M2-TB-3.8) via an existing drainage following the western edge of Elk River Rd between the tide gate (TG-20) and Swain Slough. TG-20 will be retrofitted with a side hinge flap gate to improve fish access to the site (Figure 3-16). Cattle exclusion fencing is proposed for both the constructed pond and along the existing channel that connects the pond to the tide gate.

Two abandoned buildings (B-2 and B-3; Figure 3-15) and associated fill pads will be removed (1,150 and 5,100 ft^2, respectively; Table A-4). Building B-2 is located adjacent to existing wetlands and valley wall springs that can feed seasonal wetlands as illustrated in Figure 3-8.

Building B-3, which is located between the access road and channel will be removed along with its artificial fill. The remaining lowered area will be revegetated with native species, and Nonnative weeds will be removed in the adjacent floodplain and channel.

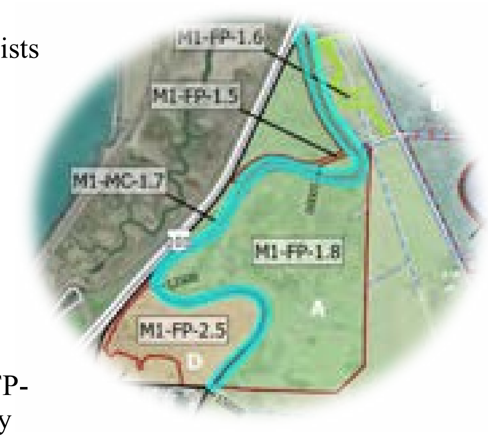
A pond will be constructed 1,350 ft upstream of TG-20. The pond will be approximately 4–6 ft deep, 175 ft long, and 70 ft wide, and it will be fed by existing springs and seeps located along the southeastern portion of AOI G. The pond will be exclusively non-tidal, as the entry of saline or brackish water will be restricted by tide gate TG-20. It will have laid back banks with gentle side slopes and a variety of depths, and woody debris will be installed within it to provide habitat complexity (Figure 3-8, Figure 3-9). The type of pond (seasonal or perennial) will be determined following additional, site specific, hydrologic studies of the springs and intermittent tributary in a later design phase.

This site is actively grazed by cattle. The pond footprint and existing channels within the pasture are covered, to various degrees, but the invasive weed known commonly as low manna grass. The channel connected to the future pond site also contains mixed cover by native brackish and freshwater hydrophytic plants. Recommended treatments to control and manage low manna grass infested areas (e.g., pond footprint and adjacent drainages) are provided in Section 3.4.5. Furthermore, invasive and nonnative naturalized communities adjacent to enhancement site features that will benefit from nonnative weed management and revegetation are illustrated in Figure 3-20 in Section 3.4.5. Native salvaged plant material from project activities (i.e., invasive weed treatments, building removal, and pond excavation) will be used to revegetate pond margins, seasonal channels, and newly exposed wetland surfaces. Supplemental planting and native seed application of native freshwater hydrophytic plants will support the development of palustrine emergent marshes—a marginal and degraded habitat within the Elk River floodplain. The principal objective of revegetation is to establish a series of palustrine floodplain wetlands with high native plant cover, forming self-sustaining stands resilient to nonnative weed invasion. These wetlands can habitat and forage for wildlife.

The new freshwater pond will provide high-quality wet-season rearing habitat for juvenile salmonids in a portion of the Planning Area where it currently does not exist. This site would offer fish that enter the floodplain corridor and restored Orton Creek (M2-TB-3.8) from Elk River via M2-FP-4.0 during flood events an additional opportunity to locate freshwater rearing habitat as flows recede. Fish who reach the pond will experience protected winter and spring rearing habitat, and the conditions within this habitat will be favorable to growth, with low turbidity relative to mainstem reaches. Because it would connect to a restored Swain Slough channel at a location where other freshwater sources are not available, this site will be an important component of a network of diverse, high-quality rearing habitats across the planning area that fish could access when conditions are favorable.

3.3.2.2 Mainstem corridor enhancement

M1-MC-1.7 mainstem – lower Elk River



This enhancement site borders AOIs A, D and F and consists mainly of localized, opportunistic habitat creation along ~7,250 ft of the lower mainstem corridor extending from Sta 7,750 to 15,000 (Figure 3-14). Proposed designs within area M1-MC-1.7 are intended to create cover in the low-flow channel of mainstem Elk River and along channel margins proximal to key off-channel features. Wood may be used to provide in-stream cover. Priority locations for wood placement are areas adjacent to existing and design off-channel habitat features such as alcoves and tidal slough channel inlets/outlets (e.g., M1-FP-1.8). Wood will help to augment in-channel fish habitat by providing predator escape and velocity cover during lower tides. As this site encompasses low-gradient intertidal and shallow subtidal mudflats and is near existing eelgrass communities, it may also be a good candidate for eelgrass (*Zostera marina*) enhancement in localized areas where design treatments promote conditions conducive to eelgrass establishment. In addition to serving as important nursey habitat for juvenile fish, healthy eelgrass communities play an important role in natural biogeochemical cycling, sediment stability, food web support and provide food and shelter for imperiled native fish and invertebrates.

The designs proposed at this site are constrained by the need to maintain navigable waters in this portion of the channel and stability issues arising from excessive buoyancy forces acting on proposed wood during high tides. This may necessitate the use of excessively large ballast and other stabilizing techniques that may render these structures impracticable.

The installation of wood along the intertidal channel banks of Elk River may overlap with the extensive Lyngbye's sedge populations growing along the intertidal channel margin. Some plants that may overlap with wood will be transplanted to other suitable enhancement site locations. To further minimize impact on this population, seed will be collected for future propagation/planting and dispersal throughout suitable habitats within the planning area.

Providing more in-channel complexity and low tide rearing habitat in this reach of lower Elk River would benefit focal fish species. Many of the higher quality rearing habitats that provide low velocities, escape cover, and feeding opportunities are associated with channel margins, alcoves, inset benches, and connected tidal slough channels. Since this reach can experience significant daily tidal fluctuations (4–8 ft) at lower tidal stages many of these habitats may become dewatered or are too shallow to support focal species, forcing fish to retreat to the low tide channel. Studies in other similar estuaries indicate that available habitat during low tides limits carrying capacity for juvenile Coho Salmon (Tschaplnski 1987). For this reason, augmenting rearing habitat and cover at lower tides is an important consideration for habitat restoration in the reach. In addition to increasing area of low velocity habitat with predator escape cover, strategic addition of large wood will facilitate fish use of adjacent productive margin or off-channel habitats at higher tides.

SS-MC-0.5 mainstem Swain Slough

This enhancement site borders AOIs B, C and F and, similar to M1-MC-1.7, consists mainly of localized, opportunistic habitat creation along ~4,750 of Swain Slough from Sta 0 to 4,750 (Figure 3-14). Proposed habitat enhancement measures are primarily intended to create cover in the low-flow channel and along channel margins proximal to key off-channel features. Wood may be installed to help to augment in-channel fish habitat, providing predator escape and velocity cover during lower tides. Priority locations for wood include areas adjacent to existing and design off-channel habitat features such as alcoves and tidal slough channel confluences. As such, the location of many potential habitat enhancement actions in Swain Slough will depend on the outcome of ongoing land acquisition efforts associated with sites SS-FP-0.4 and SS-FP-0.7. As this site encompasses low-gradient intertidal and shallow subtidal mudflats, it may also be a good candidate for eelgrass enhancement—particularly in localized areas where design treatments promote conditions conducive to eelgrass establishment.

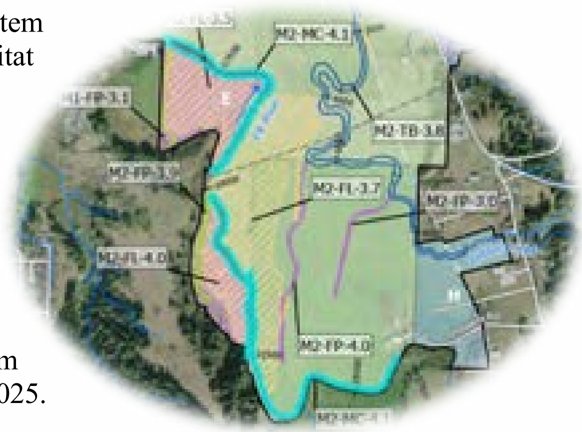
Proposed enhancement actions at this site are constrained by the need to maintain navigable waters in this portion of the channel, and stability issues arising from excessive buoyancy forces acting on wood during high tides.

Stability requirements may necessitate the use of excessively large ballast and other stabilizing techniques that may render these wood additions to the low flow channel impracticable. Later design phases will incorporate any additional opportunities/constraints emerging related to land acquisition of bordering properties.

Invasive dense-flowered cordgrass has established on intertidal benches and channel banks of Swain Slough. It has invaded sensitive natural communities (e.g., Lyngbye's sedge association) and occurs alongside special-status plants, Lyngbye's sedge, western sand-spurrey, and Humboldt Bay owl's clover (Figure 2-37). Recommended treatments to control and manage this species are provided in Section 3.4.5. Long-term management along with revegetation efforts within the treatment footprint will promote the recovery of sensitive natural communities and reduce the re-establishment and further spread of invasive weeds. Special-status plant occurrences will be preserved and, when possible, propagated and planted in suitable restored habitats, expanding population extents throughout the planning area.

As described for M1-MC-1.7 above, it is important to augment fish rearing habitat and cover in locations within the channel that are wetted at lower tides. Wood installations can help increase the overall area of low velocity habitat, provide shelter from predators, and facilitate fish use of adjacent productive channel margins or off-channel habitats at higher tides.

M2-MC-4.1 mainstem – upper Elk River



This enhancement site occupies 9,200 ft of the mainstem corridor and extends from Sta 16,600 to 25,800. Habitat restoration components for this site include riparian enhancement which includes thinning and interplanting of existing vegetation and expanding the riparian corridor, and in-channel fish habitat enhancements.

The primary constraint at the project site is a PG&E are two sets of PG&E gas lines crosses the mainstem (Figure 2-40, Figure 3-15). The downstream gas lines are planned to be abandoned by PG&E in 2025. Sections of abandoned line that would otherwise be a constraint will be removed as part of this project. The upstream gas lines will remain active and are a constraint to earthwork activities.

An additional minor constraint is a farm bridge is located at Sta 20,930. The bridge will be retained. Earthwork activities will not occur in the vicinity of the bridge.

Three culverts (C-102, C-250-E, and C-207) are proposed for removal. In future stages of design, the suitability of these locations for additional restoration actions will be evaluated. Possible actions include laying back the bank, developing alcoves, and/or adding woody debris structures (discussed below).

Expansion of the mainstem riparian corridor is proposed on west and east-side of Elk River from Sta 16,600 to 18,260 and Sta 22,560 to 25,800, respectively. The expanded riparian from Sta 21,500-25,800) will likely be flashed grazed and will be designed similar to Figure 3-13. The zone within ER-10 and ER-12 that includes thinning, interplanting, and riparian expansion will be similar to Figure 3-11. All riparian expansions zones will be designed in conjunction with enhancement of existing vegetation and removal of nonnative vegetation, described below.

Thinning and/or the removal of live wood in the Elk River channel is recommended for reaches that have high in-channel encroachment of low to midstory shrubs and channel-spanning fallen live wood (i.e., ER-10, ER-12). Individual trees and/or large diameter stems contributing to overstory canopy will be preserved and high-value native riparian trees (e.g., red alder, Pacific willow) will be retained (Figure 3-19). The areas surrounding high value trees will be cleared to enhance their performance (i.e., by increasing basal growth and height and providing regeneration opportunities).

