Appendix G

Fisheries Impact Assessments: Reclamation Ditch/Tembladero Slough Diversions

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Appendix G1

Memorandum Regarding Fisheries Impact Assessment - Reclamation Ditch/Tembladero Slough Diversion

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TECHNICAL MEMORANDUM

TO: Denise Duffy
Denise Duffy and Associates

FROM: Jeff Hagar
Hagar Environmental Science

DATE: February 28, 2015

PROJECT: Pure Water Monterey Groundwater Replenishment (GWR) Project – Reclamation Ditch and Tembladero Slough Source Water Diversion Fisheries Effects Analysis

1.1 PURPOSE

The Monterey Regional Water Pollution Control Agency (MRWPCA) is preparing an Environmental Impact Report (EIR) for the proposed Pure Water Monterey Groundwater Replenishment Project (GWR Project). The project will develop high quality replacement water for existing urban supplies; and an enhanced agricultural irrigation (Crop Irrigation) component that will increase the amount of recycled water available to the existing Castroville Seawater Intrusion Project in northern Monterey County. The proposed project would consist of source water conveyance facilities, treatment facilities, product water conveyance facilities, and replenishment/recharge facilities. Proposed source waters could include:

- City of Salinas (City) Agricultural wash water currently treated and disposed via evaporation and percolation at the Salinas Industrial Wastewater Treatment Facility;
- Storm water collection systems of the City of Salinas and the Lake El Estero watershed in Monterey; and
- Secondary or tertiary effluent from the Regional Treatment Plant.
- Blanco Drain water;
- Storm water collection systems of other MRWPCA member entities and other watersheds in the Salinas and Monterey areas; and
- Reclamation Ditch / Tembladero Slough water.

Two of these source waters, Blanco Drain water and Reclamation Ditch and Tembladero Slough water, involve potential diversions from surface waters that may support fish fauna or are tributary to waters potentially supporting fish fauna. In this report, Hagar Environmental Science (HES) has evaluated the GWR Projects related flow change effects on fish fauna and associated habitat in the Reclamation Ditch, and Tembladero Slough. Environmental effects of the project on fish fauna related to the Blanco Drain and all other Salinas River areas is treated in a separate report prepared by HDR Engineering, Inc. (2014).

1.2 ENVIRONMENTAL SETTING

The environmental setting for fisheries consists of all aquatic resources that could be directly or indirectly affected by the project. This includes the alternative diversion locations on the Reclamation Ditch near Davis Road and Tembladero Slough at the Castroville Pump Station. The setting also includes downstream aquatic habitats that may be altered by flow modifications including the Reclamation Ditch downstream to its confluence with Tembladero Slough, Tembladero Slough downstream to its confluence with the Old Salinas River channel, and the Old Salinas River downstream to Moss Landing Harbor (Figure 1). Since the project alternatives potentially influence migratory fish including steelhead (*Oncorhynchus mykiss*), the environmental setting also includes the watershed upstream of the Davis Road diversion site.

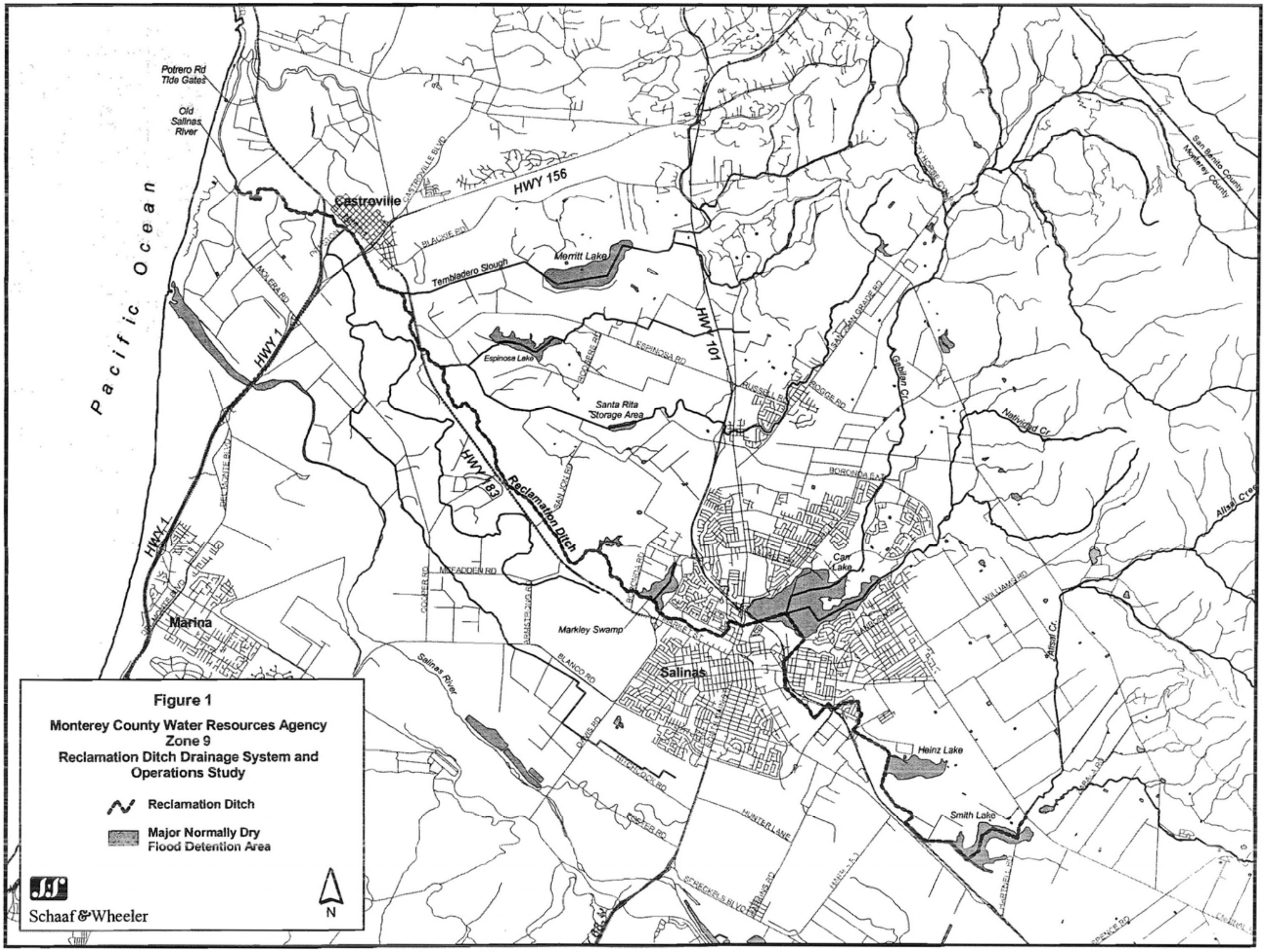

Figure 1. Project Area.

1.2.1 Reclamation Ditch, Tembladero Slough, and the Old Salinas River

The Reclamation Ditch watershed is approximately 157 square miles with headwaters in the Gabilan Range above Salinas and discharging into the Tembladero Slough then to the Old Salinas River just upstream from Moss Landing Harbor (CCoWS 2006). The lower watershed areas were formerly low lying areas with seasonal lakes, swamps, and wetland. Much of the middle and lower watershed channels have been altered for drainage and conveyance of flood flows. The watershed has five main tributaries including Gabilan Creek, Natividad Creek, Alisal Creek, Santa Rita Creek and the Merritt Lake drainage. Gabilan, Natividad, and Alisal Creeks converge at Carr Lake, a seasonal lake in the center of Salinas, and the outlet from Carr Lake forms the head of the Reclamation Ditch. During the growing season the Carr Lake bed is used for agricultural production (CCoWS 2006). The majority of runoff in the basin was historically generated in the Gabilan and Alisal Creek subwatersheds (CCoWS 2006 reproduced from Cozzens 1944).

The watershed also contains the City of Salinas and portions of Castroville and Prunedale. Summer flows are predominantly agricultural tile drainage. Winter flows include storm runoff from throughout the basin (Schaaf & Wheeler 2014).

The Salinas Reclamation Ditch was built between 1917 and 1920 to collect and drain surface runoff generated in the watershed. It includes the outlet of Carr Lake and a network of channels draining much of the City of Salinas as well as many of the former lakes and sloughs. Urban runoff from the City of Salinas drains into various channels of the Reclamation Ditch system via approximately 54 stormwater outfalls. The whole system drains into Tembladero Slough (an extended brackish, sub-tidal slough), then the Old Salinas River, and ultimately into Moss Landing Harbor through the Potrero Tide Gates (CCoWS 2006).

The Reclamation Ditch system drained an extensive system of interconnected sub-tidal lakes and swamps that formerly existed between Salinas and Castroville. These include Merritt Lake, Espinosa Lake, Santa Rita Slough, Vierra Lake, Fontes Lake, Boronda Lake, Markley Swamp, and Mill Lake (CCoWS 2006). The lakes naturally had poor drainage and were only connected during periods of high runoff. Most of the lakes are now farmed, but still flood regularly during winter storm events and are used for detention flood storage. Following the de-watering of the original lakebeds, land subsidence (Bechtel Corp 1959) of up to several feet was observed resulting in poor natural drainage of surface waters. Surface water pump stations have been installed and operated to allow continued agricultural use of these areas.

The following description of hydrologic conditions in the watershed is drawn largely from CCoWS (2006).

The streams of the Gabilan subwatershed are ephemeral in the upper-most sections, perennial or near-perennial in certain reaches mid-way down the range, and then again ephemeral in the lowest parts of the subwatershed as the streams begin to flow over old alluvium at the foot of the range. Upon entering the broad system of alluvial plains that is the Salinas Valley, most of the streams are ephemeral, sparsely vegetated, relatively small ditches. As they near the Cities of Salinas and Castroville, the ditches converge into wider ditches with perennial standing water in the dry season and storm runoff in the wet season. Water in the dry season is derived from urban runoff, agricultural tailwater, and permitted discharges. Finally, within a few kilometers of the coast, the ditches flow into Tembladero Slough.

1.2.1.1 Channel Conditions

Channel conditions vary widely in the Reclamation Ditch watershed (CCoWS 2006). At the highest elevations in the Gabilan Range the streams are mostly ephemeral with narrow channels and gentle to moderate gradient. Channel substrate is predominantly gravel and cobble and dominant streamside vegetation is primarily oak savanna with grazed riparian woodland with mixed oak, gray and coulter pines at the highest elevations. Also, there are several seasonal ranch ponds scattered throughout this area, some of which are on-stream. Adjacent land uses are predominantly cattle ranching with State Park lands at the highest elevations (CCoWS 2006).

In the steep mountain canyons of the Gabilan Range, streams are typically narrow and of steep gradient (> 4%). Channel substrate is primarily cobble/boulder. Streams generally flow year-round, especially in the mid to lower elevations of this zone. Riparian vegetation is dense, usually consisting of big-leaf maples, tan oaks, white alder, and sycamore trees. The dense vegetation helps keep the water temperatures cold throughout the year (CCoWS 2006). Adjacent land use is ranching (Casagrande 2001). The presence of pools, large woody debris, such as root wads and downed trees, in addition to cool water temperatures and well-oxygenated flow create suitable habitat conditions for fish (Hager 2001).

In the foothills and alluvial fans of the Gabilan Range, streams are usually ephemeral in some locations with moderate slope (2-4%), smaller average substrate sizes, and shift in riparian species composition from maple and tan oak to willow, box elder, and cottonwood. Riparian vegetation is still commonly found throughout much of the foothill stream reaches, although some reaches have lost a substantial portion of their streamside vegetation (CCoWS 2006). The adjacent land uses are predominantly ranching with some areas developed for row crop agriculture (Casagrande 2001).

Between the foothill zone and the city of Salinas, the stream channels are modified by human development to a greater degree. Some of these still support significant amounts of native riparian vegetation but have been channelized to some extent, thus eliminating the streams ability to fully access the adjacent floodplain during high runoff events. These stream reaches have a gentle slope (< 2%), predominantly sand substrate, and in most areas lack summer flow. Adjacent land use is row-crop agriculture, residential/urban areas, and ranching lands (Casagrande 2001). Some of these stream reaches support native warmwater fish and amphibians. Other stream reaches in this zone have steep banks that are either un-vegetated or support only introduced annual weeds. Such conditions are generally of low habitat quality for riparian-associated organisms, due to the lack of overhead cover, in-channel complexity, and sources of or woody/plant debris. The steep unvegetated banks are also more susceptible to erosion, particularly during high flows. Such bank erosion is a source of sediment that later accumulates in stream channels further downstream.