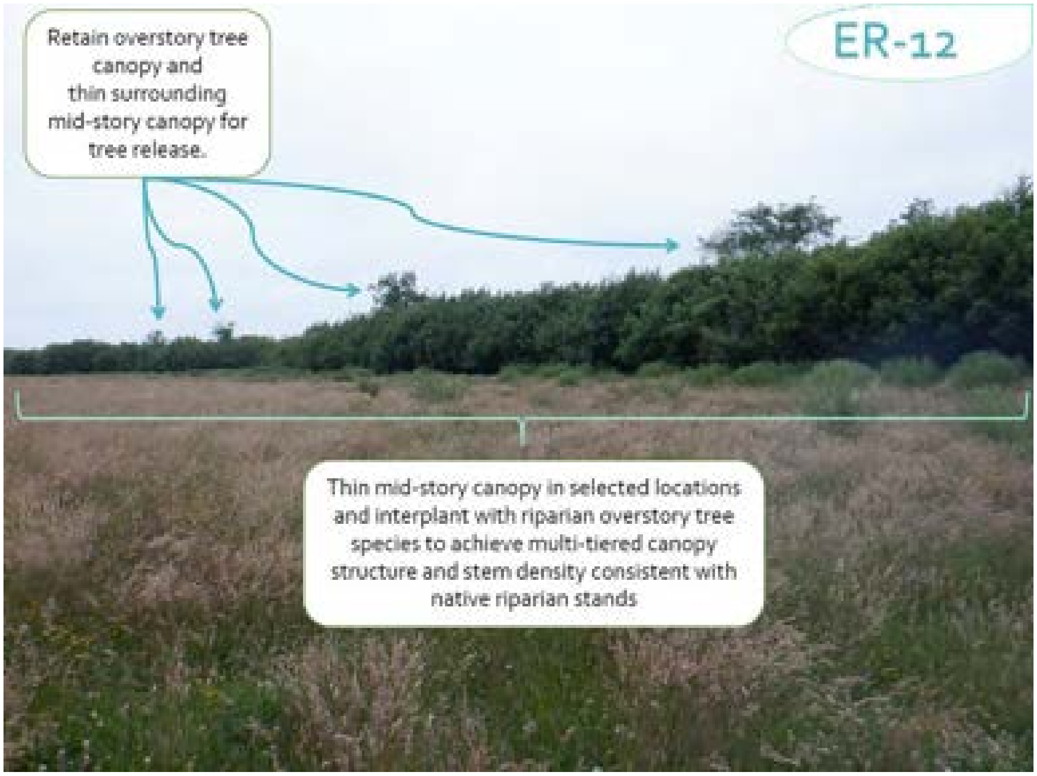


Figure 3-19. Vegetation at ER-12 where thinning and interplanting is proposed to increase structural diversity and promote stem density consistent with native riparian stands.

Riparian enhancement will be applied using a phased approach, with initial high intensity management followed by monitoring to identify whether additional localized treatments are necessary to achieve the targeted riparian habitat stem density. The objective for riparian thinning is to lower the existing small-diameter stem accumulation (Figure 3-20) to achieve a stem density that is equivalent to an intact multi-tiered native riparian community, as a lowered stem density will promote the successful establishment of additional native plant species. Qualitative measurements of tree density and canopy cover in an intact riparian forest can be used to inform the thinning prescription within the disturbed areas of the riparian corridor. A site-by-site assessment will be performed to determine which trees will be removed. In general, small diameter stems growing below the top of bank will be thinned, and large, upright live stems will be retained. Dead wood determined to provide valuable cover elements and velocity refugia for fish will also be left in the channel.

Figure 3-20. Example of high-density fine stem clonal willow growth in the channel (ER-12).

Resprouted live wood on the channel bed will need to be taken out or pruned to remove horizontal stems. Many trees are rooted along the channel bank, so the subsequent resprouting growth will be vertical from root crown or stem base. Vertically aligned resprouting growth won't contribute to channel roughness as much as the horizontal growth that is currently common in many parts of the channel. Monitoring will be conducted to assess growth patterns, but only minimal maintenance and removal is anticipated.

Riparian enhancements include interplanting with shade-tolerant natives will be performed to help improve species richness and structural diversity in areas with low overstory cover or disturbed banks. To develop an overstory canopy, maintain organic input into the system, and increase stand resiliency, tall single-stem deciduous hardwood trees will be planted. Incorporating a patchwork of evergreen conifers will increase species richness and provide year-round cover, dense shade, long-term nutrition and stream cover, as well as a future source of large wood. Increasing native conifer and hardwood trees and native understory species within the riparian corridor will not only add aquatic and terrestrial resource value but also act as a long-term vegetation management strategy. The establishment of mature overstory trees will increase understory shade and thus aid in nonnative plant control and in-channel live wood re-establishment.

Invasive weeds*, Hedera helix* (English ivy) and Himalayan blackberry live in patches within this disturbed riparian corridor. Recommended treatments to control and manage these invasive species are provided in Section 3.4.5. As these plants do not form dominant stands in this enhancement area, their control and management strategy is considered to be of low to moderate intensity. Where permitted, the expanded riparian corridor will recover some of its historic footprint and convert nonnative, naturalized grassland into high-value riparian habitat.

Large wood augmentation will be conducted in tandem with riparian enhancements to increase channel complexity and enhance winter rearing habitat for juvenile salmonids. The addition of wood structures or single large logs will be focused in reaches that lack complexity. Large wood and will be strategically placed to promote pool scour while maintaining hydraulic diversity in off-channel features. All wood structures will be installed to mirror the stability of natural wood jams using a combination of burial, wood pins. If possible, portions of steep banks will be laid back at locations where wood is placed. The installation of some wood structures will involve the placement of larger key pieces perpendicular to flow along laid-back streambanks with a portion of the wood extending into the channel to provide low velocity refugia across a range of flows. Where opportunities exist, small alcoves will be constructed in conjunction with large wood structures, to provide additional low-velocity rearing habitat along the mainstem corridor. The most likely locations are where culverts will be removed from the east side of Elk River.

Collectively, riparian enhancement, nonnative vegetation removal, and large wood augmentation will be similar to illustrations (Figure 3-11).

Alcoves will generally be excavated at least as deep as the adjacent stream channel with the main body of the alcove located a suitable distance from the main channel to minimize the chance of channel avulsion or sedimentation during high flow events. Alcoves will also be sited in locations with grade control and outside depositional areas to ensure adequate inundation across a range of flow and reduce sedimentation. Even though these design guidelines will help maximize the longevity of constructed backwater habitats by reducing sedimentation and alterations to downstream hydraulic controls, sedimentation in these areas will be unavoidable.

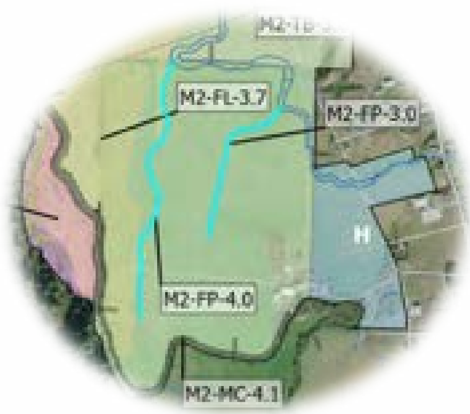
Adding large wood and associated alcoves in this reach will create complex, low-velocity pool and bank margin habitats in areas currently lacking winter flow refugia. The large wood features will also maintain alcove inlets via flow deflection and scour and/or backwatering and facilitate juvenile fish access to adjacent low-velocity floodplain and off-channel habitats.

3.3.3 Floodplain connectivity and recontouring

3.3.3.1 M2-FP-3.0 and M2-FP-4.0 (floodplain channel)

The floodplain in the upper end of AOI F is relatively flat. When Elk River overtops its banks, shallow flow spreads across the broad floodplain and is intercepted by a series of ditches and culverts that run perpendicular to the valley (Figure 2-40). Following high flow events, fish stranding and mortality at these locations is assumed to be elevated due to the existing infrastructure, shallow floodplain flow, and isolated depressions.

Floodplain enhancements are intended to realign the drainage down the valley through two primary floodplain channels (M2-FP-3.0 and M2-FP-4.0). These floodplain channels direct overbank flows into the restored Orton Creek and reconnected Swain Slough channel (M2-TB-3.8). The primary constraint on the position of the floodplain channels is the PG&E gas line that bisects the property (Figure 3-16). M2-FP-4.0 alignment will stay to the west of the PG&E gas line, while M2-FP-3.0 will stay to the east until it flows into Orton Creek.



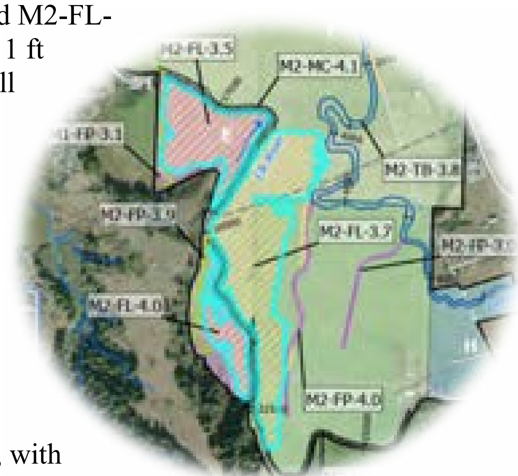
Infrastructure changes include removing a minimum of 5 culverts (C-202 to C-206, Figure 3-15), realigning fences to accommodate changes to agricultural operations, and filling or modifying ditches to drain toward the new floodplain and adding any necessary crossings. Not all drainage ditch modifications are shown.

Floodplain channels at these sites are located within agricultural grasslands and are intended to be grazed during dry periods. When Elk River overtops its banks, the floodplain channels will convey flow downstream to Orton Creek. as designed, channels are broad and shallow (~50 ft in width and 2–3 deep) with a focused low flow channel to ensure there is adequate depth for fish to use. These channels will serve as primary migration paths during receding flows, guiding fish to higher quality habitat in Orton Creek or downstream habitats adjacent to Swain Slough (e.g., M2-FP-2.7). The floodplain channels may be designed to contain wood clusters and topographically low areas to create pockets of lower velocity flow during high flows.

Low manna grass forms moderate to dense stands within the existing drainage ditches throughout the actively grazed agricultural pasture in the Elk River floodplain (Figure 3-20 in Section 3.4.5). Control and management of this invasive weed is anticipated to occur during construction, when the above- and below-ground plant biomass can be fully removed during excavation and recontouring of the channel surfaces. Measures to limit the spread of this invasive plant throughout the planning area will be applied during planned earthwork and ground moving activities (see Section 3.4.5). As the floodplain channel features will remain in active pasture, revegetation will include a landowner-approved livestock forage seed mix in combination with some native palustrine emergent vegetation plantings similar in species assemblage to the seasonally flooded swales in the Elk River valley bottom.

Since the proposed floodplain channels would pass through a working agricultural landscape, their primary values for focal fish species would be (1) minimizing both juvenile and adult salmonid mortality associated with stranding following flood events and (2) facilitating juvenile access to restored high quality rearing habitats associated with Orton Creek and adjacent to Swain Slough.

3.3.3.2 M2-FL-3.5 (lower west), M2-FL-3.7 (east), M2-FL-4.0 (upper west)



Enhancement sites M2-FL-3.5 (24 ac), M2-FL-3.7 (54 ac), and M2-FL-4.0 (9 ac) are located in AOI F areas where fill is placed up to 1 ft in depth on actively grazed agricultural grasslands. The fill will accentuate the existing topography (Figure 2-1) with the highest elevations closest to the channel and lower elevations further from the channel. The fill placement will be placed to increase the cross-sectional topographic complexity and will direct flows toward higher quality habitats such as Orton Creek, and off-channel habitat enhancement sites (M1-FP-3.1 and M2-FP-3.9). The area will be revegetated with a landowner-approved livestock forage seed mix.

Based on preliminary jurisdictional water and wetlands delineation, M2-FL-4.0 is primarily located within the upland, with a portion extending into palustrine seasonally flooded-persistent emergent wetlands. M2-FL-3.5 occurs within:

- one-parameter wetlands within the local coastal zone,
- palustrine seasonally flooded-persistent emergent wetlands
- palustrine semi permanently flooded persistent emergent wetland, and
- palustrine seasonally flooded-saturated persistent emergent wetlands

M2-FL-3.7 occurs within

- upland
- one-parameter wetlands within the local coastal zone
- palustrine seasonally flooded-persistent emergent wetlands
- palustrine semi-permanently flooded persistent emergent wetland (primarily occurring with drainage ditches).

Nonnative thistles, including *Cirsium vulgare* (bull thistle), have established in the actively grazed agricultural pasture in these enhancement sites. Pasture invasion by bull thistle displaces forage species, decreases feeding value, and interferes with livestock grazing (Randall 2000). This species can outcompete native herbaceous species within grassland habitats. Because of bull thistle's ability to spread, nonnative weed management is recommended prior to sediment application. Pairing pre-treatments in bull thistle-infested areas (e.g., mowing and removing seed heads) prior to application of sediment will reduce nonnative weed prevalence in active pasture. Depending on depth of fill, other pre-treatment activities could include thatching (e.g., sheet mulching) in weed-infested areas to effectively smother weeds and increase forage plant quality and recovery.

The primary value of these sites to focal fish species would be (1) minimizing both juvenile and adult salmonid mortality associated with stranding following flood events and (2) facilitating juvenile access to restored off-channel rearing habitats associated with M1-FP-3.1 and M2-FP-3.9

3.3.4 Tributary restoration

3.3.4.1 M2-TB-3.8 Orton Creek

Orton Creek is the largest freshwater tributary in PA-1 (1.6 km^2) after Martin Slough. Orton Creek currently enters a culvert (C-105) near the old railroad grade and is routed subsurface through a 2.5-ft diameter culvert for approximately 1,400 ft to Elk River (Figure 2-40). The restoration of Orton Creek includes:

- re-establishment/daylighting of 8,670 ft Orton Creek channel within the valley bottom and connection to Swain Slough,
- establishment of a riparian corridor along the new Orton Creek channel,
- addition of wood structures, alcoves, inset benches and complex channel (riffle, pools) to create optimal fish habitat within the restored channel,
- modification of a large tide gate on Swain Slough at Elk River Road (TG-100) to allow a muted tidal prism and fish access into the restored Orton Cree channel, upstream of Elk River Road, and
- connection with floodplain channels (M2-FP-3.0 and M2-FP-4.0) to create a fish friendly migration corridor through the agricultural lands.

The Orton Creek channel will be designed to provide high quality habitat for fish (Figure 3-13). Fish will access Orton Creek through a modified tide gate at Elk River Road (TG-100), at the head of Swain Slough or from the mainstem of Elk River during overbank events. Flows from

Orton Creek will also reduce salinity in Swain Slough, making it more hospitable to juvenile salmonids rearing there.

The general down valley alignment of the restored Orton Creek channel will bisect several parcels. Thus, new bridges will be installed (a minimum of 1 per parcel) to maintain access across Orton Creek. Drainage ditches that currently run perpendicular to the valley will be filled or graded to drain toward Orton Creek.

The C-105 culvert that currently routes Orton Creek to Elk River will be demolished and/or plugged (Figure 3-15). Culvert C-210 drains a small area north of Orton Creek to Elk River and may connect, as a lateral, to the Orton Creek culvert (C-105). This culvert may be modified through the addition of a tide gate with flap to prevent Elk River from backwatering through the culvert and flooding the ditch and adjacent agricultural fields. This modification will help reduce the potential for fish stranding during high flows. Another option is to remove C-210 and connect the drainage to the floodplain channel (M2-FP-3.0) or Orton Creek. These alternatives will be explored in the next design phase.

The tide gate at Elk River Road (TG-100) is proposed to be modified to include a side-hinge gate with a mechanism that allows a muted tide from Swain Slough upstream into Orton Creek. Importantly, the mechanism will be adjustable to enhance the structure's resilience to future sea level rise and provide flexibility to adapt to future changes in upstream constraints. The side-hinge tide gate will reduce turbulence and velocity during the ebb tide and during winter high flows. The muted tide mechanism will allow some brackish water to inundate the lower sections of Orton Creek even when the gate is shut.

The muted tide in Orton Creek will be limited to tidal range up to 5–6 ft to ensure that brackish water does not inundate existing pastures. It is anticipated that the muted tide mechanisms at TG-100 will lead to lower salinities upstream of the tide gate during periods of density stratification in Swain Slough. Despite the potential for lower salinities, the roadside ditch along the western side of Elk River Road between TG-100 and C-251 may require a separate tide gate to prevent saltwater inundation and possible damage to upstream utilities (i.e., gas and power lines; Figure 3-16). The necessity of this tide gate will be explored in consultation with PG&E in future design phases.

Some targeted fill of low areas may be required along the channel margins in select areas to ensure the pastures are not inundated with brackish water, but no levees are proposed along Orton Creek.

The proposed alignment of Orton Creek is based on the following criteria:

- intersecting the artesian well (Figure 2-4),
- limiting the crossing of the PG&E gas line to one location (Figure 3-16).
- avoid power line infrastructure and PG&E substation,
- connection to Swain Slough at Elk River Road tide gate (TG-100, Figure 3-16),
- occupying as many historic swales as possible (Figure 2-3), and
- agreement on the location of the alignment of Orton Creek at the property boundaries of the three affected landowners.

The proposed alignment of Orton Creek passes through one of the parcels that is part of the potential land acquisition. Currently, the proposed Orton Creek alignment has several straighter segments and occupies existing drainage ditches. The intention of this design is to minimize Orton's footprint. If the land acquisition is completed, there will be no need to keep the Creek small, and the alignment will be adjusted to complex meandering pattern suggested by the historic swales network on the parcel. There will also be an opportunity to substantially increase riparian corridor.

The final geometry of the Orton Creek channel will ultimately be controlled by sediment supply, valley slope, materials of the bed and banks, vegetation, channel forming flow, tidal prism, and anthropogenic constraints resulting from existing infrastructure and adjacent land use. Constraints on depth include: (1) depth of the PG&E gas line at the crossing location, (2) invert of the tide gate at Elk River Road (TG-100), and (3) capacity of the channel to convey flows below the ~1.25-year flood. Above this flow, flow from the mainstem Elk River inundates the valley bottom, including the Orton Creek channel footprint.

The upper design channel has a riffle-pool morphology in addition to the primary channel with complex banks, inset floodplains, alcoves, and wood structures that will create complex flow fields. The upper channel will transition to a more gradually sloped, lower elevation channel with planform and geometric characteristics more closely emulating a tidally influenced slough channel – including complex bank and bed features (alcoves, inset benches, pools), as well as woody structures to add hydraulic diversity and habitat complexity.

The maximum depth of Orton Creek is controlled by the depth of the PG&E gas line at the crossing location and the tide gate at Elk River Road (TG-100). The elevation of the gas line is known to be lower than the invert of the existing ditch, however, it is not substantially deeper (per landowner communication). The Orton Creek channel crossing of the PG&E gas line is proposed at the same location as the existing ditch crossing and the target invert elevation of Orton Creek is shallower than the existing ditch. In the next design phase, the gas line elevation will be surveyed and compared to the target thalweg elevation will be submitted to PG&E for review. Any additional erosion protection required will be included in the next design phase.

Channel width of Orton Creek will vary in the downstream direction and in areas where there is increased channel curvature. Channel widths will be similar to or greater than the section of Orton Creeks upstream of the existing culvert (C-105). Channel width will generally narrowest upstream where the valley slope is steeper, and wider in the downstream direction to accommodate decreasing slopes, increases flow from overbank events on the Elk River, and increasing tidal prism.

The proposed restoration of Orton Creek to Swain Slough and modification of TG-100 would allow a muted tide to extend up to 5,000 ft of new channel upstream of Elk River Road. Upstream of this tidally influenced reach, an additional 3,670 ft of new freshwater channel below the existing Orton Creek channel would be created. The tidal portion of Orton Creek would be predominately brackish during dry periods and predominately fresh during wet periods. As mentioned earlier, the return of perennial freshwater flows from Orton Creek to Swain Slough is expected to lower salinities in Swain Slough compared to existing conditions. The transition from freshwater conditions at the upper end of PA-1 to mixing of freshwater brackish water upstream of Elk River Road, to brackish water of Swain Slough mixed with freshwater from Orton Creek, Martin Slough, and intermittent tributaries and springs, will create an expansive and complex ecotone in this area.

Riparian vegetation will be planted to form a contiguous riparian corridor along the Orton Creek channel, with planting widths varying between 30 to over 150 ft from top of bank. Where present, riparian forest communities will be enhanced with additional plantings of tall single-stemmed deciduous hardwoods along with some Sitka spruce to provide long-term stream cover. Planting palettes for newly created riparian communities will reference native and historic forested and shrubland communities in the region. Adjacent land management practices will vary across the valley bottom based on landowner parcel boundaries. Permanent and semi-permanent livestock exclusion fencing will be installed to protect plantings and facilitate early establishment. In some areas, the riparian area may be subject to flash or short-term grazing. Since periodic flash grazing will impact mid- and understory vegetation growth, the planting design will be modeled off a riparian paddock. This periodically managed habitat will have a vegetative structure that can provide seasonal forage while maintaining a tall overstory. Recommendations for livestock management in riparian paddocks (e.g., minimum resting/recovery periods, suitable conditions, and timing of grazing) will reference various national published guidance documents (e.g., Hann 2015, Bellows 2003) to reduce impacts to woody native vegetation, limit soil compaction/erosion, and retain a healthy forage stand.

The actively grazed pasture within the valley bottom contains a large reed canary grass stand along with smaller patches within wetland swales (Figure 3-20 in Section 3.4.5). Low manna grass is prevalent within the drainage ditches of the actively grazed pasture throughout the valley bottom, often reaching 100% cover within the channel. Recommended treatments to control and manage these invasive species are provided in Section 3.4.5. Judging from the side of manna grass stands, a high-intensity control and management strategy will likely be needed. However, the excavation and removal efforts will depend on the accumulated biomass at each location. The long-term control of reed canary grass and low manna grass will be supported by long duration inundation and perennial shade along the riparian corridor. Vegetation communities classified by invasive and nonnative naturalized communities are illustrated in Figure 3-20 in Section 3.4.5.

Focal fish species will benefit immensely from the reconnection and restoration of Orton Creek because of the length of restored channel, the position of this new channel within the immensely productive and important stream-estuary ecotone, and the contribution of perennial flow to Swain Slough. By routing Elk River flood flows into a new channel that is connected to Orton Creek, Swain Slough, and other connected restoration sites, this enhancement will not only significantly lesson stranding by juvenile salmonids but will lead them to mosaic of high-quality wet-season habitats. The tidally influenced and brackish portion of the site will provide a large area highly productive slough-like habitat that may be used by larval Longfin Smelt and Tidewater Goby in addition to salmonids. The existing and daylighted freshwater reaches of Orton Creek will offer persistent wet-season refugia for juvenile salmonids during flood events and have potential to provide spawning habitat for Coastal Cutthroat Trout and possibly Coho Salmon. If restored, the persistent and cool flows in these reaches will likely support year-round rearing by young-of-the year salmonids. Moreover, reconnecting Orton Creek to its historical channel would lower salinities and help maintain water quality for longer periods in the restored tidal slough network and Swain Slough downstream of Elk River Rd.

3.3.5 Nonnative weed management

Vegetation communities that can benefit from nonnative weed control and management treatments are depicted in Figure 3-20. Nonnative weed management areas span the enhancement design footprints described in Sections 3.4.1 through 3.4.4 and the surrounding features in the AOI. Invasive weeds in the planning area live in a range of patterns, from large stands to discrete patches within native vegetation communities (Figure 3-21). In general, stands characterized by invasives are anticipated to require a high intensity approach for control and management while other naturalized nonnative stands and native communities containing invasive weeds do not require as much management (Figure 3-21). This nonnative weed management map (Figure 3-21) is intended to provide an overview of vegetation communities that can be enhanced by nonnative weed removal. The map does not capture all invasive weed occurrences, nor does it identify native habitats that can benefit from other enhancement activities (e.g., interplanting, increasing cover by native plants). The invasive weed management plan that will be developed in later phases of the design will describe the approach for site-specific strategies to manage invasive weed occurrences, large and small. As noted in Section 3.3.6, the invasive weed management plan will: (1) outline invasive weed management objectives within the planning area, (2) detail the integrated pest management approach for targeted nonnative weed occurrences, and (3) summarize the best management practices to avoid the spread of invasives plants and reduce non-target effects during enhancement activities. The integrated pest management approach for invasive weeds in the planning area may include treatments detailed in the following sections.

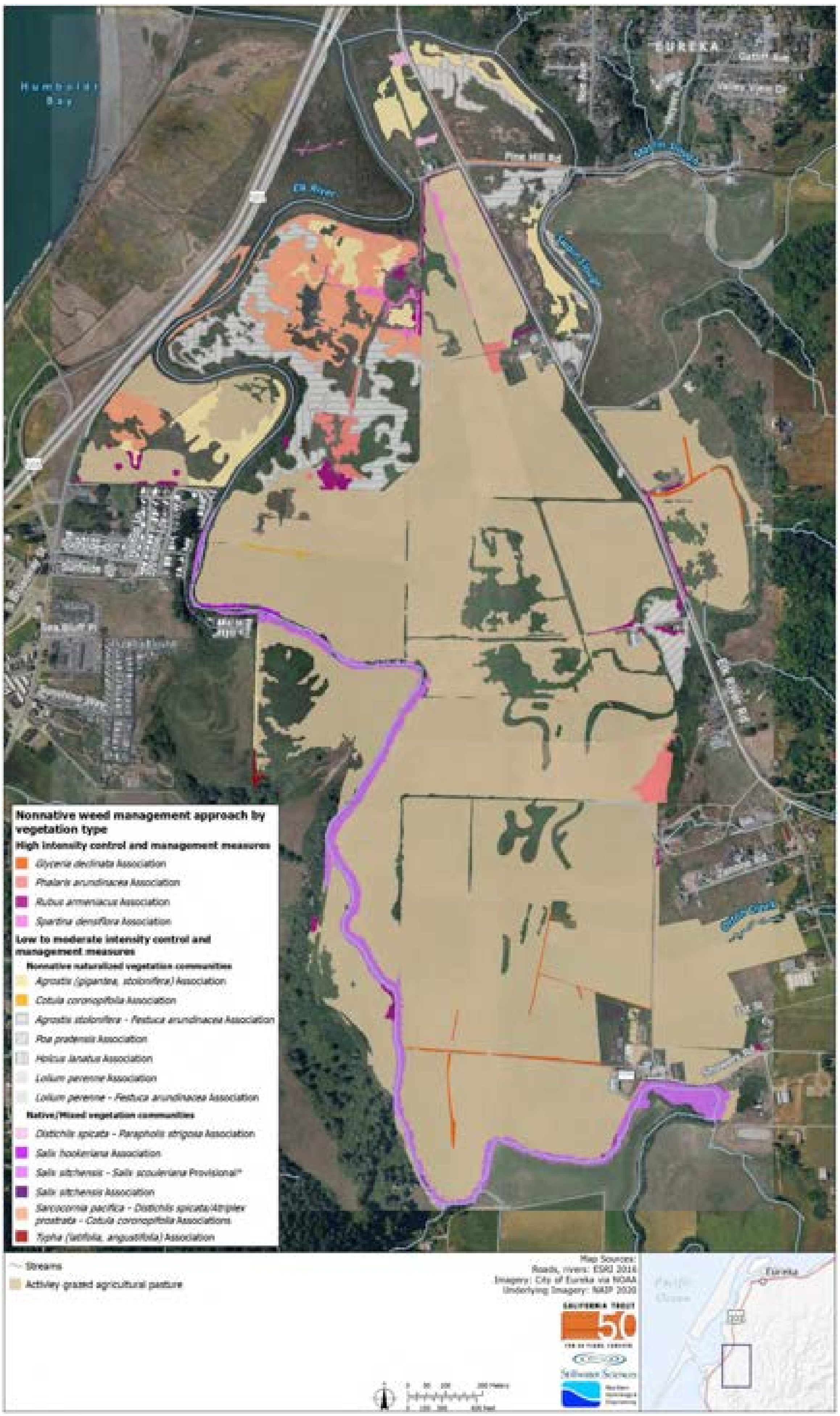


Figure 3-21. Vegetation communities associated with invasive and nonnative naturalized stands and nonnative weed occurrences in the planning area. The legend identifies the intensity scale for nonnative weed management within the Elk River planning area 1.