Most of the stream channels of lower valley bottom have been converted into ditches or drainage canals (Figure 2). These ditches generally have steep side slopes without native riparian vegetation or access to a floodplain, a substrate of primarily fine-grained sediment (mostly silts and clays), and an undefined low-flow channel. The lack of pools and in-stream complexity limits the amount of shelter or overwintering habitat for fish and amphibian species. Sections of the ditch system are occasionally lined with riprap to protect against erosion. Their dry-season flow today is artificially perennial from local urban and agricultural runoff sources (CCoWS 2006). These channels are generally maintained as a drainage canal without tree canopy. The adjacent agricultural lands are used for growing table crops (leafy greens, berries, and artichokes). The growers prevent vegetation from establishing along the Reclamation Ditch banks to discourage birds and rodents from nesting near their fields (Schaaf & Wheeler 2014). Within the City of Salinas, the Reclamation Ditch is an urban watercourse with steep sides and numerous pipe culverts or bridges with lined inverts. (Schaaf & Wheeler 2014). The Reclamation Ditch generally has low gradient though at some locations, particularly bridges, there is a local increase in gradient that presents potential issues for fish migration (Figure 3).

Figure 2: Reclamation Ditch near Davis Road proposed project site.

Figure 3: Reclamation Ditch at San Jon Road and USGS gage weir.

Downstream of the Highway 183 crossing, the Reclamation Ditch becomes known as Tembladero Slough (Figure 4). At this point the slope flattens significantly, lowering flow velocity and allowing increased sediment deposition (Schaaf & Wheeler 1999). Tembladero Slough is a broad, gentle sloped (< 2%), sinuous channel with slow-moving, perennial flows and fresh water with salinity levels generally lower than 1.5 parts per thousand (ppt) (CCoWS 2006). Riparian vegetation, which is managed by use of herbicides, is sparse, occurring in clusters. Where vegetation is present, it is usually annual weeds along with an occasional clump of willows, tules and/or watercress (CCoWS 2006). Tembladero Slough is tidally influenced from the Old Salinas River up to Highway 183 in Castroville (Schaaf & Wheeler 2014).

Figure 4: Tembladero Slough at Castroville proposed project site.

Tembladero Slough joins with the Old Salinas River, which carries the controlled outflow from the Salinas River Lagoon, and together they form a back-beach swale that runs behind the dunes toward Moss Landing Harbor. The Tembladero- Old Salinas River confluence is just downstream of Molera Road and the Old Salinas River flows down through the Potrero Road tide gates to Moss Landing Harbor. This reach also has a gentle slope and meandering channel but is tidally influenced and has brackish water and salt concentration fluctuations due to the tidal cycle (CCoWS 2006). The banks support vegetation tolerant of saltwater, such as pickleweed and/or salt grass. Channel substrate is fine silts and clays.

The Potrero Road tide gates are installed on the Old Salinas River just upstream of Moss Landing Harbor. The tide gates consist of ten box culverts each with a flap gate on the downstream side. During periods of high stream flow and low tide, the gates are opened by the differential water pressure. When the tide is high, the gates close, impeding the flow of the tide up the Old Salinas River. Under conditions of simultaneous high outflows and high spring tides, the gates can impede outflows and increase stage in Tembladero Slough.

1.2.1.2 Streamflow

The flow regime varies significantly in different parts of the watershed. The hydrology of the study area has been dramatically altered. The impervious area has increased significantly with the expansion of the cities of Salinas and Castroville. Compare flow at the Gabilan Creek Gage (Table 1) just upstream of Salinas with flow at the San Jon Gage, downstream of Salinas (Table 2). The final result in the middle to lower sections of the watershed is that there is less standing water in the dry season, and more runoff in the wet season. The entire system is highly episodic, with little or no flow for most of the time, interrupted occasionally by large runoff events during the wet season (CCoWS 2006). Sources contributing to the stream flow vary seasonally, and include, urban runoff, agricultural tile drain water, and permitted discharge in the dry season and stormwater/urban runoff in the wet season (CCoWS, 2014).

The USGS streamflow gage at San Jon Road (Station 11152650, Reclamation Ditch near Salinas, CA) is located just downstream of the Davis Road proposed diversion site and is relevant for this project. The period of record is 28 years and is split into October 1970 to February 1986 and June 2002 to the present. Measured daily mean discharge at the San Jon Road location ranges from 0 cubic feet per second (cfs) to over 500 cfs and is highest in December through April (Table 2). This seasonal pattern is typical of the Mediterranean climate of Central California.

Table 1: Summary of Daily Mean Discharge (cfs) by Month for USGS Flow Data, Station 11152600, Gabilan Creek near Salinas, California, for the Period of Record (October 1970 to February 1986, June 2002 to October 2014).

Month	Minimum	Average (cfs)	Maximum
Oct	0	0.11	11
Nov	0	0.54	120
Dec	0	2.54	200
Jan	0	6.23	194
Feb	0	10.55	279
Mar	0	13.22	159
Apr	0	9.64	298
May	0	2.20	41
Jun	0	0.90	20
Jul	0	0.39	6.1
Aug	0	0.21	5.7
Sep	0	0.11	3.3

Table 2: Summary of Daily Mean Discharge (cfs) by Month for USGS Flow Data, Station 11152650, Reclamation Ditch at San Jon Road, for the Period of Record (October 1970 to February 1986, June 2002 to December 2013).

Month	Minimum	Average (cfs)	Maximum
Oct	0.10	6.32	163.00
Nov	0.03	11.6	263.0
Dec	0.00	16.9	310.0
Jan	0.20	27.8	450.0
Feb	0.29	32.2	401.0
Mar	0.61	36.6	524.0
Apr	1.10	22.2	473.0
May	0.63	8.02	91.00
Jun	0.27	6.10	34.00
Jul	0.23	5.76	30.00
Aug	0.38	6.06	31.00
Sep	0.63	5.19	58.00

The Reclamation Ditch is perennial downstream of agricultural and urban development. According to USGS records, flow west of Salinas at the San Jon Road gage only ceased on three days between 1971 and 1985, and on those days, standing water was probably still present throughout most of the Reclamation Ditch (Schaaf & Wheeler 2014). The presence of standing water is reflective of historical conditions, since the area was a system of lakes, while the presence of dry-season flow is a consequence of dry-season urban discharges and agricultural tailwater discharge. Average annual runoff at the San Jon Road gage has declined by almost a third in recent years as water conservation practices have reduced the amount of agricultural irrigation (Schaaf & Wheeler 2014).

There are no instream flow requirements for fisheries or aquatic life in the Reclamation Ditch watershed. There are no known studies that methodically document passage obstacles or barriers in the watershed and no studies of instream flow needs for fish species, including steelhead.

1.2.1.3 Water Quality

The water quality in the Reclamation Ditch is generally poor, containing high levels of nitrates and pesticides and low levels of dissolved oxygen. The Reclamation Ditch (Salinas Reclamation Canal) and all of its tributary streams are on the California Listing of Water Quality Limited Stream Segments, as reported under Section 303(d) of the Federal Clean Water Act (Central Coast Regional Water Quality Control Board (CCRWQCB 2011). The CCRWQCB Water Quality Control Plan for the Central Coast Basin (Basin Plan) designated beneficial uses of the Reclamation Ditch as including water contact recreation, non-contact water recreation, wildlife habitat, warm water fish habitat and commercial or sport fishing. Tembladero Slough is designated as having additional beneficial uses of estuarine habitat, rare/threatened/endangered species, and spawning/reproduction/early development habitat (CCRWQCB 2011).

The Reclamation Ditch (Salinas Reclamation Canal) and Tembladero Slough are listed as impaired water bodies pursuant to Section 303(d) of the Clean Water Act for ammonia, fecal coliform, pesticides, nitrate, toxicity, dissolved oxygen, and other parameters. Water quality has been sampled and monitored for the past 15 years under various programs, including the Central Coast Ambient Monitoring Program (CCAMP) under the RWQCB, the Central Coast Watershed Studies (CCoWS) program of the Watershed Institute at California State University Monterey Bay, and the Cooperative Monitoring Program under the Conditional Waiver of Waste Discharges from Irrigated Lands (Ag Waiver) (Schaaf & Wheeler 2014). Many of these parameters can be at levels that result in toxicity to aquatic life (CCRWQCB Order No. R3-2012-0011 (Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands).

1.2.2 Fish Fauna

The fish community in the Project Area, and especially in the Reclamation Ditch, has been influenced by habitat alteration during the course of human settlement and development. The fish community, like the Salinas and Pajaro River Watersheds, is similar to and was likely derived from that of the Sacramento/San Joaquin Watersheds (Snyder 1913). There are no known fish surveys of the Reclamation Ditch watershed though anecdotal information (CCoWS 2006) and surveys in nearby water bodies are indicative of species that are likely to be found there (Table 3).

Table 3. Fish Species Occurring in the Reclamation Ditch Watershed and Vicinity.

Common Name	Scientific Name	**Rec Ditch Watershed** *(CCoWS 2006)*[1]	**Old Salinas River** *HES 2001*	**Salinas Lagoon** *HES 2014*	*Snyder (1913), Hubbs (1947)*[2]
NATIVE FRESHWATER SPECIES					
Pacific lamprey	*Lampetra tridentata*	X		X	X
California roach	*Hesperoleucus symmetricus*	X			X
Hitch	*Lavinia exilicauda*	X	X	X	X
Sacramento blackfish	*Orthodon microlepidotus*	X		X	X
Sacramento pikeminnow	*Ptychocheilus grandis*	X	X	X	X
Speckled dace	*Rhinichthys osculus*				X
Sacramento sucker	*Catostomus occidentalis*	X	X	X	X
Steelhead/rainbow trout	*Oncorhynchus mykiss*			X	
Chinook salmon	*Oncorhynchus tshawytscha*			X	
Threespine stickleback	*Gasterosteus aculeatus*	X	X	X	X
Prickly sculpin	*Cottus asper*	X		X	X
Coastrange sculpin	*Cottus aleuticus*				X
Riffle sculpin	*Cottus gulosus*				X
Sacramento perch	*Archoplites interruptus*				X
Tule perch	*Hysterocarpus traski*				X
ESTUARINE SPECIES					
Pacific herring	*Clupea pallasii*		X	X	X
Topsmelt	*Atherinops affinis*			X	
Pacific staghorn sculpin	*Leptocottus armatus*		X	X	X
Striped bass	*Morone saxatilis*			X	
Shiner surfperch	*Cymatogaster aggregata*			X	X
Yellowfin goby	*Acanthogobius flavimanus*			X	
Arrow goby	*Clevelandia ios*			X	
Tidewater goby	*Eucyclogobius newberryi*			X	X
Starry flounder	*Platichthys stellatus*			X	X
INTRODUCED WARMWATER SPECIES					
Threadfin shad	*Dorosoma patenense*			X	
Goldfish	*Carassius auratus*	X			
Carp	*Cyprinus carpio*	X	X	X	X
Golden shiner	*Notemigonus chrysoleucas*	X			
Fathead minnow	*Pimephales promelas*	X			
Bullhead	*Ameiurus sp.*	X			
Mosquitofish	*Gambusia affinis*	X	X	X	
Sunfish	*Lepomis sp.*	X			
Bluegill	*Lepomis macrochirus*	X			
Largemouth bass	*Micropterus salmoides*	X			
Black crappie	*Pomoxis nigromaculatus*		X		

[1] Fish kill in Tembladero Slough reported by CDFG (2002) and various observations by J. Casagrande and J. Hager.
[2] Snyder collections near Salinas, Spreckels, and "Blanco"; Hubbs collections in Salinas River Lagoon.

Based on habitat characteristics it is likely that the headwater perennial streams in the Reclamation Ditch watershed support riffle sculpin (*Cottus gulosus*), speckled dace (*Rhinichthys osculus*), trout (*Oncorhynchus mykiss*), and possibly Sacramento sucker (*Catostomus occidentalis*). Trout have been observed in Gabilan Creek recently (CCoWS 2006) including young trout (1 to 2 inches), along the downstream side of the Old Stage Road Crossing in June 2004 (CCoWS 2006). In early March 2004, a 30-inch adult female steelhead was found dead in Gabilan Creek along Little River Drive (CCoWS 2006). The fish had not spawned and was found at the base of a sediment stabilizer structure. The exact cause of death was not determined but was possibly the lack of suitable flow combined with a possible migration barrier (CCoWS 2006). The fish was found as flows dropped from higher levels on February 25-28 following a storm, and the timing is consistent with a fish attempting to migrate to spawning habitat higher in the watershed.

Although trout have been stocked by landowners in the watershed historically (CCoWS 2006), the presence of suitable habitat in Gabilan Creek, occupied by *O. mykiss* (likely resident life-history form), and the adult steelhead found in 2004 indicate that the Reclamation Ditch watershed should be considered as potential steelhead habitat. Suitable habitat conditions for rainbow trout/steelhead are also likely to exist in the upper reaches of Alisal, Towne, and Mud Creeks (CCoWS 2006).

Spawning habitat is only found within the upper foothill and mountainous reaches of the Gabilan Range where suitable substrate (gravel/cobble) is dominant and stream flow is still abundant (CCoWS 2006). Additionally, the middle reaches of the Reclamation Ditch are characterized by degraded water quality and maintained drainage channels devoid of vegetation that do not provide cover for fish. In order to reach the spawning habitat upstream, steelhead would have to navigate through a series of man-made obstacles. Most are passable during periods of prolonged stream flow to achieve suitable flow depth and duration for passage (CCoWS 2006). The duration of adequate flow in the middle reaches of the Reclamation Ditch Watershed is, in average years, brief and because of this, the migration window is very short (CCoWS 2006). Although the duration of adequate flow in the middle reaches of the Reclamation Ditch Watershed is brief in most years, the distance between Moss Landing Harbor and the upper reaches of Gabilan Creek is not excessive for migrating steelhead.

The middle reaches of the watershed (between the Gabilan Mountains and the City of Salinas) are ephemeral and thus do not support fish. Some intermittent reaches support California roach (*Hesperoleucus symmetricus*) and threespine stickleback (*Gasterosteus aculeatus*) which are both tolerant of high temperature and low dissolved oxygen (CCoWS 2006).

The downstream habitats of the watershed support warm-water fish communities (i.e., minnows, suckers, and introduced fishes). The slow, warmwater habitats of lower Natividad Creek/Laurel Pond, the lower Santa Rita Creek drainage, the Reclamation Ditch, Tembladero Slough, and the Old Salinas River support most of the original native warmwater fish species as well as introduced warmwater species. Species include the native Sacramento sucker, Sacramento blackfish, Sacramento pikeminnow, hitch, California roach, threespine stickleback and a variety of introduced fish like carp, fathead minnow and mosquito fish.

The Salinas River Lagoon fishery has been sampled at intervals since the early 1900's (Snyder 1913, Hubbs 1947) and most recently in the early 1990's (Gilchrist et al. 1997) and in annual surveys by MCWRA from 2002 to 2014 (HES 2014). The fish species assemblage in the Salinas River Lagoon may be representative of other aquatic environments in the lower Salinas Valley including the Old Salinas River Channel and Tembladero Slough. The Lagoon supports a mixed assemblage of marine, freshwater, and estuarine species generally typical of lagoons along the Central California Coast (Table 3). The mix of species in any year is influenced by freshwater inflows, opening and closing of the sandbar at the mouth of the Lagoon, and the resulting conditions of water quality and productivity.

Native freshwater species using the Lagoon included Sacramento blackfish (*Orthodon microlepidotus*), hitch (*Lavinia exilicauda*), Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), prickly sculpin (*Cottus asper*), and threespine stickleback. Several other freshwater species have been collected historically in the Lagoon but are no longer found there. Hubbs collected Sacramento perch from several areas of the Lagoon and recorded speckled dace (*Rhinichthys osculus*) as rare at a single site in the freshwater portion (Hubbs 1947). Thicktail chub (*Gila crassicauda*), an extinct large minnow formerly occupying lowland streams and estuaries, have been well documented at archaeological sites in the Pajaro and Salinas Basins (Gobalet and Jones 1995) and probably occurred in the Salinas River Lagoon. Introduced freshwater species include carp and white bass. The single white bass taken in 1990 probably came from the population in Nacimiento Reservoir and is likely a transient species in the Lagoon. Other reservoir species, such as threadfin shad, may be expected to reach the Lagoon during wet years when large flood control releases are made. In years with low freshwater inflow and saline conditions in the Lagoon, freshwater species may be restricted to the upper reaches of the Lagoon or to freshwater areas upstream of the Lagoon (Gilchrist et al. 1997).

Several marine species use the Lagoon for reproduction or juvenile rearing. Starry flounders spawn in the ocean but juveniles enter the Lagoon and can rear there for two or more years. As they grow older they become less tolerant of fresh water and leave the Lagoon. Staghorn sculpin also enter the Lagoon as juveniles but usually only remain for a year. In 1991, five species of surfperch, both adults and young-of-year, were found in the Lagoon during the summer. Other marine species found include Pacific herring, topsmelt, surf smelt, northern anchovy, jacksmelt, striped bass, and English sole (Gilchrist et al. 1997). The green sturgeon reported by CDFW in 1975 is probably atypical since they usually use larger rivers further north.

1.2.3 Sensitive Aquatic Resources

There are two special status fish species that have historically been found in the Lower Salinas River, Salinas River Lagoon, or nearby aquatic environments: the South-Central California coastal steelhead (*Oncorhynchus mykiss*) and the tidewater goby (*Eucyclogobius newberryi*). These species and key life history features are discussed in the following sections. Tidewater goby were first reported from the Lagoon in 1946 but were not recorded there again until 2013 (HES 2014). The Lagoon is important to steelhead in that it may provide rearing habitat for juvenile steelhead under certain conditions and it is the passageway through which spawning adults enter the river and seaward migrating juveniles enter the ocean. Occasional use of the Lagoon by juvenile steelhead has been reported only in recent years (HES 2012, HES 2013, HES 2014). Current water management practices can influence the quality of Lagoon habitat and the ability of steelhead to move between the Lagoon and the ocean.

1.2.3.1 South-Central California Coastal Steelhead

NMFS listed the South-Central California Coast steelhead (SCCC steelhead) as threatened in 1997 (62 FR 43937) and affirmed the listing in 2006 (71 FR 834). In September 2012, NMFS completed a 5-year status review of the SCCC steelhead Distinct Population Segment (DPS). Based upon a review of available information, NMFS (2011) recommended that the SCCC steelhead DPS remain classified as a threatened species. The SCCC steelhead DPS includes all naturally spawned anadromous populations of *O. mykiss* in coastal river basins from the Pajaro River in Monterey County southward to but not including the Santa Maria River in San Luis Obispo County (65 FR 36074, 71 FR 834). Although *O. mykiss* exhibits both resident and anadromous life history characteristics, the SCCC steelhead DPS includes only the anadromous life form of *O. mykiss*.

Critical Habitat Designation

Critical Habitat for SCCC steelhead was designated in February 2000 (65 FR 7764) and was reaffirmed in 2005 (70 FR 52488). Section 3 of the ESA (16 U.S.C. 1532(5)) defines critical habitat as ''(i) the specific areas within the geographical area occupied by the species, at the time it is listed on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed. The freshwater primary constituent elements of critical habitat include: 1) spawning habitat, including spawning substrate, and adequate water quantity and quality; 2) freshwater rearing habitat including floodplain connectivity, and natural escape and velocity cover; and 3) freshwater migration corridors free of obstructions, with water quantity and quality conditions that allow movement" (NMFS 2005, MCWRA 2013).

The Critical Habitat designation includes Gabilan Creek, the Reclamation Ditch, Tembladero Slough, the Old Salinas River and Salinas River Lagoon, and Lower Salinas River. The primary constituent element of critical habitat that could potentially be affected by the Proposed Project is migration habitat in the Reclamation Ditch, Tembladero Slough and Old Salinas River.

Life History Overview

Steelhead/rainbow trout have a very flexible life history. *O. mykiss* that migrate to the ocean (anadromous) undergo physiological changes in the process of smoltification that allow them to adapt to seawater. These fish, commonly referred to as steelhead, spend a variable amount of time in the ocean, typically one to two years, grow rapidly and return to spawn, generally in the stream where they hatched. Some *O. mykiss* within any given stream, and the proportion may vary considerably depending on local circumstances, do not migrate to the sea. These fish reach sexual maturity and spawn without entering the ocean and are often known as resident or stream rainbow trout. They mature at smaller sizes than sea-run steelhead and produce fewer eggs. Resident *O. mykiss* can persist for generations in locations where migration to sea has been precluded such as above landslides and dams and during extended droughts. There are a number of documented life-history strategies that are intermediate between resident populations and fully anadromous populations. Intermediate life-history patterns include fish that migrate within the stream (potadromous), fish that migrate only as far as estuarine habitat, and fish that migrate to near-shore ocean areas. These life-history patterns do not appear to be genetically distinct, and have been observed interbreeding (Shapovalov and Taft 1954, Barnhart 1986, Pearcy 1992, Busby et al. 1996, Hayes et al. 2011).

There are selective advantages to both anadromous and resident strategies (Cramer et al. 1995). Anadromous fish grow faster and reach a larger size thereby gaining a potential to produce more offspring than resident fish. At the same time, however, migratory fish are exposed to many sources of mortality and there is a risk that conditions may become unsuitable for migration, particularly in California where fluctuating climatic conditions can result in long periods when streams have tenuous connection to the ocean. In California, many streams support both resident and anadromous forms with no observable genetic differentiation. During extended drought periods it is possible for populations to sustain themselves through resident spawning and then revert to an anadromous life history when suitable conditions return. Presence of resident rainbow trout populations tends to increase in the southern part of the range (Cramer et al. 1995). Rainbow trout observed in freshwater habitat may be the offspring of either anadromous or resident fish; it is not possible to distinguish them based on external observation.

All steelhead within the SCCC steelhead DPS are considered "winter steelhead" based on their migratory timing and behavior. They ascend streams during the winter when winter rainfall results in suitable flow and temperature (Busby et al. 1996, Moyle 2002). Steelhead along the Central California coast enter freshwater to spawn when winter rains have been sufficient to raise streamflows and breach the sandbars that form at the mouths of many streams during the summer. Increased streamflow during runoff events also appears to provide cues that stimulate migration and allows better conditions for fish to pass obstructions and shallow areas on their way upstream. The season for upstream migration of steelhead adults lasts from late October through the end of May but typically the bulk of migration (over 95% in Waddell Creek) occurs between mid-December and mid-April (Shapovalov and Taft 1954, NMFS 2007). Steelhead are unique among the other Pacific salmonids in that they do not all die after spawning. Some return immediately to the ocean (generally by the late spring but dependent on runoff conditions), others return after holding for a period in freshwater.

Steelhead have strong swimming and leaping abilities that allow them to ascend streams into small tributary and headwater reaches. Steelhead can swim at rates of up to 4.5 feet per second (fps) for extended periods of time and can achieve burst speeds of 14 to 26 fps during passage through difficult areas (Bell 1986). Leaping ability is dependent on the size and condition of fish and hydraulic conditions at the jump. Given satisfactory conditions, a conservative estimate of steelhead leaping ability is a height of 6 to 9 feet (Bjornn and Reiser 1991), though other estimates range from 11 feet (Bell 1986) to as high as 15 feet (McEwan 1999).

O. mykiss select spawning sites with gravel substrate and with sufficient flow velocity to maintain circulation through the gravel and provide a clean, well-oxygenated environment for incubating eggs. Preferred flow velocity is in the range of 1-3 feet per second (Raleigh et al. 1984) and preferred gravel substrate is in the range of 0.25 to 4 inches in diameter for steelhead and 0.25 to 2.5 inches for non-anadromous rainbow trout (Bjornn and Reiser 1991). Typically, sites with preferred features for spawning occur most frequently in the pool tail/riffle head areas where flow accelerates out of the pool into the higher gradient section below. In such an area, the female will create a pit, or redd, by undulating her tail and body against the substrate. This process also disturbs fine sediment in the substrate and lifts it into the current to be carried downstream, cleaning the nest area. Incubation and emergence success are influenced by accumulation of fine sediments (less than 3.3 mm) in the substrate. Embryo survival for steelhead decreases when the percentage of substrate particles less than 6.4 mm reaches 25-30% and is extremely low when fines are 60% or more. Emergence of steelhead fry is generally high when fine sediments are less than 5% of substrate volume but drops sharply with fine sediment volume of 15% or more (Bjornn and Reiser 1991).

O. mykiss hatch in the gravel-cobble substrate of the streambed. After two to three weeks the young fry emerge from the gravel and begin to feed in the stream. Some begin to disperse downstream in the months following their emergence but the rest continue to rear in the stream for a period of up to a few years (Shapovalov and Taft 1954). After emergence from the gravel, fry inhabit low velocity areas along the stream margins. As they feed and grow they gradually move to deeper and faster water (Bjorkstedt et al. 2005). Cover in the form of fallen trees, roots, undercut banks, boulders, and overhanging vegetation are important components of rearing habitat. Heads of pools generally provide classic conditions where trout can hold in lower velocity areas as currents bring food from the riffles upstream. Often, local populations thrive under conditions that may depart widely from species norms (Behnke 1992). Trout can inhabit quite small streams, particularly in coastal streams. Often habitat may be far more limiting for older juveniles than habitat for younger fish. The critical period is during base flow conditions that generally occur between May and October in Central California. Streamflow can drop to very low levels with loss of depth and velocity in riffle and run habitats, or in the extreme, only isolated pools with intervening dry sections of stream. Any diversion or other depletion of streamflow during this critical period can be potentially damaging to rearing juvenile steelhead. During winter as water temperatures decrease and flows increase, juveniles seek hydraulic refuge within pools, interstitial spaces in cobble and boulder substrates, or near large woody debris (MCWRA 2013).