3.3.5.1 Reed canary grass

Suitable approaches for controlling reed canary grass in the planning area include various cultural, mechanical, and thermal control methods. These measures do not include all known approaches but were selected based on landscape conditions and size of the infestation. Although herbicide application is discussed as an option, it is not considered a vital management approach since practitioners at multiple reed canary grass restoration sites noted it had a limited short-term effect on control for this species (Sinks et al. 2021). Following an integrated pest management approach, these methods are intended to work in tandem with one another and not be standalone treatments. Furthermore, there is no single approach known to completely control reed canary grass.

When paired with other treatments (i.e., inundation and/or herbicide application) disking (tillage) reed canary grass stands has proven effective (Gedik Biological Associated 2006). Successful control has been recorded in fields that had three disking events that were followed by herbicide application (Paveglio and Kilbride 1996, as cited in Gedik Biological Associates 2006). Disking followed by subsequent inundation may be applicable for infested areas that are within a designed waterway footprint. However, these methods require a lengthy timeline and repeat application that may not be ideal for land managers. The preferred and likely most effective control treatment in the planning area involves an initial high intensity mechanical removal method. This treatment involves a one-time excavation of above and below ground reed canary grass biomass, which is then disposed of off-site. Excavation would include the removal of the upper soil surface to capture some seedbank material along with the entire root biomass (typically 8-in depth) (Gedik Biological Associates 2006).

Excavated reed canary grass will be hauled to upland areas to be stored and covered with tarps for approximately two years as it decomposes. The periodic rotation of these offsite spoils will accelerate decomposition time. Another disposal option for excavated material involves burying reed canary grass spoils. Application of thatch, immediate revegetation by natives, and/or changed hydrology (e.g., long-duration ponding, tidal water exposure) will aid in suppression of reed canary grass reestablishment. Implementation of these approaches can be aided by flash grazing and flaming to reduce reed canary grass recruitment and allow native plants to re-establish. Long-term management strategies for controlling reed canary grass involves the restoration of natural tidal hydrology, creation of features with inundation depths of at least 18 in and planting persistent perennial trees and shrubs to introduce shade that has shown to suppress reed canary grass vigor and reduce root and overall biomass (Formann et al. 2000, Miller et al. 2008, Annen et al. 2009).

3.3.5.2 Dense-flowered cord grass

Dense-flowered cord grass currently occupies narrow, linear bands along the intertidal channels in the planning area. The mechanical removal treatment known as the "grind method," developed by Humboldt Bay National Wildlife Refuge, is recommended as the initial control for these stands. The grind method involves the use of a tri-bladed brush cutter to mulch the above-ground cordgrass biomass and macerate the below-ground rhizomes. Successful control of an emerging dense-flowered cordgrass invasion was documented using the mechanical grind method in a 6.2-ac tidally muted coastal salt marsh adjacent to Buhne Slough (i.e., from 12% relative cover prior to initial treatment to less than 1% relative cover for three consecutive years following initial treatment) (Stillwater Sciences 2008). Handheld rototillers may also be used during the initial treatment as they can more easily reach and macerate the below-ground rhizomes. Manual removal (hand pulling or digging) is effective in small areas and may be useful when minimal ground disturbance is required. Following initial treatment, both brush cutter and flaming treatments are effective against resprouts and seedling recruitment. There are no dense-flowered cordgrass stands within the planning area that currently warrant the use of large amphibious equipment (e.g., Marsh Master). However, where restoration designs involve earthwork, mechanical excavation of dense-flowered cord grass will be the preferred method. To preserve native salt marsh vegetation communities, it will be important to detect this aggressive salt marsh invader in the early stages of project implementation and manage it consistently over the long term. . Annual maintenance treatments will be necessary since the enhancement sites will continually receive seed deposits via tidal waters and wildlife movements from the large dense-flowered cord grass populations throughout Humboldt Bay. If regularly maintained, annual maintenance will require much less effort than the initial control efforts.

3.3.5.3 Himalayan blackberry

Himalayan blackberry removal should be prioritized in areas with dense growth that are also near roads or pastures, making them easily accessible by mechanized equipment (e.g., field mower/weed-eater, excavator, backhoe, etc.). Mechanized equipment should be used in such a way as to minimize above-ground damage to neighboring native woody vegetation.

The entire blackberry root crown must be removed to reduce resprouting potential and repeat treatment. Consequently, ground disturbance will occur in the upper 1 to 2 ft of soil. Mechanized removal methods will occur during the dry season or dry channel conditions will reduce potential for soil compaction and sediment delivery when near waterways. If ground disturbance is not possible and the entire root crown cannot be removed, then the optimum time to cut the above-ground plant material is immediately upon flowering (i.e., when reserve food supply in the roots is nearly exhausted) followed by herbicide application to deter extensive regrowth from the root crown. As cuttings from removal efforts can root, care should be taken to dispose of plant material. An effective disposal method for Himalayan blackberry is to burn plant material (Hoshovsky 2000).

Resprouted material should be treated early via manual or mechanized spot treatment methods. Himalayan blackberry is largely shade-intolerant, so revegetation by perennial shrubs and trees will suppress re-establishment.

3.3.5.4 Low manna grass

Low manna grass, also known as waxy mannagrass, is an invasive weed well-adapted to long duration inundation. It is a common invader to wetland swales, ditches, and stock ponds. In the planning area, it forms dense stands in drainage ditches that cross actively grazed agricultural pasture (Figure 3-20). The minimal spread into adjacent pastures indicates the species may be controlled by grazing when it is accessible to livestock. Many of the narrow channels invaded by low manna grass are included in the floodplain connectivity and recontouring enhancement sites (Section 3.4.3), and the tributary restoration enhancement sites (Section 3.4.4). The mechanical excavation of above- and below-ground portions of low manna grass will occur concurrently with design treatments (i.e., during excavation and recontouring of channels in the Elk River floodplain). String-trimmers or flaming can also be used to reduce above ground biomass and seed production. Since this species can propagate from vegetative fragments, and the sediment within affected drainage ditches are likely to have high seed loads, treatment of removed sediment and disturbed soils (e.g., solarization, stale seedbed technique) will be necessary to reduce the invasive weed seedbank. Prompt revegetation of treatment areas with livestock forage or native plant mixes will aid in the long-term suppression of this weed. The timing of control treatments, along with other best management practices to reduce the spread of low manna grass throughout the planning area, will be outlined in the invasive weed management plan.

3.4 Hydraulic Model

This summary provides a brief overview of a 2-dimensional (2D) hydraulic model constructed to simulate a range of habitat and peak-flood flows through a ~19,000-ft reach of the Elk River within the Recovery Program Planning Area 1 (PA-1; Figure 3-22). The goal of the modeling exercise was to simulate existing conditions (EG) and 10% design conditions (DG) to evaluate the hydraulic impacts of proposed design actions. The design conditions model incorporated a suite of design concepts, including:

i) modification of drainage infrastructure (e.g., levees, tide gates, culverts, and drainage ditches),
ii) minor recontouring of floodplains and excavation of floodplain channels to improve habitat and flow conveyance,
iii) in-channel vegetation management,
iv) daylighting and connection of Orton Creek with Swain Slough, and
v) excavation of off-channel habitat (e.g., alcoves, floodplain ponds and wetlands).

Collectively, these actions are intended to increase salmonid summer and winter habitat by improving lateral connectivity and restoring natural tidal and fluvial processes that will increase channel and marsh habitat quantity and quality. The restoration of more natural flow pathways and drainage characteristics is also intended to facilitate better flood-flow conveyance, thereby reducing the frequency, magnitude, and duration of nuisance flooding for adjacent property owners. Please refer to Appendix F for a more detailed outline of model development and findings.

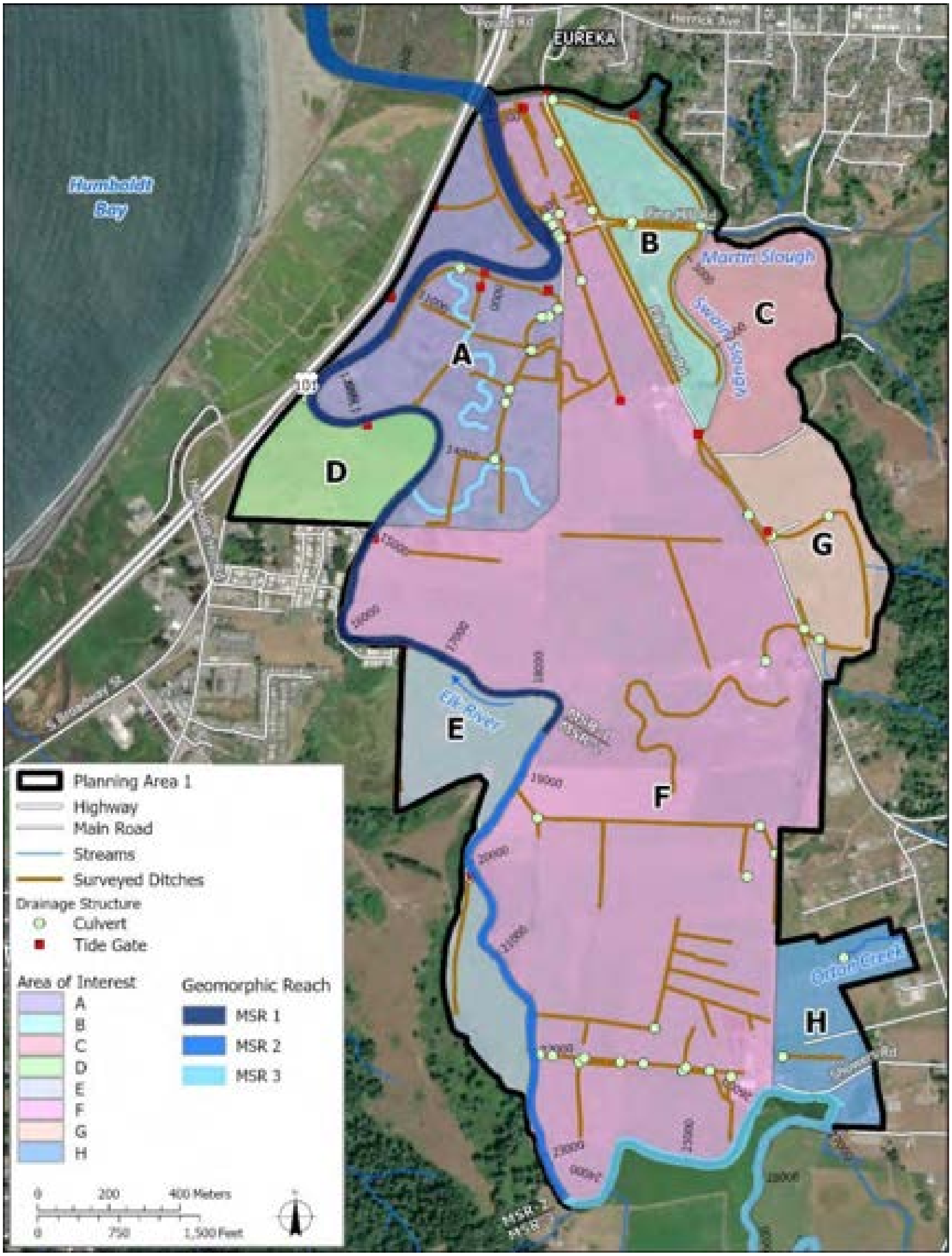


Figure 3-22. Overview of the Planning Area 1 project site, including Areas of Interest (AOI), geomorphic reaches (MSR) and surveyed drainage infrastructure.