Temperature is an important factor for *O. mykiss*, particularly during the over-summer rearing period. In many Central California streams growth slows or ceases in conjunction with warm, low flow conditions in late summer. Upper incipient lethal temperature for Pacific salmonids is in the range of 75°F to 77°F (24ºC to 25ºC) for continuous long-term exposure (Brett 1952; Brett et al. 1982). Elevated temperature below the lethal threshold can have indirect influence on survival due to depression of growth rate, increased susceptibility to disease, lowered ability to evade predators, decreased migratory behavior, and influences on smoltification (Zaugg and Wagner 1973, Adams et al. 1975). Preferred temperatures for steelhead parr range from 54°F to 64°F (12ºC to 18ºC), although optimum growth rates may occur at slightly higher temperatures if food is abundant (Smith 1999, Hokanson, et al. 1977, Myrick and Cech 2005). Behnke (1992) has found native redband trout in intermittent desert streams thriving in water of 83°F (28ºC) and actively feeding at that temperature. These populations have apparently become adapted to conditions in the region.

During the dry season a lagoon forms at the mouths of many California coastal streams. Lagoon habitat has been shown to be very important for rearing juvenile steelhead. Smith (1990) estimated that relatively large numbers of juvenile steelhead were present in San Gregorio, Pescadero, and areas, particularly larger individuals; that juvenile steelhead that rear in the lagoon experience higher growth rates than stream-reared fish; and that lagoon-reared fish comprise a high percentage of returning adult steelhead. Similarly, Bond (2006) found both high growth rates and high rates of return for estuary-reared steelhead in Scott Creek. Bond calculated that estuary-reared steelhead comprised between 8% and 48% of all downstream migrating juveniles but 85% of the returning adult population. Juvenile *O. mykiss* can migrate downstream to a lagoon at almost any point from the time they emerge from the gravel until they migrate to sea as smolts. Some *O. mykiss* rear in a lagoon until maturity and return upstream to spawn without entering the ocean.

After 1 to 3 years of rearing in freshwater, whether in the stream or in a lagoon, anadromous *O. mykiss* undergo the process of smoltification and enter the ocean. Seaward migration of smolts occurs primarily in the late-winter or spring, typically in March through late-May (Shapovalov and Taft 1954, Hayes et al. 2011). These fish may reside in the ocean for between 2 and 4 years (Barnhart 1986, Moyle 2002) prior to returning to spawn. Migrating smolts require adequate flows for passage and downstream movement, suitable temperature and water quality conditions, and cover from predators (NMFS 2007). Increased flow provides greater depths, currents, and surface turbulence all of which help to increase travel rates and survival of smolts (NMFS 2007)

Habitat conditions for steelhead in the Salinas Basin are distinct from most other streams in the South-Central California Coast (MCWRA 2001). The Salinas River drains an inland valley separated from the ocean by the coastal mountains. The Salinas Valley is expected to have significant differences in rainfall, air temperature, vegetation, and summer fog. These in turn are expected to influence steelhead habitat conditions including stream temperature during the summer rearing periods and the duration and frequency of streamflow conditions suitable for migration (NMFS 2007). Steelhead in the Salinas River may experience a greater number of years when access to the ocean is not possible due to low streamflow. Migration of adults from the ocean may begin later in the season, and seaward migration of juveniles may be truncated in the spring as compared to the other coastal drainages (MCWRA 2001). Climate conditions in the Reclamation Ditch watershed, located in the far northern part of the Salinas Valley and close to Monterey Bay, may be somewhat moderated in this respect.

1.2.3.2 Tidewater Goby

Status and Distribution

Tidewater goby (*Eucyclogobius newberryi*) are a small, short-lived California endemic species that inhabits coastal brackish water habitats entirely within California, ranging from Tillas Slough (mouth of the Smith River, Del Norte County) near the Oregon border south to Agua Hedionda Lagoon (northern San Diego County) (Figure 5). Tidewater goby are currently listed as endangered under the Federal ESA (59 FR 5494) but have been proposed for reclassification as threatened (79 FR 14340). Tidewater goby are considered to be a species with moderate threats and a high potential for recovery (USFWS 2005). Tidewater goby has had fully protected status from the State of California since 1987.

Hubbs (1947) reported collecting tidewater goby in low to moderate abundance at three locations in the Salinas River Lagoon in August 1946. Tidewater gobies were recently collected again there in 2013 (HES 2014). Tidewater goby have also been found in Bennett Slough (northern end of Elkhorn Slough) (USFWS 2005). The critical habitat designation for tidewater goby includes Bennett Slough (north of the project area) and the Salinas River (USFWS 2013).

Life History

Tidewater goby are uniquely adapted to coastal lagoons and the uppermost brackish zone of larger estuaries, rarely invading marine or freshwater habitats (USFWS 2005). Tidewater gobies are small fish (rarely exceeding two inches in length) that generally live for only 1 year, with few individuals living longer than a year (Moyle 2002 cited in USFWS 2005). Reproduction occurs at all times of the year, as indicated by female tidewater gobies in various stages of ovarian development (Swenson 1999 cited in USFWS 2005). The peak of spawning activity occurs during the spring and then again in the late-summer. Fluctuations in reproduction are probably due to death of breeding adults in early summer and colder temperatures or hydrological disruptions in winter (Swift et al. 1989 cited in USFWS 2005). Reproduction takes place in water between 48°F and 77°F (9°C and 25°C) and at salinities of 2 to 27 ppt (Swenson 1999 cited in USFWS 2005).

Male tidewater gobies begin digging breeding burrows in relatively unconsolidated, clean, coarse sand (averaging 0.5 millimeter [0.02 inch] in diameter), in April or May after lagoons close to the ocean (Swift et al. 1989; Swenson 1995 cited in USFWS 2005). Swenson (1995 cited in USFWS 2005) has shown that tidewater gobies also prefer this substrate in the laboratory. Burrows are at least 70 to 100 millimeters (3 to 4 inches) from each other. After hatching, the larval tidewater gobies, measuring 4 to 5 millimeters (mm) in standard length (SL), emerge from the burrow and swim upward to join the plankton (Wang 1986, Swift et al. 1989). Juvenile tidewater gobies become benthic dwellers at 16 to 18 mm SL (Moyle 2002). Tidewater gobies are known to be preyed upon by native species such as small steelhead, prickly sculpin, and staghorn sculpin (Swift et al. 1989 cited in USFWS 2005).

Figure 5: Tidewater goby, Salinas River Lagoon, October 2013. (*photo J. Hagar*)

Tidewater goby abundance fluctuates spatially and seasonally, due in part to their predominantly annual life cycle (Swenson 1999). Tidewater goby populations also vary greatly with the varying environmental conditions (e.g., drought, El Niño) among years (USFWS 2007). This environmental variation is a normal phenomenon, but one that makes the determination of trends in population size difficult. For example, tidewater goby populations decrease during the rainy season when lagoons are open and influenced by flood events, and then recover during the following summer (USFWS 2007). Swift et al. (1989) estimated that individual tidewater gobies within a population at Aliso Creek Lagoon ranged from 1,000 to 1,500 in the late winter-early spring and 10,000 to 15,000 tidewater gobies in the late summer-early fall.

Their short life span and restricted habitat make individual populations vulnerable to unique catastrophic events (floods, toxic events, introduction of predator species, drought, or habitat alteration). Nevertheless, available information indicates that *Eucyclogobius* is tolerant of a very wide range of salinity, temperature, and other water quality conditions.

The USFWS characterizes tidewater goby populations (i.e., localities) along the California coast as metapopulations (a group of distinct populations that are genetically interconnected through occasional exchange of animals) (USFWS 2007). While individual populations may be periodically extirpated under natural conditions, a metapopulation is likely to persist through colonization or re-colonization events that establish new populations (USFWS 2007). Local populations of tidewater gobies occupy coastal lagoons and estuaries that in most cases are separated from each other by the open ocean. Very few tidewater gobies have ever been captured in the marine environment (Swift et al. 1989), which suggests this species rarely occurs in the open ocean (USFWS 2007). Some tidewater goby populations persist on a consistent basis (potential sources of individuals for re-colonization), while other tidewater goby populations appear to experience intermittent extirpations. Local extirpations may result from one or a series of factors, such as the drying up of some small streams during prolonged droughts, water diversions, and estuarine habitat modifications (USFWS 2007). Some localities where tidewater gobies have been extirpated apparently have been re-colonized when extant populations were present within a relatively short distance of the extirpated population (i.e., less than 6 miles (10 kilometers)). More recently, another tidewater goby researcher has suggested that re-colonizations have typically been between populations separated by no more than 10 miles (16 kilometers) (Swift 2007 cited in USFWS 2007). Flooding during winter rains can contribute to re-colonization of estuarine habitats where tidewater goby populations have previously been extirpated. The closest known populations that could recolonize the Salinas River Lagoon are in the Pajaro River and Elkhorn Slough (USFWS 2005, Kukowski 1972, Swift et al. 1989). The mouth of Elkhorn Slough is connected to the Salinas River Lagoon through the Old Salinas River. The mouth of the Pajaro River is about 3 miles (5 kilometers) north of the mouth of Elkhorn Slough and about 7 miles (11 kilometers) north of the Salinas River Lagoon.

Habitat Characteristics

The tidewater goby favors the calm conditions that prevail when the lagoons are cut off from the ocean by beach sandbars. They are bottom dwellers and are typically found at water depths of less than 3 feet. Tidewater gobies typically inhabit areas of slow-moving water, avoiding strong wave action or currents. Particularly important to the persistence of the species in lagoons is the presence of backwater, marshy habitats, which provide refuge habitat during winter flood flows (J. Smith pers. comm. 1999 as referenced in Environmental Science Associates 2001). Optimal lagoon habitats are shallow, sandy-bottomed areas 20 to 10 cm deep, surrounded by beds of emergent vegetation. Open areas are critical for breeding, while vegetation is critical for overwintering survival (providing refuge from high flows) and probably for feeding as well (Moyle 2002).

Swift et al. (1989) found that all sizes of *E. newberryi* usually occur at the upper end of lagoons at salinities of 10 ppt or less. Of 60 collections, 65% were at 0-10 ppt, 20% were at 10-20 ppt, 17% at 20-30 ppt, and 2% at 42 ppt. The collection at 42 ppt was made at Bennett Slough, a tributary of Elkhorn Slough in Monterey County (Swift et al. 1989). In lab tests conducted by the CDFW, tidewater gobies were maintained in freshwater, 10-15 ppt, 20 ppt, and normal seawater (33 ppt) with reproduction taking place under all four conditions (Worcester and Lea 1996). Differences in reproductive success, if any, were not reported. Worcester and Lea also held tidewater gobies in hypersaline water (45-54 ppt) for 6 months with no mortality. Holding temperatures during these tests ranged from 39°F to 71°F (4.0°C to 21.5°C). In salinity tolerance tests reported by Swift et al. (1989), tidewater gobies in salinities above 41 ppt experienced high mortality. In an experiment where salinity increased slowly due to evaporation, over half the gobies survived hypersaline conditions up to 1.75 times that of seawater.

Swift et al. (1989) list several criteria for lagoon conditions that favor tidewater gobies. These include: little or no channelization; allowing closure to the ocean for much of the year so that tidal fluctuation is absent or minimal; fresh unconsolidated sand is optimal for reproduction; high quality of inflowing water to increase habitable area of a lagoon in summer. Nutrient enrichment can stimulate algal blooms, deplete oxygen, and lead to hydrogen sulfide formation. Most fish species are intolerant of low dissolved oxygen and high hydrogen sulfide concentrations. Introduced predatory fish should be excluded. Centrarchid fish (sunfish and bass) and tidewater gobies are not usually found together and may not be able to coexist (Swift et al. 1989).

Gobies may move upstream during winter rains and high flows of inlet streams (Swift et al. 1989) as well as during the summer when algal blooms and hydrogen sulfide forms in the substrate and enters the water column. During this period most fish are at the upper end of lagoons where freshwater inflow occurs or at the seaward end where occasional waves wash into the Lagoon (Swift et al. 1989).

Currently, the majority of the most stable and largest tidewater goby populations consist of lagoons and estuaries of intermediate sizes (5 to 125 acres or 2 to 50 hectares) that have remained relatively unaffected by human activities (USFWS 2005). Many of the localities where tidewater gobies are regularly present may be "source" populations for localities that intermittently lose their tidewater goby populations. Large wetlands are likely to have lower rates of extirpation than small wetlands. In addition, populations at small sites were sensitive to drought, presumably because droughts can eliminate suitable habitat at small wetlands (USFWS 2007).

1.3 EFFECTS ASSESSMENT

1.3.1 Significance Thresholds and Evaluation Criteria

The California Environmental Quality Act (CEQA) Guidelines provide a discussion of significance criteria for evaluation of environmental effects of a project. Appendix G of the CEQA Guidelines suggests the following evaluation criteria for biological resources:

Would the project:

- Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service?
- Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?
- Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service;
- Conflict with any local policies or ordinances protecting fishery resources; or
- Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Conservation Community Plan, or other approved local, regional, or state habitat conservation plan.

In order to apply these general criteria to any particular project, it is helpful to identify specific, measurable, indicators that can be used to compare baseline (without project) conditions for potentially effected resources to conditions that are expected to occur with the project or various alternatives.

The GWR project would potentially alter habitat conditions by changing flow patterns. Flow would be diverted at certain locations and times in varying amounts. This would also require construction of facilities to divert and conduct flows to desired locations. Therefore, indicators for this assessment are primarily related to changes in flow. It is important that impact analyses include assessment of components of the flow regime that can be used to characterize the entire range of flows and specific hydrologic phenomena (e.g., floods and low flows) that are vital to the integrity of river ecosystems, and thus fish species. These components of the flow regime include: (1) magnitude; (2) frequency; (3) duration; (4) timing; and (5) rate of change of hydrologic conditions (Poff et al. 1997). Furthermore, Poff et al. (1997) report that by defining flow regimes in these terms, the ecological consequences of particular human activities that modify one or more components of the flow regime can be considered explicitly. Therefore, effects analysis for the GWR project relied heavily on evaluating changes to the hydrographs caused by project water diversions.

In order to identify potential effects of the Project's Diversion Scenarios on stream flow, a 10 percent decrease in flow relative to existing conditions was defined as a relevant indicator of potential effects. A decrease in flow of 10 percent or greater during a relevant evaluation period has been previously identified by various environmental documents as an appropriate criterion to evaluate flow changes (USFWS et al. 1999, USDOI et al. 1999, JSA 2003).

Accordingly, evaluation of the GWR project relies on previously established information and uses changes in flow of 10 percent or greater, as expressed by flow exceedance probabilities, as an indicator of potential effects on riverine habitat. Further, since SCCC steelhead are the only protected species using riverine portions of the project area (tidewater goby are an estuarine species), additional analysis was developed for this species.

Migration, both upstream for adults and downstream for adults (kelts) and juveniles (smolts) are the potentially affected steelhead life stages. Potential project affects to these life stages are related to changes in flows resulting from each of the different Diversion Scenarios. This analysis used previously established minimum flow thresholds for steelhead migration to assess changes in the duration of periods available for migration. Modeled hydrologic data reflecting project operations scenarios was used to evaluate the amount of time project flows were in a range suitable for migration and this was compared to the amount of time flow is in a suitable range under baseline conditions.

For the purposes of this analysis, the effect of a Diversion Scenario would be considered less than significant if it would result in either of the following:

- A change in stream flow during relevant analytical periods of less than 10%.
- A change in frequency of occurrence of flow at or above migration thresholds of less than 10%, relative to specific flow thresholds during steelhead adult or smolt migration periods.

A change in streamflow of 10% or more may or may not be considered significant depending on the species and lifestages likely to be present, habitat requirements and behavior of those species or lifestages, and potential for the given flow change to influence key habitat features. Furthermore, for an impact to be considered less than significant, implementation of a Diversion Scenario will not cause creation of an obstacle or hazard to migrating steelhead (adults, juveniles or smolts) or other native resident or migratory fish.

Five diversion scenarios (Cases) are evaluated:

- Case 0: Base Condition Flow = USGS San Jon Road gage (11152650), scaled down by a factor of 0.937 for Davis Road location and scaled up by a factor of 1.4 for Castroville location.
- Case 1: Divert up to 2.99 cfs of available flow from Reclamation Ditch at Davis Road and up to 2.99 cfs of available flow from Tembladero Slough at Castroville; leave a minimum base flow of 2 cfs December-May, or 0.69 cfs June-November at Davis Road location and leave constant minimum base flow of 1 cfs in Tembladero Slough.
- Case 2: Divert up to 6.0 cfs of available flow from Reclamation Ditch at Davis Road and up to 2.99 cfs of available flow from Tembladero Slough at Castroville; leave minimum base flows of 2 cfs December-May, or 0.69 cfs June-November at Davis Rd location and leave constant minimum base flow of 1 cfs in Tembladero Slough.
- Case 3: Divert up to 2.99 cfs of available flow from Reclamation Ditch at Davis Road and up to 2.99 cfs of available flow from Tembladero Slough at Castroville; leave minimum base flows of 1.0 cfs year-round in both Tembladero Slough and Reclamation Ditch.
- Case 4: Divert up to 6.0 cfs of available flow from Reclamation Ditch at Davis Road and up to 2.99 cfs of available flow from Tembladero Slough at Castroville; Leave minimum base flows of 1.0 cfs year-round in both Tembladero Slough and Reclamation Ditch.

1.3.2 Construction Related Effects

1.3.2.1 All Cases

The diversion facility would include an inlet consisting of a concrete box with a screened inlet in the channel bottom (Schaaf & Wheeler 2014). The inlet structure would measure a minimum of 4-ft. wide by 6-ft. long and the channel invert would be concrete lined with a permanent low-flow channel adjacent to the inlet. This would prevent capturing the required minimum by-pass flows. The channel banks above the inlet structure would be protected with grouted rip-rap to prevent scour and potential bank sloughing into the by-pass and inlet (Schaaf & Wheeler 2014). Dewatering the channel to complete construction of the in-channel structures would represent a short-term temporary impact to aquatic habitat and aquatic species within the construction area. Effects could be avoided and minimized to less than significant levels by completing the work during the low flow season when migratory steelhead would not be present. Best management practices (BMPs) including removal of fish and other aquatic species prior to construction would minimize effects on aquatic habitat or species to less than significant levels. Tidewater goby are not expected to be present at the Davis Road site due to its degraded condition and distance upstream from estuarine habitat. There is a potential for tidewater goby to be present at the Castroville site. Preconstruction surveys would be completed to determine whether tidewater goby are present at the site and if so, consultation with the USFWS would be required to determine appropriate avoidance and minimization measures.

1.3.3 Operation- Effects of Diversion Structures

1.3.3.1 All Cases

The inlet would be screened to minimize entrainment of fish (Schaaf & Wheeler 2014). The screening system would be in compliance with Statewide Fish Screening Policy (http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenPolicy.asp) and Fish Screening Criteria developed by CDFW for structure placement, approach velocity, sweeping velocity, screen openings, and screen construction (http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp).

The Statewide Fish Screening Policy is structured to comply with existing fish screening statutes, the National Environmental Policy Act (NEPA), CEQA, the Federal Endangered Species Act (ESA), the California Endangered Species Act (CESA), and court decisions in place at the time of its adoption.

Compliance with these policies and criteria would reduce potential effects of the diversion structure to less than significant levels. Due to the possibility of migrating steelhead in Tembladero Slough and the Reclamation Ditch, facilities in those locations would also be in compliance with NMFS Anadromous Salmonid Passage Facility Design criteria and specifications (NMFS 2008). Compliance with these policies and criteria and would reduce potential effects of the diversion structure to less than significant levels.

1.3.4 Operation- Alteration of Flows

Potential project effects on flows were determined by comparing estimated flows with the project to present conditions for each Case. Modeled flow results are used for comparative purposes, rather than for absolute predictions, and the focus of the analysis is on comparative differences between the scenarios (e.g., a comparison of estimated conditions under Case 1, relative to conditions without the project). All of the assumptions (e.g., hydrologic conditions, climatic conditions, upstream storage conditions, etc.) are the same for both the with-project and without-project flow estimates, except assumptions associated with the diversion Case itself, and the focus of the analysis is the differences in the results.

Flow data used in these analyses were provided by Schaaf & Wheeler. The analyses use

USGS gaged flow from the San Jon Road gage (Station 11152650, Reclamation Ditch near Salinas, CA). The gage is located just downstream of the Davis Road proposed diversion site and is relevant for this project. The period of record is 28 years and is split into October 1970 to February 1986 and June 2002 to the present. Average annual runoff at the San Jon Road gage has declined by almost a third in recent years as water conservation practices have reduced the amount of agricultural irrigation (Schaaf & Wheeler 2014). Therefore, only the 2002-2013 data were used in this analysis. The years in this limited data set have mean annual flows with a higher minimum, lower maximum, and lower average than the longer data set.

Changes in flow were estimated for both the Davis Road proposed project site and the Castroville proposed project site. Schaaf & Wheeler calculated the sub-basin sizes for the entire Reclamation Ditch watershed (Schaaf & Wheeler 2014). Based on those data, the basin size above the USGS gage is 109.4 square-miles. The drainage basin above the proposed diversion point on the Reclamation Ditch at Davis Road is 102.5 square-miles, or 93.7% of the gaged area. Historic mean daily flows at the diversion point were calculated by scaling the recorded flows at San Jon Road by that factor. For alternatives at the Castroville proposed project site (Case 3 and 4), the gaged flow record from the San Jon Road gage was also used; however, since the drainage basin above the MRWPCA Castroville Pump Station is 148.5 square-miles, or 136% of the gaged area, the historic mean daily flow records were scaled by 136%.

Daily estimated flow data were used to develop exceedance probability distributions (exceedance curves) by three separate seasonal periods including: adult steelhead upstream migration (December through April), steelhead smolt migration (March through May), and dry season (June through September). These exceedance probability distributions were developed from ranked and sorted data, and show the percentage of time (probability) that a given value is exceeded. These curves show the differences in general long-term flow patterns between the base Case and each of four alternative diversion scenarios.

Effects of the project on steelhead migration were assessed by calculating changes in periods of time when flows are sufficient to allow migration. Minimum flows for migration of both adult steelhead moving upstream to spawn and smolts moving downstream to the ocean were determined through site specific studies in the Reclamation Ditch (HES 2015). Minimum passage flow thresholds were estimated at two critical passage sites: the USGS stream gage weir at San Jon Road and at a site near Boronda Road (Table 4). Flow thresholds for steelhead passage were estimated from measured channel geometry and application of the Manning equation (HES 2015*).* Due to error inherent in the method for obtaining these estimates, the accuracy of the threshold estimates is assumed to be no better that +/- 30% (HES 2015). Estimates of the number of days when stream flow equaled or exceeded these thresholds during the appropriate migration season were calculated for the Base Case and each of the diversion Cases. Migration seasons were defined to encompass the major period for each life stage typical of the Salinas River basin: December through April for adults and March through May for smolts. Although migration can occur outside these windows under some conditions, expanding the analytical period can minimize the potential effects by including greater time periods with low potential for occurrence of the species (e.g. a change of 10 days of suitable passage would be considered significant over a 90 day migration season but not over a 120 day season). For adult migration the migration season is designated by the year it ends (e.g. the 2003 migration season starts December 1, 2002 and ends April 30, 2003.

Table 4: Minimum Passage Flow Estimates for Steelhead Migrating Through the Reclamation Ditch Downstream of Davis Road *(Source: Hagar Environmental Science 2015).*

Location	Adult	Smolt
San Jon Road (USGS gage weir)	78 cfs	31 cfs
Boronda Road critical riffle	32 cfs	11 cfs

1.3.4.1 Case 1

> ***Divert up to 2.99 cfs of available flow from Reclamation Ditch at Davis Road and up to 2.99 cfs of available flow from Tembladero Slough at Castroville with minimum bypass flow of 2 cfs December-May and 0.69 cfs June-November at Davis Road location and 1 cfs in Tembladero Slough.***

For Case 1 during the adult migration period, the largest proportional flow reductions downstream of Davis Road would occur when Base Case flow is in the range of 1 to 30 cfs (Figure 6). Flow reductions for base case flows over 30 cfs would be 10% or less. The 2.99 cfs diversion at Castroville under Case 1, combined with the Davis Road diversion, results in larger flow reductions in Tembladero Slough and downstream reaches to Monterey Bay with flow reductions of 10% or more for Base Case flows of 1 to 60 cfs (Figure 7).

Steelhead are most likely to migrate during high flows that occur during winter storm runoff. Minimum migration flows for adult steelhead passage in the Reclamation Ditch have been estimated at 32 cfs to 78 cfs with the most difficult passage conditions at the San Jon Road stream gage (HES 2015). Diversion of 2.99 cfs would curtail periods when migration for adult steelhead is possible. Assuming a minimum passage flow of 78 cfs at the San Jon Road stream gage site, it is estimated that there would be reductions of 0% to 20% (average 8%) in the number of days annually meeting the minimum migration threshold for adult steelhead (Figure 8, Table 5). The number of potential migration days is reduced in 9 years out of the 11 modeled and in 4 years the reduction is 10% or more. Although the actual number of days involved is generally small (1 to 2 fewer days meeting migration criteria), the migration windows (periods when flows are in a suitable range) are also relatively short. One or 2 days of additional flow could make the difference between successful passage through the lower watershed and failure. If migration periods are curtailed when the diversion causes flows to drop below passage thresholds, adult steelhead could become stranded below difficult passage locations such as the stream gage at San Jon Road. Given the species status as threatened, a change in flow of this magnitude (10% or more reduction in migration periods in 36% of years) is potentially significant for migrating adult steelhead.

Flow reductions in Tembladero Slough downstream of the Castroville proposed diversion would have less effect on steelhead migration than the diversion at Davis Road since Tembladero Slough has a very low gradient downstream of the Castroville proposed project site and there are no critical passage sections such as the riprap and gaging weir at San Jon Road upstream. Tembladero Slough is tidally influenced from the Old Salinas River up to Highway 183 in Castroville and the backwater condition caused by the tide gates would prevent measurable reductions in water levels throughout that reach (Schaaf & Wheeler 2014).