3.4.1 Methods

The 2-dimensional hydraulic model described in the following section was developed using the U.S. Army Corps of Engineers' (USACE) HEC-RAS River Analysis System Version 6.3.1 (USACE 2022), which solves the 2D (depth-averaged) Saint Venant shallow water equations. The key steps in the development of the hydraulic model included:

i) creating high-resolution terrain surfaces of the existing and design channel, drainage network and floodplains from a combination of LiDAR and field survey data,
ii) building a computational mesh and land cover layer for existing and design ground that encompasses PA-1 (Figure 3-23),
iii) development of upstream and downstream boundary conditions (Table 1 in Appendix F),
iv) calibration of roughness coefficients to observed water levels (section 2.4.6 in Appendix F),
v) 2D modeling of existing and design terrains and hydraulic structures over the suite of freshwater and tidal boundary conditions, and
vi) post-processing and analysis of key EG and DG hydraulic results (e.g., inundation extent & duration, flow velocity, depth, and water surface elevations) to quantify hydraulic impacts and habitat benefits of 10% design concepts.

Please refer to Appendix F for a detailed description of hydraulic modeling methodology.

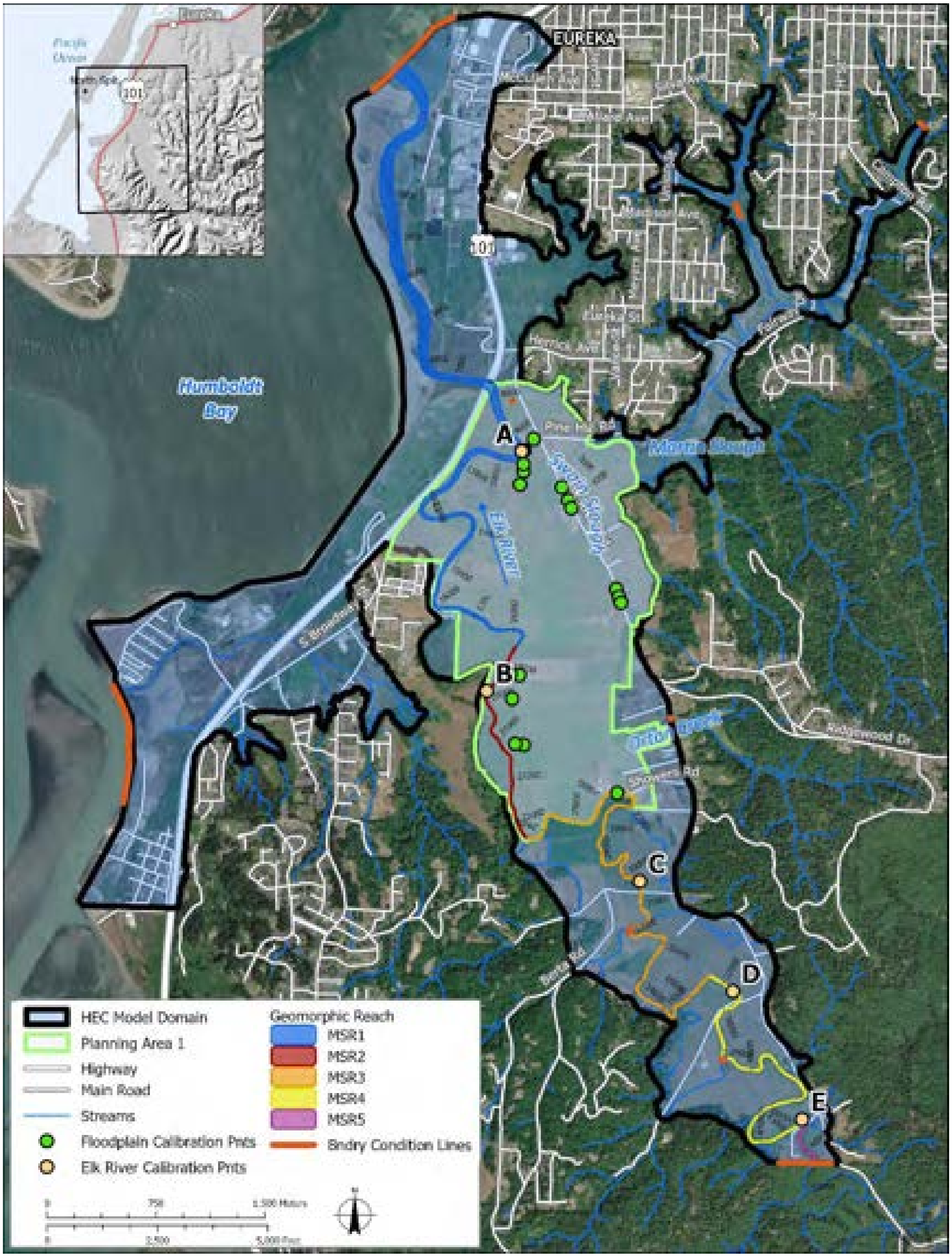


Figure 3-23. Model domain illustrating the location of continuous in-channel calibration points, discrete high water mark calibration points on the floodplain and boundary condition lines.

3.4.2 Results

The following sections provide an overview of the hydraulic model results for both the existing and design conditions scenarios. Results will generally be summarized in the context of different areas of interest (AOIs)—as well as the three key geomorphic reaches in the project area (Figure 3-22). As evidenced by section 2.4.6 in Appendix F, the model calibrated quite well to observed in-channel and floodplain highwater marks (i.e., correlation coefficients > 0.98, percent biases < 4% and Nash-Sutcliffe Coefficients > 0.8 at all monitoring locations in PA-1; see section 2.4.6 in Appendix F). Additionally, the model was qualitatively validated via consultation with local landowners whose long-term observations of flooding and drainage characteristics corroborated model results.

3.4.2.1 Existing Conditions

Inundation Extent and Duration

Model results indicate that PA-1 is prone to extensive, shallow, long-duration flooding even during relatively small flood events (e.g., 10% exceedance probability flow), suggesting the Elk River has limited channel conveyance capacity. For instance, at the 10% exceedance flow, roughly 44% of the floodplain area (355 ac) was inundated and at the 2-year flow, 87% of the floodplains were inundated (692 ac; Table 10 in Appendix F). A large portion of the EG overbank flooding during smaller storms (< 2-year) occurs in AOI F (Figure 3-24) due to backwatering of the existing ditch network in the southern portion of the corridor—while the bulk of the remaining flooding stems from overtopping of the Elk River near the MSR2 and MSR3 boundary (river station 24,300 ft; Figure 3-24). AOIs near the downstream model boundary (AOIs A and B) experienced frequent, widespread inundation across all modeled flows due to strong tidal influences and the relatively large tidal stages used in the boundary conditions. Apart from overtopping Hwy 101 at the 100-year event, there is little change in area inundated beyond the 2-year storm.

In addition to frequent, widespread floodplain inundation, the model suggests that much of PA-1 has poor drainage characteristics leading to long durations of inundation. For example, over the course of a modified 4.5-day calibration flow event (Calibration-Decay; see Table 1 in Appendix F), the main floodplain corridor through AOI F demonstrated a median inundation time of approximately 2 days and central portions of the floodplain corridor and associated grassy swales were inundated for well over 3 days (Figure 21 in Appendix F).

Table 3-2. Median time of inundation for all Areas of Interest in PA-1 for existing conditions during the 2015 Calibration-Decay event.

Area of Interest	Median (days)	Median (hrs)
D	0.34	8.2
H	1.33	32.0
C	1.57	37.8
E	1.66	39.8
G	1.84	44.3
F	2.09	50.3
A	2.10	50.5
B	3.20	76.8
PA-1	**1.8**	**42.0**

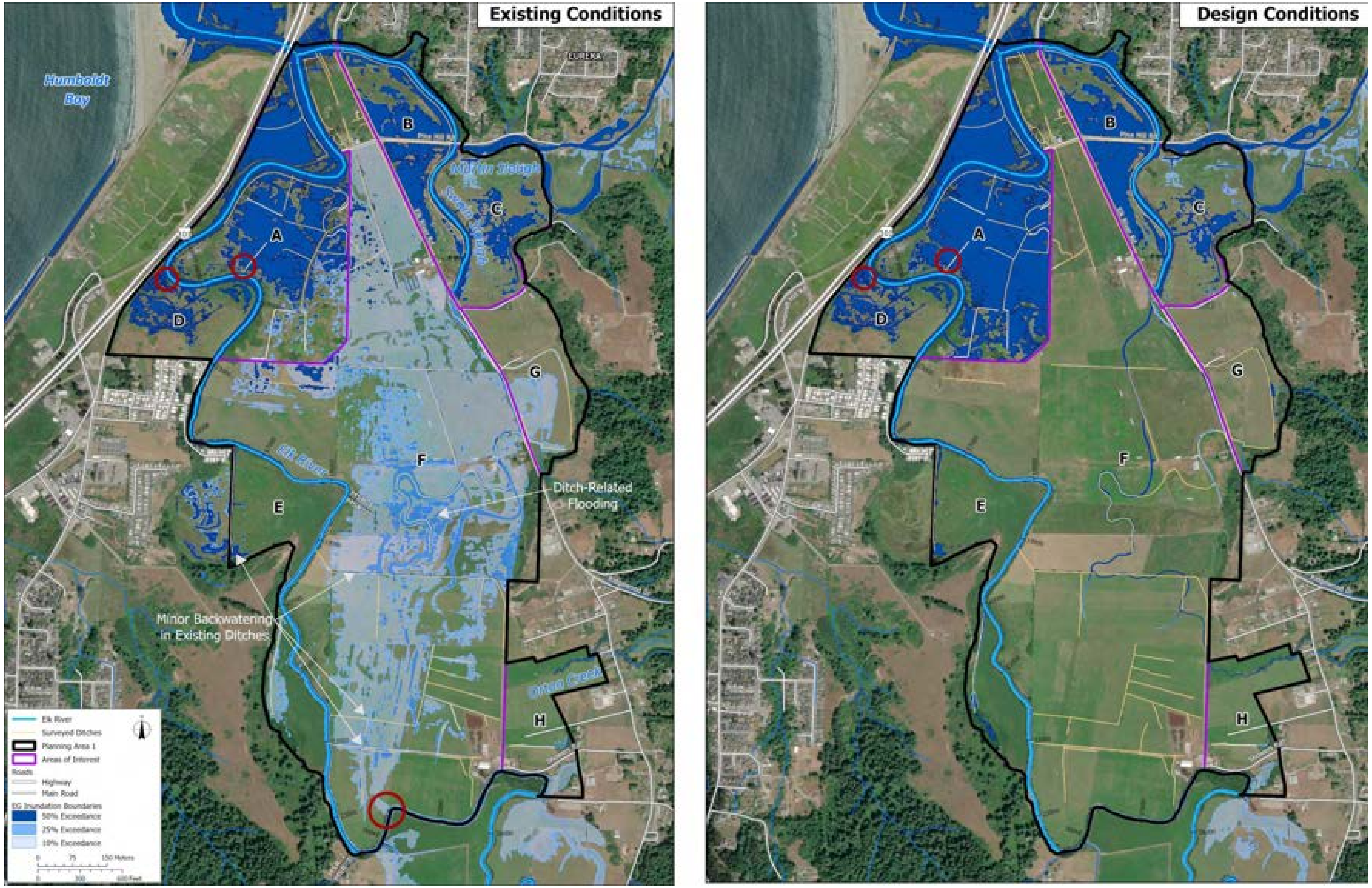


Figure 3-24. Inundation boundaries for 10%, 25% and 50% exceedance flows under existing and design conditions. Shallow, broad existing areas of inundation throughout most of PA-1 are reduced significantly under design conditions.