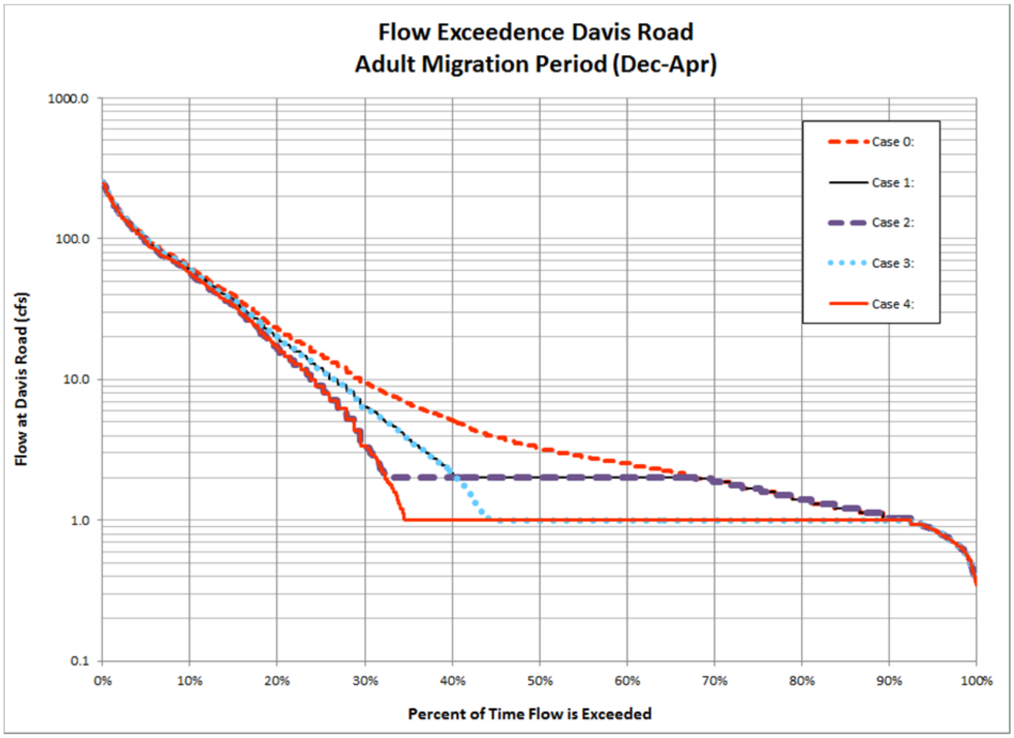

Figure 6. Flow exceedance curve for Davis Road proposed project site during adult steelhead migration period.

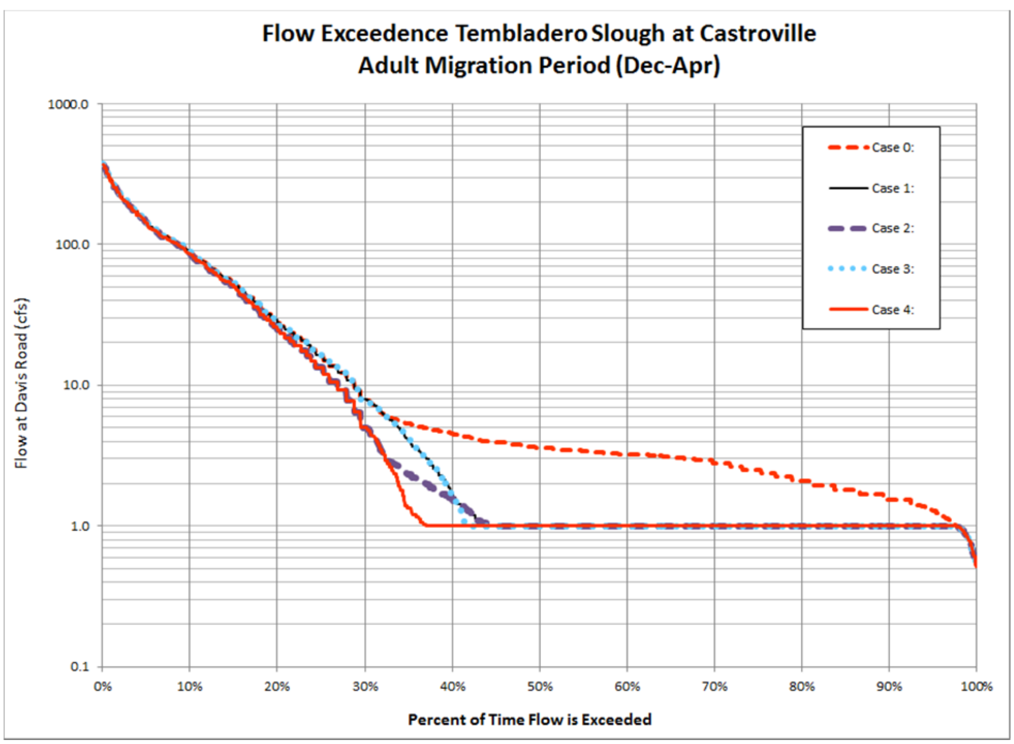

Figure 7. Flow exceedance curve for Tembladero Slough at Castroville proposed diversion site during steelhead smolt migration period.

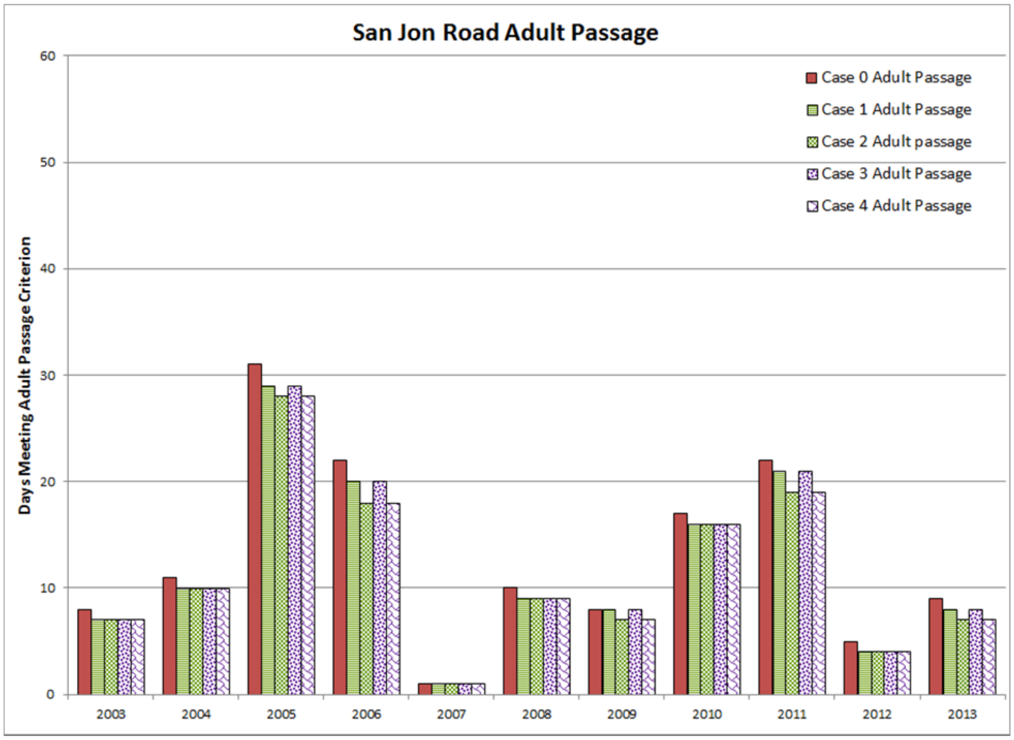

Figure 8. Number of days meeting minimum passage flow (78 cfs) for adult steelhead downstream of the Davis Road proposed project site during December through April.

Table 5: Simulated number of days meeting migration criteria (and percent reduction from base case) at San Jon Road during adult steelhead migration seasons. *Note*: migration season begins December 1 and ends April 30 the following year and is designated by the year it ends; partial periods (2002 and 2014) are omitted.

	Number of Days Meeting Adult Migration Criteria (78 cfs)				
Migration Period	**Case 0**	**Case 1**	**Case 2**	**Case 3**	**Case 4**
2003	8	7 (-13%)	7 (-13%)	7 (-13%)	7 (-13%)
2004	11	10 (-9%)	10 (-9%)	10 (-9%)	10 (-9%)
2005	31	29 (-6%)	28 (-10%)	29 (-6%)	28 (-10%)
2006	22	20 (-9%)	18 (-18%)	20 (-9%)	18 (-18%)
2007	1	1 (0%)	1 (0%)	1 (0%)	1 (0%)
2008	10	9 (-10%)	9 (-10%)	9 (-10%)	9 (-10%)
2009	8	8 (0%)	7 (-13%)	8 (0%)	7 (-13%)
2010	17	16 (-6%)	16 (-6%)	16 (-6%)	16 (-6%)
2011	22	21 (-5%)	19 (-14%)	21 (-5%)	19 (-14%)
2012	5	4 (-20%)	4 (-20%)	4 (-20%)	4 (-20%)
2013	9	8 (-11%)	7 (-22%)	8 (-11%)	7 (-22%)
Total	144	133 (-8%)	126 (-13%)	133 (-8%)	126 (-13%)

During the smolt migration period (March through May), flows at the Davis Road site are generally lower than during the adult migration period and proportional reduction in flow from the diversion would be greater (Figure 9). The 2.99 cfs Tembladero Slough diversion would similarly reduce flows downstream of the Castroville proposed diversion location (Figure 10). As described for adult migration, smolt migration flows are more an issue in the Reclamation Ditch, upstream of Tembladero Slough than in Tembladero Slough which is a low-gradient channel without critical passage sections and with tidal influence that tends to backwater the channel as far upstream as the Castroville Diversion location.

Although smolts need less flow to migrate in the Reclamation Ditch than adults, the channel is severely lacking in cover and smolts are exposed to potential predation from birds. Minimum migration flow for smolts is estimated at between 11 cfs and 31 cfs, depending on location, again with the most difficult passage at the San Jon Road stream gage (HES 2015). Proportional reductions in flow can be quite large in this range (Figure 9). For example, a flow of 3 cfs or more occurs at the Davis Road proposed project site approximately 56% of the time under the base case but only about 28% of the time with Case 1.

Based on a minimum passage flow for smolts of 31 cfs at the San Jon Road site, the number of days with flows meeting minimum smolt passage criteria is reduced by 0% to 7% annually or an average of 4% (Figure 11, Table 6). The reduction is never more than 10%. The number of days meeting smolt migration criteria is reduced under Case 1 compared to the base case (Case 0) in 2 years out of 11 years simulated. In some cases the actual reduction in terms of days is small however; the number of days available in the base case is also small at times (e.g. 2011). Flow alterations downstream of the Davis Road site of this magnitude do not meet the significance criteria during the smolt migration period and would be considered less than significant. It should be noted however, the accuracy of the flow threshold estimate for smolt migration is +/- 30%. If the lower end of the range were used for minimum passage flow for smolts (30% of 31 cfs is 22 cfs), the number of days meeting the passage criteria would be reduced by up to 17%, and 27% of years would have reductions of 10% or more.

Table 6: Simulated number of days meeting migration criteria (and % reduction from base case) at San Jon Road during simulated steelhead smolt migration seasons (March-May).

	Number of Days Meeting Smolt Migration Criteria (31cfs)				
Migration Period	**Case 0**	**Case 1**	**Case 2**	**Case 3**	**Case 4**
2003	4	4 (0%)	4 (0%)	4 (0%)	4 (0%)
2004	2	2 (0%)	2 (0%)	2 (0%)	2 (0%)
2005	19	19 (0%)	18 (-5%)	19 (0%)	18 (-5%)
2006	41	38 (-7%)	35 (-15%)	38 (-7%)	35 (-15%)
2007	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
2008	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
2009	5	5 (0%)	5 (0%)	5 (0%)	5 (0%)
2010	17	17 (0%)	16 (-6%)	17 (0%)	16 (-6%)
2011	15	14 (-7%)	13 (-13%)	14 (-7%)	13 (-13%)
2012	9	9 (0%)	9 (0%)	9 (0%)	9 (0%)
2013	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Total	112	108 (-4%)	102 (-9%)	108 (-4%)	102 (-9%)

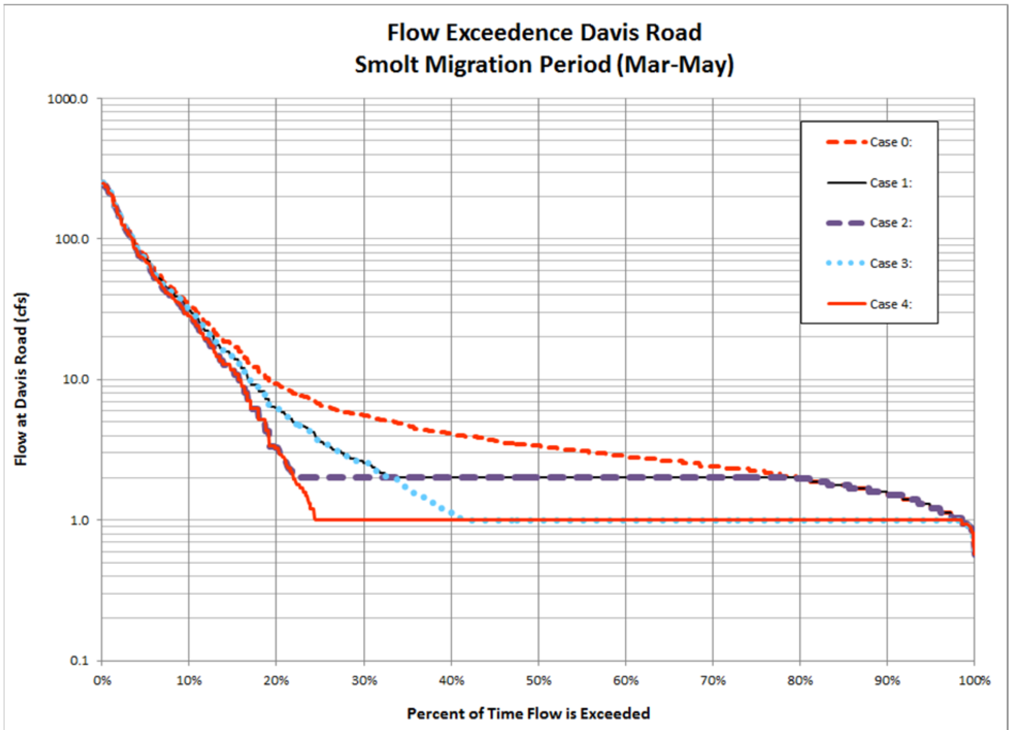

Figure 9. Flow exceedance curve for Davis Road proposed project site during steelhead smolt migration period.

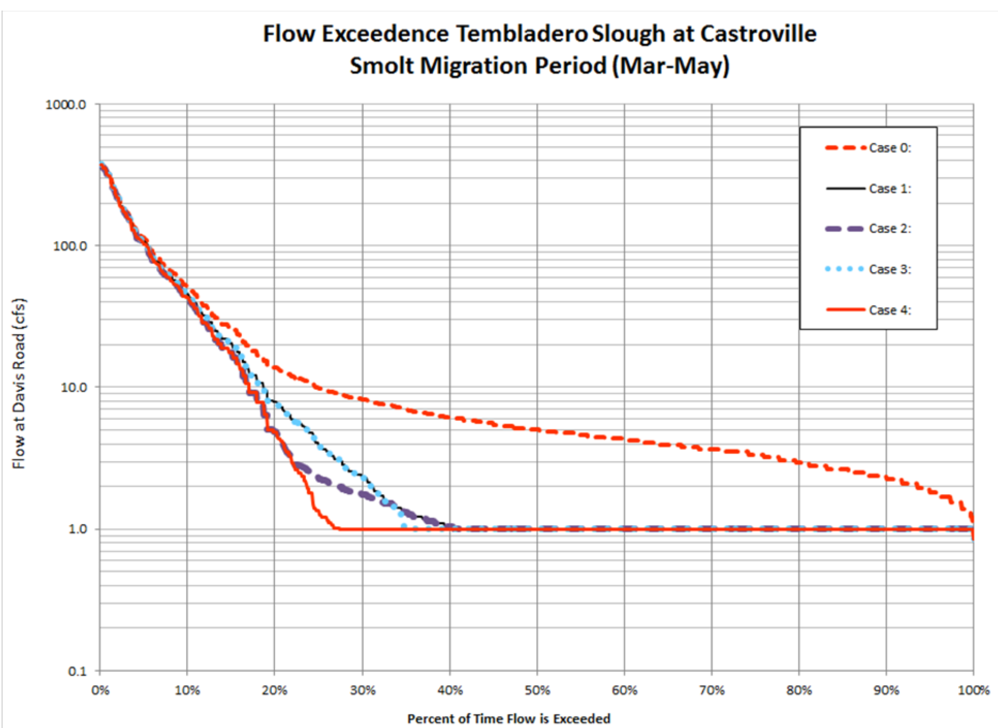

Figure 10. Flow exceedance curve for Tembladero Slough at Castroville proposed project site during steelhead smolt migration period.

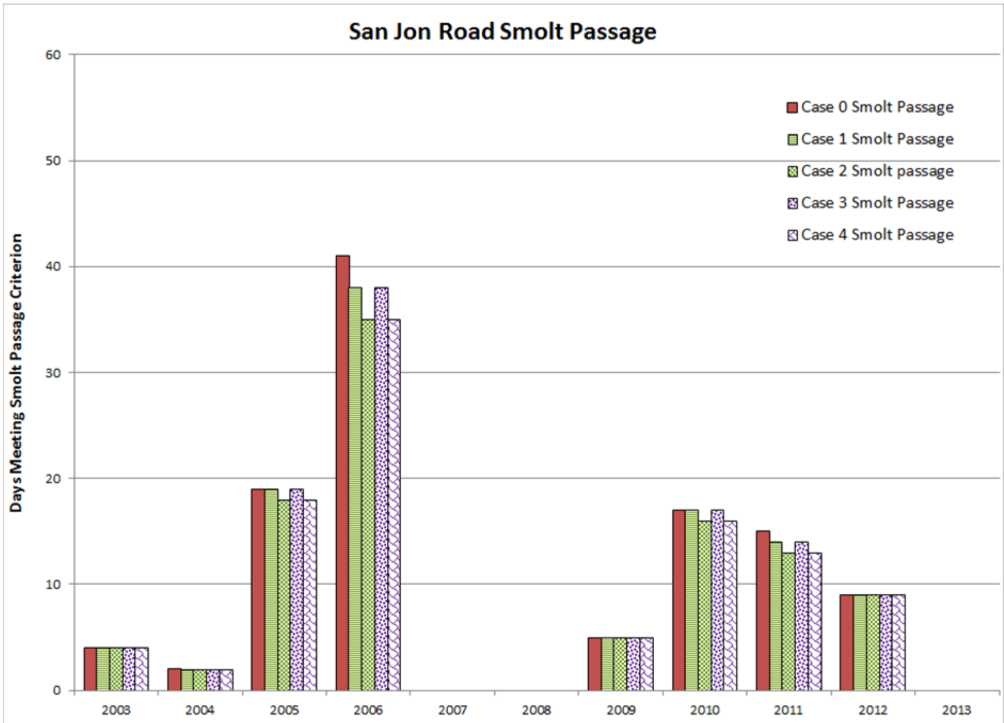

Figure 11. Number of Days meeting minimum passage flow (31 cfs) for steelhead smolts downstream of the Davis Road proposed project site during March, April, and May.

Flow reductions during the dry season exceed 10% across the majority of the range of flows simulated at Davis Road and Castroville (Figures 12 and 13). However, during the dry season (June-September), special status species are not expected to be present in the Reclamation Ditch downstream of the Davis Road proposed project site. Steelhead use these reaches only for migration, during the winter and spring, and potential dry season rearing habitat exists only in headwater reaches. There is a limited potential for tidewater goby near or downstream of the Castroville project site. Since goby prefer quiescent conditions, and since the channel is tidally backwatered in this reach, flow reductions in the range simulated would not be expected to have a detrimental effect on them, should they be present. Native and introduced warmwater species likely to be present are not migrating during this period. The 0.69 cfs minimum flow maintains base habitat conditions for species likely to be present. Flow changes from Case 1 during the dry season (Figures 12 and 13) would have a less than significant effect.

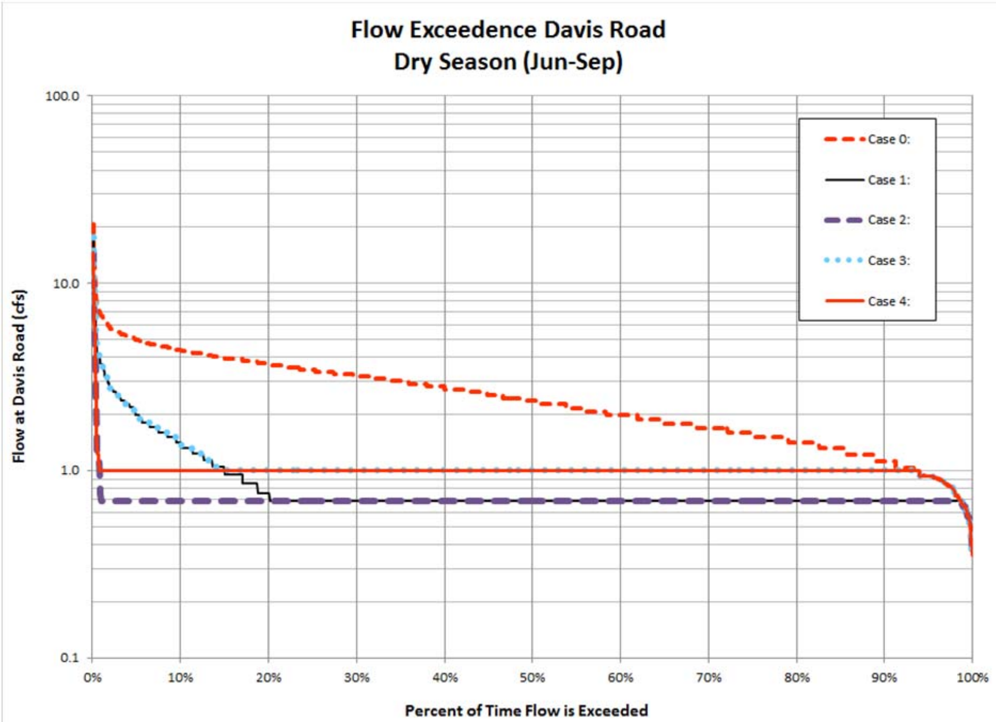

Figure 12. Flow exceedance curve for Davis Road proposed project site during summer dry-season.

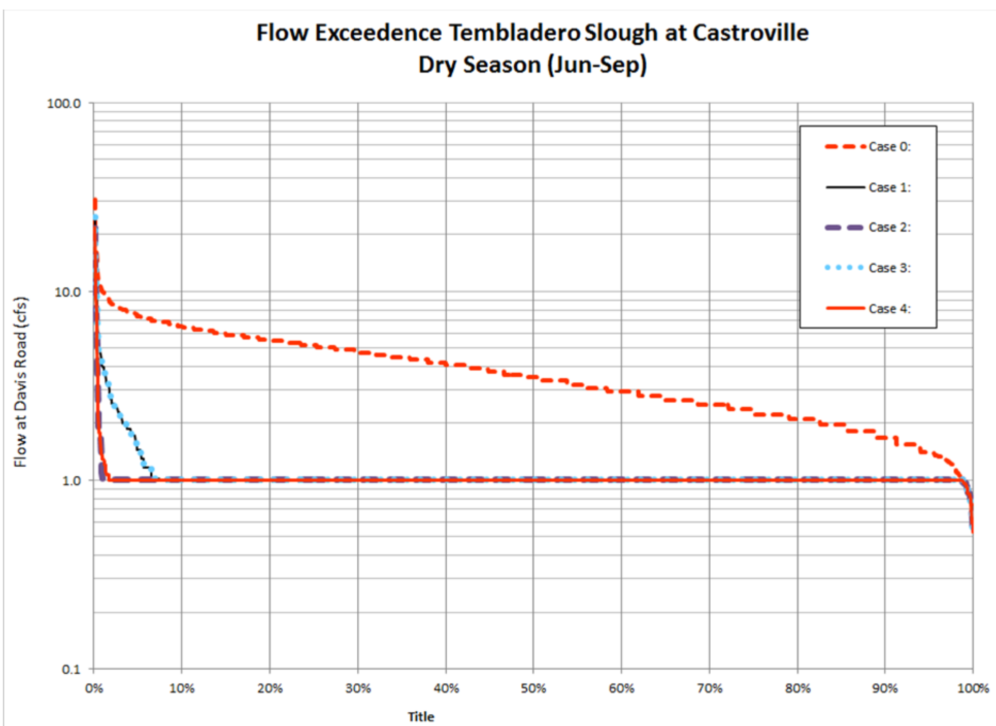

Figure 13. Flow exceedance curve for Tembladero Slough at Castroville proposed project site during summer dry-season.

1.3.4.2 Case 2

Divert up to 6.0 cfs of available flow from Reclamation Ditch at Davis Road and up to 2.99 cfs of available flow from Tembladero Slough at Castroville with minimum bypass flow of 2 cfs December-May and 0.69 cfs June-November at Davis Road location and 1 cfs in Tembladero Slough.