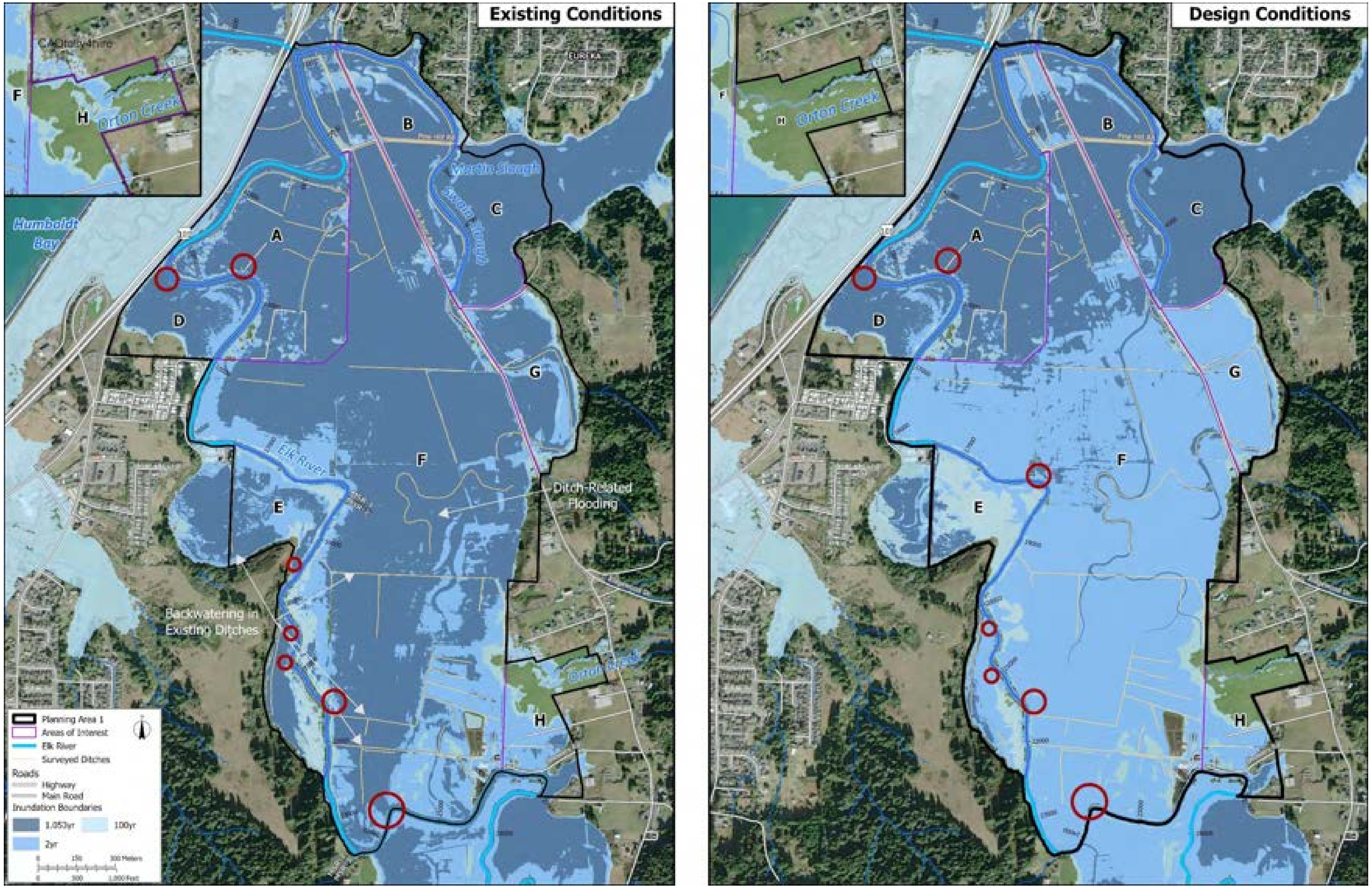


Figure 3-25. Inundation boundaries for 1.053-year, 2-year and 100-year peak flows indicating whether any cell was wet during the simulation under existing and design conditions

Flow Depths and Velocities

In-channel flows in all geomorphic reaches in PA-1 were quite slow and deep (> 3 ft deep flowing < 2 ft/s) across the majority of modeled flows (Table 11 in Appendix F). This is consistent with previous modelling results (California Trout et al. 2018) and likely related to very dense in-channel vegetation (especially in MSR2 and MSR3) coupled with channel entrenchment. Overall, depths and maximum flow velocities were highest in MSR1 due to channel geometry, cumulative inflow volumes, low channel roughness, and strong tidal influence.

Floodplain flow depths and velocities in PA-1 were also quite slow and generally shallow (< 1.5 ft flowing < 0.5 ft/s) until storm magnitudes exceeded the 2-year event (Table 12 in Appendix F). This is especially the case for AOIs D, E, F and G, where well over 50% of these areas were inundated < 1 ft deep and flowing < 1 ft/s during the relatively frequent 1.053-year event (Table 13 in Appendix F). For peak flows larger than the 2-year event, floodplain flow depths increased substantially and generally ranged from 2.5-6 ft. Across all modeled flows, overbank flow velocities remained quite slow and generally did not exceed 0.5 ft/s until the 100-year flood.

3.4.2.2 Design Conditions

Modeling results for design conditions are described in a general manner and summarized primarily by contrasting DG conditions with EG. Refer to Appendix E for additional detail.

Inundation Extent and Duration

The hydraulic model suggests that the proposed design actions will result in substantial changes to flooding extents and duration and that these changes vary with location, tidal stage, and flow magnitude. Overall, the DG model results indicated that the total area of inundation in PA-1 was reduced for all storm events with significant overbank flow (> 25% exceedance; see “Total” in Table 3-3). These reductions in wetted areas were principally related to significant declines in AOIs E, F, G and H (~24–96% reductions). Conversely, flow events that were more confined to the Elk River mainstem (≤ ~50% exceedance) demonstrated a net increase in inundated area over PA-1 (~11%), driven mostly by design actions in AOIs A, B, and E that increased inundation by promoting tidal marsh restoration and creation of off-channel habitat through improvements to lateral floodplain connectivity.

Importantly, significant overbank flooding occurs in the EG scenario at roughly the 10% exceedance flow (467 cfs), whereas in the DG scenario, overbank flooding does not occur until the ~2% exceedance flow (1,443 cfs, equivalent to the 1.25-year event). This not only suggests a ~5-fold decrease in the frequency of occurrence of significant overbank flooding, but also that design conditions in non-tidal reaches are much more in line with those of natural/stable channels where the return period of bankfull flow is usually ~1.5 years (Dunne and Leopold, 1978).

Table 3-3. Percent difference in DG vs. EG areas of inundation. Positive values indicate increased DG areas of inundation.

AOI	Exceedance flows				Peak flows		
	90%	50%	25%	10%	1.053-yr	2-yr	100-yr
A	37.3%	36.8%	36.3%	28.9%	0.1%	-1.5%	0.0%
B	9.1%	8.6%	9.0%	8.8%	0.6%	4.3%	0.0%
C	-29.1%	-28.8%	-23.8%	-17.9%	-0.2%	0.7%	0.0%
D	-7.1%	-7.0%	-4.2%	-0.8%	1.0%	-3.4%	0.0%
E	90.9%	90.9%	90.9%	-47.9%	-74.1%	-41.9%	0.8%
F	-73.6%	-72.5%	-86.2%	-97.4%	-80.0%	0.0%	-0.2%
G	--	--	--	-90.5%	-95.5%	4.2%	0.0%
H	--	--	0.0%	-47.6%	-59.4%	-23.6%	-16.8%
Total	**11.4%**	**11.0%**	**-4.4%**	**-60.4%**	**-54.1%**	**-2.5%**	**-0.5%**

The average duration of inundation for the modified 4.5-day calibration flow event (Calibration-Decay; see Table 1 in Appendix E) under design conditions was 29 hours, which represents a reduction in inundation time of ~0.5 days for PA-1 over the course of a real-world 4.5 day, ~ 1.65-year event. Areas of Interest E, F, G, and H experienced considerable decreases in the median time of inundation (13–27 hours; Table 3-4). These results indicate that design actions in these AOIs, such as floodplain channel excavation, hydraulic structure modification (e.g., levee alteration, tide gate removal), daylighting Orton Creek and placement of floodplain fill will help reduce diffuse overbank flows and facilitate drainage through a more natural, interconnected channel network that creates opportunities for high quality aquatic habitat. AOI F had the largest area of reduced inundation duration and the second largest reduction in median time of inundation relative to existing conditions (Table 3-4 and Figure 3-26). Additionally, many areas within AOI F, especially the central portions, demonstrated reductions in inundation time of 50 to over 70 hours (Figure 3-26). Such large decreases in the time of inundation during relatively frequent flood events could have significant agricultural, ecological and flood hazard benefits.

Table 3-4. Median difference in time of inundation for all AOI in PA-1 for DG vs. EG during the 2015 Calibration-Decay event. Negative values represent a decrease in inundation duration in the DG scenario.

Area of interest	Median difference in time of inundation (hrs)
A	1.74
B	0.50
C	2.25
D	0.25
E	-12.50
F	-23.01
G	-15.75
H	-26.76
PA-1	**-16.26**

In contrast, the downstream-most AOIs in PA-1 (A, B, and C) all demonstrated a minor to moderate increase in average inundation period (Table 3-4 and Figure 3-26). This suggests that proposed design actions (e.g., levee modifications and tidal channel excavation), which focus on enhancing lateral hydrologic connectivity, are functioning as intended in these AOIs. Elevated inundation times in AOI C, which were not an explicit restoration goal, are due mostly to: (1) the connection of Orton Creek to Swain Slough and (2) the redirection of flows along the central floodplain corridor to Swain Slough.

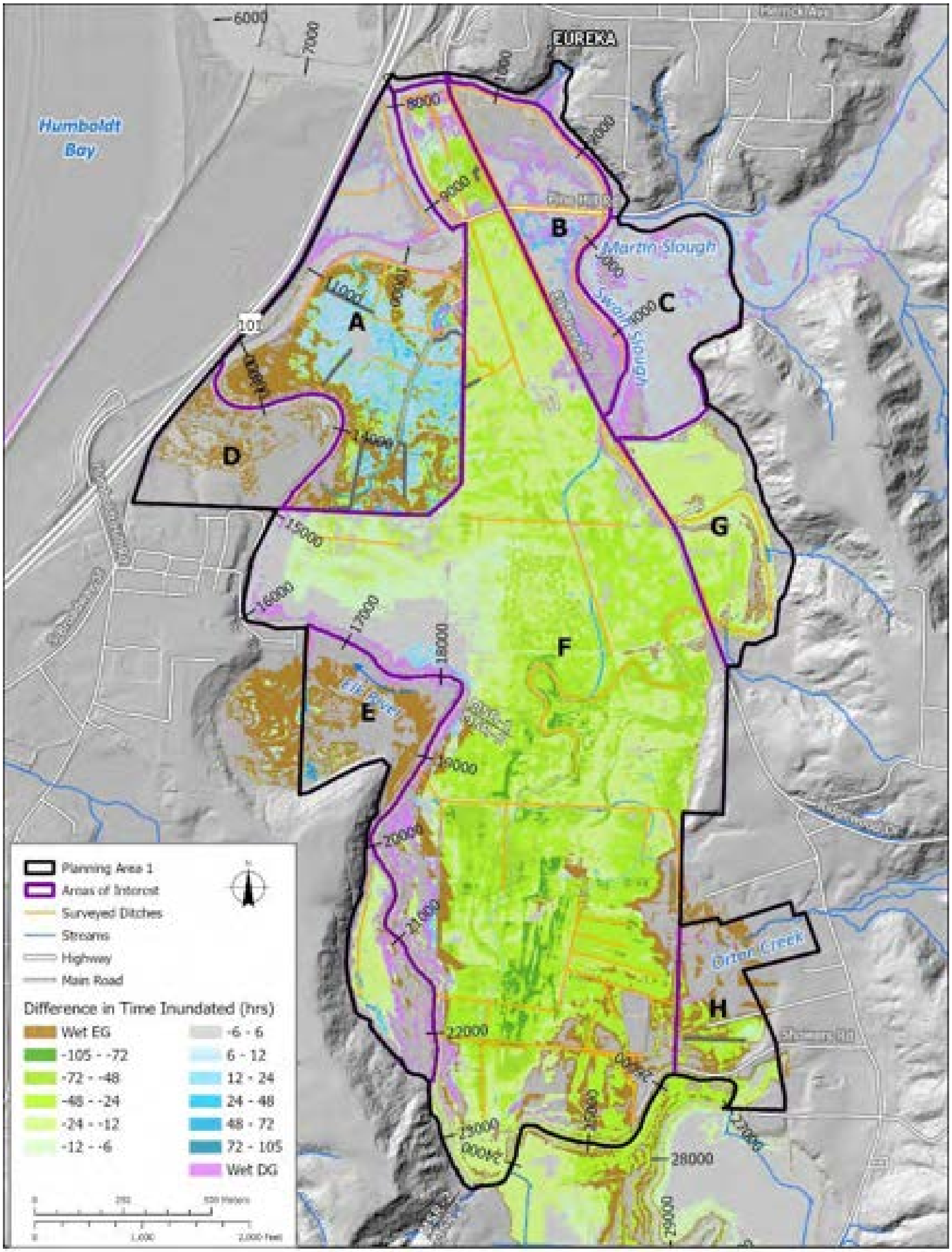


Figure 3-26. Differences in design vs. existing condition time of inundation (hrs). Positive values indicate increased time of inundation for design conditions. Wet EG and wet DG represent cells that were wet only under EG vs. DG conditions, respectively.

Flow Depth and Velocities

Relative to existing conditions, in-channel maximum flow depths for the DG mainstem were moderately lower in MSRs 1, 2, and 3 (0.01–1.5 ft; Table 21 in Appendix F), whereas flow velocities were higher (0.05–1.2 ft/s) during more frequent storm events (< 2-year; Table 26 in Appendix F). These results are related to reduced DG channel roughness in these reaches and indicate that design actions substantially enhanced mainstem conveyance capacity. The relative differences between EG vs. DG flow depths diminished significantly during higher flows and, apart from slightly higher DG water surface elevations in MSR2 (~0.2 ft; river station 18,500–22,500 ft), differences were minimal at the 100-year event (<0.1 ft). In contrast, differences in channel velocities tended to grow with increasing discharge in MSR2 and MSR3. In general, changes in channel flow depth and velocity in MSR1 were insignificant for most modeled flow events.

Differences in EG vs. DG floodplain flow depths and velocities were highly variable in space, time, and flow rate. In most cases, DG average floodplain flow depths and velocities were either unchanged or greater than EG conditions for the smaller, more frequent exceedance flows (e.g., 10% exceedance flow in Tables 22 and 27 in Appendix F). AOI F, for example, exhibited increased median flow depths over 1 ft for flows < 1.053-year, due to design actions that reduced the extent of shallow inundation, increased longitudinal connectivity (muted tide through modified, fish-friendly Swain Slough tide gate; TG-100), and concentrated diffuse overland flows into higher quality, deeper channel habitat in the central floodplain corridor (AOI F; Table 22 in Appendix F). Increased depths in AOI A & E during lower flows are attributable to the addition of several key design elements, including: (1) floodplain ponds/wetlands, (2) tidal/floodplain channels, (3) alcoves at the confluence with the Elk River mainstem, and (4) levee modifications to increase lateral connectivity. DG floodplain flow depths were lower in some AOIs (E & H) during higher flows due to DG fill placement, levee modifications or removal of undersized hydraulic structures. Overall, there were minimal differences in average EG vs. DG floodplain velocities; however, this does not necessarily reflect more considerable localized increases in flow velocities associated with design floodplain channels which can be over two times greater than existing conditions (Figures 27 and 28 in Appendix F).

3.4.3 Conclusions

In summary, the 2D hydraulic model indicates that the proposed design elements will have meaningful impacts on flow hydraulics in PA-1 and will be largely successful in achieving project objectives. Salient findings include:

- Design conditions broadly increase inundation frequency, extent, duration, and depths in tidal areas where the focus of restoration efforts (e.g., levee removal, slough channel excavation, etc.) was to enhance marsh and floodplain connectivity and estuary expansion.
- Conversely, inundation frequency, extent and duration decreased significantly in less tidally influenced areas of PA-1 (AOIs E, F, G, and H), where the focus of enhancement efforts was the restoration of natural flow pathways, improvement of longitudinal connectivity and flood conveyance, and augmentation of off-channel habitat.
- Overbank flows in the design scenario were generally more concentrated into well-connected channel networks, facilitating fish passage, increasing access to critical habitat and cover, minimizing stranding mortality and restoring more natural drainage characteristics.
- In all areas of PA-1, design actions aimed at estuarine and riverine habitat creation resulted in considerable, but localized increases in flow depths and durations of inundation, suggesting meaningful habitat benefits.

- Design actions (i.e., in-channel vegetation management) enhanced flood conveyance capacity of the Elk River mainstem, leading to lower in-channel flow depths and increased in-channel velocities.
- Disconnection of derelict drainage infrastructure and enhanced flood conveyance capacity in the Elk River mainstem resulted in a ~5-fold decrease in the frequency of occurrence of significant overbanks flows (reducing an ~10% exceedance probability of overbank flow to. ~2% for DG). Such large decreases in flood frequency, extent and duration could have significant agricultural, ecological and flood hazard benefits.
- Apart from mainstem channel velocities, the differences in EG vs. DG hydraulics generally declined with increasing storm magnitude. Additionally, besides some localized increases in water surface elevations due to specific actions (e.g., floodplain recontouring), differences between EG and DG 100-year water surface elevations were negligible, mostly resulting in a decrease in DG water depths.

Moving forward, these preliminary results will be used by the design team to inform the selection of preferred design alternatives, which will be the subject of further analysis and refinement. Appendix F details a number of recommendations to support such future analyses.

3.5 Climate Change

Initial proposals for this project did not include an analysis of climate change impacts, but, as the project developed, climate change impacts became increasingly difficult to ignore. Our work occurs within the productive, complex, and rapidly changing Elk Estuary, which is responding to the highest rates of relative sea level rise in the state. Landowners in the Estuary are already seeing a conversion to salt marsh, and several of them have begun working with the project team to develop strategies for managed retreat. A drinking water supply line crossing the estuary faces continued and accelerating impacts from corrosive saltwater intrusion, and several buildings lie within an expanded (and expanding) 100-year flood zone. We also became increasingly aware that, unless we can get enough sediment deposition across the marsh plain, our extensive and transformative plans for restoration of this important ecosystem could result in development of mud flat instead.

Sea level rise is an important climate impact in the Elk Estuary, but it is not the only form that climate change will take. Within the Humboldt Bay watershed, average annual maximum temperatures are predicted to rise 4.3–7.1°F by the end of the century, with rainfall intensity increasing 8.7–15% over that timeframe (CEC 2022). The North Coast region will experience prolonged dry seasons, reduced soil moisture, increased flooding and drought, and increased wildfire frequency and extent (Grantham 2018). Consequences include habitat loss, alternations in vegetation types, reduced productivity of working lands, increased risks to public health, and risks to critical infrastructure, including water supply.

North Coast rivers are particularly vulnerable to climate change. As precipitation varies, peak flows become higher and low flows lower. Higher flows can increase scour, initiate landslides, and mobilize increased amounts of sediment. Rising ambient air temperatures lead to rising water temperature, which impacts other water quality parameters such as dissolved oxygen and biological oxygen demand (Grantham 2018).

These impacts, along with sea level rise, may make all Recovery Plan goals and objectives—including, protection of existing agricultural uses, the recovery of water quality, sediment remediation, reduction of flooding, salmonid recovery, recovery of sensitive biological communities, and restoration of tidal marsh, estuarine, riparian, and riverine function—more difficult to achieve. Much of the work we have already proposed to address watershed health will also increase climate resilience, but the efficacy of actions depends on the magnitude of coming changes and the timescale considered. Although broader patterns of temperature change and other parameters with rising greenhouse gas emissions are relatively well understood, the response of the Elk Watershed and stewardship area to these broader changes is not (See climate change modeling technical memorandum in CalTrout 2022[5]).

The project team stepped in to address this knowledge gap, augmenting existing funding for the Elk Estuary with private donations. This funding allowed us to identify some key, near-term vulnerabilities in the Estuary along with some concepts to be incorporated into design at the 10% or later stages. These near-term vulnerabilities include increased inundation of drinking water infrastructure and agricultural land, the movement of the stream-estuary ecotone upriver, and the impacts of sea level rise on the marsh plain.

The project team is working with the Humboldt Community Services District to advance planning, design and funding for the replacement of a vulnerable water pipeline with a climate-resilient design. The water line is composed of brittle, corrosive materials and located within an area where it is increasingly subject to contact with salt water. The climate resilient design will place it at a depth where it will no longer be in contact with salt water, and it will be constructed of non-corrosive materials. Current designs, including the eco-levee surrounding the ERWA, are designed to protect productive agricultural land from tidal influence. Some lower-elevation agricultural land already converting to salt marsh is part of a managed retreat strategy (for more on this, see Section 3.2 and 3.3).

Sea level rise would increase tidal prism into some off-channel features at the stream-estuary ecotone, thereby increasing salinity magnitudes and durations. There will need to be an evaluation of the benefits of tide gate removal versus installation of modern and adjustable tide gates that allow fish passage but can be fine-tuned to achieve desirable salinities and maximize fish use and habitat capacity, as well as limit impacts of saltwater on pasture lands. Tide gates could also buy time to allow for more gradual adaption of the sites and associated ecosystems to sea level rise in some locations along the stream-estuary ecotone, such as on M2-FP-3.9 and M1-FP-3.1.

By opening up formerly diked and drained land to a full to a full tidal prism, the project will encourage sediment deposition from the Elk River onto the restored marsh plain. This restored estuarine process may allow marsh accretion to keep pace with sea level rise, at least at current rates. If sea level rise accelerates in the future, marsh migration will be possible along the higher elevation gradient adjacent to the tidal channels. The low gradient eco-berm and surrounding high brackish marsh communities throughout this area should provide space for migration of vegetation communities within the low to high saltmarsh range. However, the size/extent of the footprint between salt marsh to high brackish marsh communities is uncertain at this stage of the

[5] Climate planning requires an understanding of uncertainty overlain on variability. In dealing with any system, particularly a complex natural system such as a river, one must be comfortable working with some uncertainty stemming from variation in rainfall, changes to topography, precision in measurements of topography, etc. These are "known unknowns," and variability is more easily estimated from existing data and, in the case of hydrology, historical record. Climate planning involves another layer of uncertainty, as the choices made globally by governments, corporations, and individuals will drive future watershed processes in the Elk.

design process. Larger brackish marsh and grassland ecotone habitat zones may reduce initial creation of saltmarsh habitat but provide future opportunities for salt marsh migration if SLR accelerates.

To increase resilience to sea level rise, restored marsh and wetland habitats will be composed of a diverse planting palette that will include species that have brackish to freshwater tolerances allowing for the shifting salinities throughout the year and provide community resilience from the potential increased salinity over time (e.g., maintained vegetative cover that will retain habitat value for wildlife/sensitive species and abate nonnative weed establishment). Plantings as part of riparian vegetation enhancement will also include a diverse group of coastal riparian species that have varying salinity tolerances to maintain riparian cover, shade, aquatic food sources, and other ecosystem functions. For more on how these concepts were incorporated into design, see Sections 3.3. and 3.4.

Further work will be needed to identify vulnerabilities systematically and robustly. We recommend systematic vulnerability assessments for focal aquatic species, habitats, or ecosystems to help identify key vulnerabilities that should be considered when planning and designing restoration actions. Assessing sensitivity, exposure, and adaptive capacity of target species to predicted climate change stressors would help in developing designs that mitigate impacts and allow for adaptation.
Key vulnerabilities in geomorphic and fluvial processes were identified for future study and consideration in design. These include:

- Coastal shoreline and marsh erosion in response to sea level rise and/or increased tidal prism.
- Integrity/functionality of existing natural berms, levees, and other flood control infrastructure.
- Basin sediment delivery in response to changes in hydrology.
- Estuary sedimentation and the associated relationship between marsh accretion and sea level rise (with complex influences on estuary ecological zonation).
- Geomorphic changes in fluvial stream channels and estuary tidal slough channels (e.g., channel vs floodplain flow conveyance, sediment mobility and grain size, simplification, stability, vegetation changes, and aquatic habitat availability). Design for/allow for dynamic channel geometry/morphology.

We have included in proposals a plan to develop a conceptual design of climate impacts in the Stewardship Area and quantitative and qualitative analyses to help efficiently and robustly identify and address these and other key vulnerabilities. Sea level rise to date has been incorporated into the existing and design conditions models, and we anticipate funding for future modeling efforts will also include support for modeling of future sea level rise and possibly other impacts including water quality, hydrology, hydraulics, and sediment transport as needed.

3.6 Summary of Project Benefits and Regulatory Assessments

The 857-ac Elk River lower valley project area was once an ecologically rich and variable landscape, comprised of dunes and tidal marshes, prairie grasslands, patches of deciduous and coniferous forests, and productive wetland aquatic habitat. Nearly all this habitat was lost to agricultural conversion following Euro-American colonization of the region beginning in the 1850s. Restoration of this area is of paramount importance to the ecological function of the Elk

River watershed, resilience to climate change, and to the recovery of salmon, steelhead, and other fish and wildlife populations.

This Planning Area is also acutely vulnerable to sea level rise. Directly opposite the Humboldt Bay harbor entrance and characterized by low-elevation, subsiding, diked former tidelands, the water control infrastructure is aged and neglected, and as a result, habitat conversion is already occurring in unmaintained pastures. Pastures and roads in this vicinity flood during seasonal king tides. This condition is expected to worsen in coming years (Laird et al. 2013).

The Project proposes to restore natural tidal and fluvial drainage patterns across the 857-ac Project Area by removing and upgrading drainage infrastructure (tide gates, culverts, drainage ditches), reducing or removing levees and a breaching a relict railroad grade, restoring tidal sloughs and tidal creek channels and their connectivity to mainstem channels, and lightly recontouring portions of the floodplain with hummocks and swales to guide winter flood-flows across the floodplain and back into the slough channel network toward suitable aquatic habitat. Construction of off-channel ponds and backwater features connected to Elk River will provide seasonal waterfowl and winter salmonid rearing habitat (primarily for Federally listed coho salmon).

On the east side of the valley paralleling Elk River Road, Swain Slough would be extended an additional 1.3 miles up the valley, and a tide gate would be modified to reconnect the restored tidal channel and allow flood-flows to drain through Swain Slough. Several tributary creeks are proposed to be reconnected to Swain Slough to improve drainage and provide a perennial freshwater source for aquatic habitat. Approximately 75 ac of former tidelands may be acquired in the Swain Slough vicinity, and other acquisitions are possible. On the 104-ac CDFW Elk River Wildlife Area, relict farm buildings, drainage culverts and tide gates, and internal levees would be removed to restore tidal marsh habitat and expand riparian vegetation. Portions of Elk River require vegetation management to remove Spartina and reed canary grass and reduce encroachment of willow thickets in the channel to improve flood conveyance. Many tens of acres of native wetland and riparian vegetation would be planted along Elk River and Swain Slough, which would increase species richness and canopy diversity.

3.6.1 Forthcoming regulatory analysis

The Elk River Recovery Plan (CalTrout et al. 2022) provides a detailed overview of the regulatory compliance process, including CEQA and permit authorizations, that will be applied in the Elk River Recovery Program. This process includes the use of the newly developed State Water Resources Control Board (SWRCB) Statewide Restoration General Order (General Order) and associated Programmatic Environmental Impact Report (PEIR) that were adopted by the State Water Board in mid-2022. All Stewardship Actions appear to align with categories of project types proposed in the General Order. The project will also be required to comply with all applicable federal, state, and local regulatory statutes summarized in Recovery Plan. An alternative CEQA compliance process could seek to utilize the recently approved CEQA Statutory Exemption for Restoration Projects (SERP).

As noted in the Recovery Plan, the General Order Notice of Intent application form would be filed as an initial step to utilize the SWRCB's PEIR as a CEQA pathway. In this 10% design report, we provide the first steps in this process, describing the proposed actions, and summarizing the extent of these actions and their temporary impacts and benefits in quantitative terms required by the NOI application. The NOI benefit/impact table is replicated in Table 3-5. The information presented here is the first step in the regulatory process, intended to express the scope and scale of benefits of our proposed actions; temporary and permanent impacts resulting from our proposed actions will be determined in the next phase of the project, during development of the 65% engineering designs and basis of design report.

Table 3-5. "Table B" from the Statewide Restoration General Order Notice of Intent, listing temporary project impacts and benefits to waters of the State. NOI Instructions require: (1) the area(s) in acres and linear feet that will be temporarily impacted and permanently impacted by the project, (2) the volume of excavation and/or fill in each water body type in cubic yards, and (3) the water body type(s) that will be enhanced, restored, or rehabilitated for each of the applicable water body type(s) listed. The impact analysis is only partially complete at this 10% design stage.

Water Body Type	10% Design Proposed Actions	Name	Temporary Impacts				Resource Enhanced or Restored	
			Acres	Cut (yd3)	Fill (yd3)	Linear Ft	Acres	Linear Ft
Wetlands								
	Tidal Marsh							
	SS-FP-0.3	SS NE Tidal Marsh	0.8	1,500	250	341	0.8	TBD (tidal channel length)
	SS-FP-0.4	SS Tidal Marsh 1	21.1	15,700	15,700	2,007	21.1	TBD (tidal channel length)
	SS-FP-0.7	SS Tidal Marsh 2	16.0	12,400	12,400	1,705	16.0	TBD (tidal channel length)
	M1-FP-1.5	ERWA North [Dike]	17.3	3,500	3,500	2,706	17.3	TBD (tidal channel length)
	M1-FP-1.8	ERWA South [Marsh]	84.7	88,400	88,400	3,258	84.7	TBD (tidal channel length)
	M1-FP-2.5 & 2.7	Western Tidal Marsh [Bull]	26.9	TBD			26.9	TBD (tidal channel length)
	M1-FP-1.8	ERWA Bldg Demo	0.15	TBD			0.15	
	SubTotal						**166.9**	
	Freshwater Wetland							
	M2-FP-2.7	Vroman Bldg Demo	0.2	TBD			0.2	TBD (wetland type)
		SS Wetland	TBD	TBD			99.7	TBD (wetland type)
		SS Bldg Demo	0.7	TBD			0.7	TBD (wetland type)
	SubTotal						**100.6**	
Streambed and Stream Banks								
	Stream-Estuary Ecotone							
	Mainstem							
	M1-MC-1.7	Lower Mainstem Elk	18.8	TBD		7140	18.8	7,140 (intermittent portions)
	M2-MC-4.1	Upper Mainstem Elk	7.3	TBD		TBD	7.3	9,200 (intermittent portions)
	SS-MC-0.5	Lower Swain Slough	6.3	TBD		4840	6.3	4,840 (intermittent portions)
	SubTotal						**32.4**	**21,200**
	Off-Channel							
	M1-FP-1.6	Confluence Wetlands	2.8	3,200	650	1,810	2.8	1,300
	M1-FP-3.1	Western Off-Channel DS	2.8	4,300	1,100	1,834	2.8	1,400
	M2-FP-3.9	Western Off-Channel US	1.8	4,900	360	1,527	1.8	1,100
	M2-FP-2.7	Old SS Channel	0.4	1,300	TBD	273	0.4	273
	SubTotal						**7.7**	**4,073**
	Tributary							
	M2-TB-3.8	Orton Extension	9.9	31,000	1,400	8,670	9.9	**8,670**
	SubTotal						**25.3**	**16,816**
Riparian (Non-Native and Native Vegetation)								
	Non-Native Vegetation							
	Reed canary grass		5.76				5.76	
	Dense-flowered cord grass		2.47				2.47	
	Himilayan blackberry		5.77				5.77	
	Lowmanna grass		2.32				2.32	
	M1-FP-2.5 & 2.7 (Bull Pasture)						7.9	
	Native Riparian Vegetation							
	M1-FP-3.1	Western Off-Channel DS					2.8	
	M2-FP-2.7	Old SS Channel					0.4	
	M2-FP-3.8	Orton Extension					12.8	
	M2-FP-3.9	Western Off-Channel US					1.8	
	M2-FP-4.0	Floodplain E-W Swales					3.5	
	M2-FP-4.1	Veg Management	7.3					
	M2-FP-4.2	Veg Planting					7.3	
	SubTotal						**28.6**	
Floodplain								
	M2-FP-3.0	Floodplain East Swale	1.2	1,600	TBD	1,570	1.2	1,570
	M2-FP-4.0	Floodplain West Swale	3.1	5,700	500	2,898	3.1	2,898
	M2-FP-3.5; 3.7; 4.0	Sediment Re-Use	87.1		66,800	8,404	87.2	
	SubTotal						**91.5**	**4,468**

3.6.2 Benefits of proposed project actions

In the tidal and estuarine areas of Planning Area 1, design actions are intended to modernize the drainage infrastructure to restore natural tidal inundation patterns. Proposed actions significantly increase marsh and floodplain connectivity and promote estuary expansion. Within the CDFW ERWA, proposed actions include removal of ~4,870 ft of levees adjacent to Elk River, two interior levees (1,100 ft), three tide gates, ten culverts, several drainage ditches, and a milk barn structure and artificial fill. This outdated and poorly functioning drainage infrastructure would be replaced with fish-friendly tide gates, enlarged and reconnected culverts (where necessary), and a network of reconnected slough channels. Across PA-1 an additional 13 culverts and 4 tide gates would be removed or replaced, and ~2,600 ft of pasture drainage ditches filled. In the upper portion of PA-1 dominated by agricultural wetlands, longitudinal connectivity and flood conveyance would be upgraded by construction of 4,400 linear ft of naturally contoured floodplain swales reconnected to Swain Slough; lateral connectivity to off-channel habitats is also improved, while the frequency, extent and duration of winter flood inundation on agricultural pastures is considerably reduced.

Restoring a full tidal prism to the CDFW Elk River Wildlife Area and several surrounding parcels will improve resiliency to sea level rise by restoring natural rates of sediment deposition and marsh accretion. Combined with strategic property acquisitions, this combination of actions would enable tidal marsh and estuarine conditions to recover, keep pace with sea level rise, and persist into the foreseeable future. The loss of diked former tidelands and the conversion of those low-lying agricultural lands back to natural tidal marsh habitats is accelerating and irreversible. The design actions proposed here would accelerate the recovery of those lands to natural habitats, while prolonging the viability of remaining agricultural lands.

Over 90% of Humboldt Bay's salt marsh and intertidal channels were diked, drained, and converted to agricultural uses over the past 170 years. Design actions proposed herein would restore approximately 170 ac of former tidal marsh lands to full tidal connectivity. These marshes would be enhanced by the removal of defunct and constraining drainage infrastructure, the creation of tidal slough and creek channels, and the enhancement of marsh topography to create a mosaic of aquatic habitats and wetland and riparian vegetation. Reconnection of tidal marshes adjacent to Elk River and Swain Slough mainstem channels would significantly improve aquatic habitat in those mainstems by increasing food resources, salinity gradients, and access to refugia during winter floods.

In the stream-estuary ecotone, intermittent portions of approximately 21,000 ft of Elk River and Swain Slough mainstems would be rehabilitated by recontouring banks, creating alcoves, removing live willow vegetation rooted in the channel bed and banks, and replacing this wood with more functional large wood structures. Approximately 17.6 ac of off-channel winter habitat for coho salmon would be created in several locations along the valley to provide a range of freshwater and brackish water conditions. These habitat areas would be fenced from cattle and protected by riparian habitat. Several proposed freshwater ponds will capture cold-water springs and seeps emerging from hillsides and remain productive habitat year-around. The reconnection of Orton Creek to Swain Slough would restore over 8,600 linear ft of tidally influenced freshwater habitat, as well as reduce the potential for juvenile salmonid stranding in pasture drainage ditches.

Nonnative weed and invasive plant species (e.g., reed canary grass, dense-flowered cordgrass, Himalayan blackberry, low manna grass) would be treated across approximately 30 ac of estuarine and palustrine wetlands to reduce their presence and ability to spread. Treated areas would be replaced with native plant species to form a natural mosaic including emergent low salt marsh, intertidal brackish marsh, mixed high salt marsh, high brackish marsh, and mesic grassland. Further along the elevation gradient, 21.3 ac of native riparian scrub, shrub, and forested communities will be restored.

4 NEXT STEPS

The analysis presented herein shows, at a preliminary level, feasibility of project actions to create habitat for focal species and reduce flooding. Of course, further work will need to be performed to ready designs for construction, demonstrate cost effectiveness, prove feasibility for elements not yet studied, and expand designs to take advantage of new opportunities. If land acquisitions progress as planned, the project team will be able to substantially expand designs to benefit sensitive species. Expanded design in these areas is still contingent on the outcome of the acquisition process, so conceptual designs in these areas must be developed in future phases.

The following data and analyses are required to support the next phase of planning and design:

- Refinement of available topography.
- Groundwater, streamflow, and water quality monitoring.
- Soils evaluation for sediment reuse in agricultural areas.
- Springs inundation and dissolved oxygen characterization.
- Refinement of hydraulic modelling, including:
  - Acquisition and incorporation of high-resolution, rigorously post-processed LiDAR data and ground surveys.
  - Incorporation of new or existing bathymetric data for the Elk River mainstem, Martin and Swain Slough in order to improve the accuracy of hydraulic results, especially at lower habitat flows.
  - Calibration of future model runs over a larger range of observed flows (particularly low flows) with data that corresponds to the current bed conditions and expanding the calibration data to include Orton Creek, Swain Slough, and Martin Slough.
  - Inclusion of sea level predictions and concomitant changes to salinity.
- Development of a monitoring plan.

The CalTrout, NHE, GHD, and SWS team has articulated a vision for the progression of work through the project’s next phases which includes a streamlined permitting approach based on the Statewide Restoration General Order and design to the 65% stage. We plan to include the following in the next phase of design:

- A climate change vulnerability assessment, including creation of a climate change conceptual model, literature review, and hydraulic and water quality modeling.
- Restoration designs, including the actions and grading activities described in section 3.4, and expanded conceptual designs on newly transferred properties. This will include:
  - a 90% grading plan,
  - 65% design for project elements (tide gates, et cetera),
  - a materials management plan,
  - a draft plan for construction and revegetation phasing and sequencing,
  - 100% plans for pilot implementation, and

- reporting.

Reporting for 30, 65, and 100% designs will build off this document. At 30%, we will check in with landowners, agencies and interested parties; at 65%, we will update this document with updated designs, new studies, and analyses, including an appended, updated hydraulic modeling report. Project elements will be described in the CEQA NOI, and a basis of design report for 100% any design elements.

CalTrout and our partners are aware of the urgent need for implementation of this project to help respond to a changing climate, recover declining salmonid populations, and relieve Elk Estuary residents and landowners of persistent flooding and water quality impairment. We are actively seeking support for the next stages of design and planning so that this project can be constructed soon. To this end, we want to move efficiently through the design process; at this stage, this means, if possible, addressing any comments or suggestions for major alterations or substantive analysis in the next stages of design rather than iterating at the 10% stage.

We developed many productive working relationships as 10% design progressed. We want to thank all of those who contributed to this effort, including landowners, funders, agency partners, the Wiyot Tribe, and everyone with ties to the Elk River and Elk River watershed communities. We look forward to continuing our work with you to envision and implement this transformative and long-anticipated project.

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