Analysis of Case 2 was identical to Case 1 except the Target Diversion at the Davis Road site was 6 cfs instead of 2.99 cfs. For Case 2 during the adult migration period, the largest proportional flow reductions in the Reclamation Ditch would occur in the range of 1 to 60 cfs. Flow reductions for base case flows of 60 cfs or less would be 10% or more for the Reclamation Ditch (Figure 6). The 2.99 cfs diversion at Castroville under Case 2, combined with the Davis Road diversion, results in larger flow reductions in Tembladero Slough and downstream reaches to Monterey Bay with flow reductions of 10% or more for Base Case flows of 1 to 90 cfs (Figure 7).

Case 2 has a greater potential effect on adult steelhead migration than Case 1 given the larger diversion rate. Assuming a minimum passage flow of 78 cfs at the San Jon Road stream gage site, it is estimated that there would be reductions of 0% to 22% (average 13%) in the number of days annually meeting the minimum migration threshold for adult steelhead (Figure 8, Table 5). The number of potential migration days is reduced in 10 years out of the 11 modeled and in 8 years the reduction is 10% or more. Although the actual number of days involved is generally small (1 to 4 fewer days meeting migration criteria), the migration windows (periods when flows are in a suitable range) are also relatively short. One or 2 days of additional flow could make the difference between successful passage through the lower watershed and failure. Curtailment of migration flows by this amount could limit the ability of steelhead to reach spawning habitat in the upper watershed and adult steelhead could become stranded below difficult passage locations such as the stream gage at San Jon Road. Given the species status as threatened, a change in flow of this magnitude (10% or more reduction in migration periods in 73% of years) is potentially significant for migrating adult steelhead.

As discussed previously for Case 1, flow reductions in Tembladero Slough downstream of the Castroville proposed diversion would have less effect on steelhead migration than the diversion at Davis Road since Tembladero Slough has a very low gradient downstream of the Castroville proposed project site and there are no critical passage sections such as the riprap and gaging weir at San Jon Road upstream. Tembladero Slough is tidally influenced from the Old Salinas River up to Highway 183 in Castroville and the backwater condition caused by the tide gates would prevent measurable reductions in water levels throughout that reach (Schaaf & Wheeler 2014).

During the smolt migration period (March through May), flows at the Davis Road site are generally lower than the adult migration period and proportional reduction in flow from the diversion would be greater (Figures 9 and 10). Although smolts need less flow to migrate than adults, the channel is severely lacking in cover and smolts are exposed to potential predation from birds. As previously described, smolt migration flows are more an issue in the Reclamation Ditch, upstream of Tembladero Slough than in Tembladero Slough which is a low-gradient channel without critical passage sections and with tidal influence that tends to backwater the channel as far upstream as the Castroville Diversion location.

Minimum migration flow for smolts is estimated at between 11 cfs and 31 cfs, depending on location, again with the most difficult passage at the San Jon Road stream gage (HES 2015). Based on a minimum passage flow for smolts of 31 cfs at the San Jon Road site, the number of days with flows meeting minimum smolt passage criteria is reduced by 0% to 15% annually or 9% on average (Figure 11, Table 6). The reduction is 10% or more in 2 of the 11 years simulated. The number of days meeting smolt migration criteria is reduced under Case 2 compared to the base case (Case 0) in 4 of 11 years simulated. In some cases the actual reduction in terms of days is small however; the number of days available in the base case is also small at times. Flow alterations of this magnitude during the smolt migration period, particularly given the sensitivity of smolts migrating through this degraded habitat, and considering the low accuracy of the method for estimating minimum passage flow, would be potentially significant downstream of the Davis Road site.

Flow reductions during the dry season (June-September) exceed 10% across the majority of the range of flows simulated at Davis Road and Castroville (Figures 12 and 13). Flow reductions from Case 2 result in the minimum bypass flow of 0.69 cfs at Davis Road and 1 cfs at Castroville occurring virtually the entire time (Figures 12 and 13). Special status species are not expected to be present in the Reclamation Ditch downstream of the Davis Road proposed project site during this period. Tidewater goby, if present in Tembladero Slough downstream of the Castroville site, are not likely to be affected by the flow changes projected. Native and introduced warmwater species likely to be present are not migrating during this period. The 0.69 cfs minimum flow maintains base habitat conditions for species likely to be present. Flow changes from Case 2 during the dry season would have a less than significant effect on fish species in the Reclamation Ditch and Tembladero Slough.

1.3.4.3 Case 3

> ***Divert up to 2.99 cfs of available flow from Reclamation Ditch at Davis Road and up to 2.99 cfs of available flow from Tembladero Slough at Castroville with 1 cfs bypass flow at both locations.***

Case 3 differs from Case 1 only in the amount of bypass flows provided: 1 cfs at both

Davis Road and Castroville in Case 3 vs. 2 cfs in winter and 0.69 cfs in summer below Davis Road for Case 1. For Case 3 during the adult migration period, the largest proportional flow reductions in the Reclamation Ditch at Davis Road would occur in the range of 1 to 30 cfs. Flow reductions in the Reclamation Ditch for base case flows in that range would be 10% or more (Figure 6). The 2.99 cfs diversion at Castroville under Case 3, combined with the Davis Road diversion, results in larger flow reductions in Tembladero Slough and downstream reaches to Monterey Bay with flow reductions of 10% or more for Base Case flows in the range of 1 to 60 cfs (Figure 7).

As discussed previously for Case 1, diversion at Castroville would have less effect on steelhead migration than diversion at Davis Road since Tembladero Slough has a very low gradient downstream of the Castroville proposed project site and there are no critical passage sections such as the riprap and gaging weir at San Jon Road upstream. Tembladero Slough is tidally influenced from the Old Salinas River up to Highway 183 in Castroville and the backwater condition caused by the tide gates would prevent measurable reductions in water levels throughout that reach (Schaaf & Wheeler 2014).

Assuming a minimum passage flow of 78 cfs at the San Jon Road stream gage site, it is estimated that there would be reductions of 0% to 20% (average 8%) in the number of days annually meeting the minimum migration threshold for adult steelhead (Figure 8, Table 5). This is identical to Case 1. The number of potential migration days is reduced in 9 years out of the 11 modeled and in 4 years the reduction is 10% or more. Although the actual number of days involved is generally small (1 to 2 fewer days meeting migration criteria), the migration windows (periods when flows are in a suitable range) are also relatively short. One or 2 days of additional flow could make the difference between successful passage through the lower watershed and failure. Curtailment of migration flows by this amount could limit the ability of steelhead to reach spawning habitat in the upper watershed and adult steelhead could become stranded below difficult passage locations such as the stream gage at San Jon Road. Given the species status as threatened, a change in flow of this magnitude (10% or more reduction in migration periods in 36% of years) is potentially significant for migrating adult steelhead.

During the smolt migration period (March through May), flows at the Davis Road site are generally lower than the adult migration period and proportional reduction in flow from the diversion would be greater (Figures 9 and 10). Although smolts need less flow to migrate than adults, the channel is severely lacking in cover and smolts are exposed to potential predation from birds. As previously described, smolt migration flows are more an issue in the Reclamation Ditch, upstream of Tembladero Slough than in Tembladero Slough which is a low-gradient channel without critical passage sections and with tidal influence that tends to backwater the channel as far upstream as the Castroville Diversion location.

Minimum migration flow for smolts is estimated at between 11 cfs and 31 cfs, depending on location, again with the most difficult passage at the San Jon Road stream gage (HES 2015). Based on a minimum passage flow for smolts of 31 cfs at the San Jon Road site, the number of days with flows meeting minimum smolt passage criteria is reduced by 0% to 7% annually or an average of 4% (Figure 11, Table 6), identical to Case 1. The reduction is never more than 10%. The number of days meeting smolt migration criteria is reduced under Case 3 compared to the base case (Case 0) in 2 years out of 11 years simulated. In some cases the actual reduction in terms of days is small however; the number of days available in the base case is also small at times (e.g. 2011). Flow alterations downstream of the Davis Road site of this magnitude do not meet the significance criteria during the smolt migration period and would be considered less than significant. As for Case 1, it should be noted that the accuracy of the flow threshold estimate for smolt migration is low and that if the lower end of the range were used for minimum passage flow for smolts the number of days meeting the passage criteria would be reduced by up to 17% from the Base Case, and 27% of years would have reductions of 10% or more.

Flow reductions during the dry season (June-September) exceed 10% across the majority of the range of flows simulated at Davis Road and Castroville (Figures 12 and 13). Flow reductions from Case 3 are comparable to Case 1 during the dry season except that Case 3 has the higher minimum bypass flow occurring in the Reclamation Ditch for about 80% of the time (Figures 12 and 13). Special status species are not expected to be present in the Reclamation Ditch downstream of the Davis Road proposed project site during the dry season. Tidewater goby, if present in Tembladero Slough downstream of the Castroville site, are not likely to be affected by the flow changes projected. Tidewater goby prefer quiescent conditions and the channel is tidally backwatered in this reach and should not experience significant drawdown related to project diversions. Native and introduced warmwater species likely to be present are not migrating during this period. The 1 cfs minimum flow maintains base habitat conditions for species likely to be present. Flow changes from Case 3 would have a less than significant effect on fish species in the Reclamation Ditch and Tembladero Slough during the dry season.

1.3.4.4 Case 4

> ***Divert up to 6.0 cfs of available flow from Reclamation Ditch at Davis Road and up to 2.99 cfs of available flow from Tembladero Slough at Castroville with 1 cfs bypass flow at both locations.***

Case 4 is identical to Case 2 except for the amount of bypass flows provided: 1 cfs at both Davis Road and Castroville in Case 4 vs. 2 cfs in winter and 0.69 cfs in summer below Davis Road for Case 2. During the adult migration period, the largest proportional flow reductions for Case 4 would occur in the range of 1 to 60 cfs for the reach downstream of Davis Road. Flow reductions for base case flows of 60 cfs or less would be 10% or more for the Reclamation Ditch (Figures 6). The 2.99 cfs diversion at Castroville under Case 4, combined with the Davis Road diversion, results in larger flow reductions in Tembladero Slough and downstream reaches to Monterey Bay with flow reductions of 10% or more for Base Case flows of 1 to 90 cfs (Figure 7).

Case 4 has a greater potential effect on adult steelhead migration than Case 1 or Case 3 given the larger diversion rate. Assuming a minimum passage flow of 78 cfs at the San Jon Road stream gage site, it is estimated that there would be reductions of 0% to 22% (average of 13%) in the number of days annually meeting the minimum migration threshold for adult steelhead (Figure 8, Table 5), identical to Case 2. The number of potential migration days is reduced in 10 years out of the 11 modeled and in 8 years the reduction is 10% or more. Although the actual number of days involved is generally small (1 to 4 fewer days meeting migration criteria), the migration windows (periods when flows are in a suitable range) are also relatively short. One or 2 days of additional flow could make the difference between successful passage through the lower watershed and failure. Curtailment of migration flows by this amount could limit the ability of steelhead to reach spawning habitat in the upper watershed and adult steelhead could become stranded below difficult passage locations such as the stream gage at San Jon Road. Given the species status as threatened, a change in flow of this magnitude (10% or more reduction in migration periods in 73% of years) is potentially significant for migrating adult steelhead.

As discussed previously for Case 1, flow reductions in Tembladero Slough downstream of the Castroville proposed diversion would have less effect on steelhead migration than the diversion at Davis Road since Tembladero Slough has a very low gradient downstream of the Castroville proposed project site and there are no critical passage sections such as the riprap and gaging weir at San Jon Road upstream. Tembladero Slough is tidally influenced from the Old Salinas River up to Highway 183 in Castroville and the backwater condition caused by the tide gates would prevent measurable reductions in water levels throughout that reach (Schaaf & Wheeler 2014).

During the smolt migration period (March through May), flows at the Davis Road site are generally lower than the adult migration period and proportional reduction in flow from the diversion would be greater (Figures 9 and 10). Although smolts need less flow to migrate than adults, the channel is severely lacking in cover and smolts are exposed to potential predation from birds. As previously described, smolt migration flows are more an issue in the Reclamation Ditch, upstream of Tembladero Slough than in Tembladero Slough which is a low-gradient channel without critical passage sections and with tidal influence that tends to backwater the channel as far upstream as the Castroville Diversion location.

Minimum migration flow for smolts is estimated at between 11 cfs and 31 cfs, depending on location, again with the most difficult passage at the San Jon Road stream gage (HES 2014). Based on a minimum passage flow for smolts of 31 cfs at the San Jon Road site, the number of days with flows meeting minimum smolt passage criteria is reduced by 0% to 15% annually or an average of 9% (Figure 11, Table 6), identical to Case 2. The reduction is 10% or more in 2 of the 11 years simulated. The number of days meeting smolt migration criteria is reduced under Case 4 compared to the base case (Case 0) in 4 of 11 years simulated. In some cases the actual reduction in terms of days is small however; the number of days available in the base case is also small at times. Flow alterations of this magnitude during the smolt migration period, particularly given the sensitivity of smolts migrating through this degraded habitat, and considering the low accuracy of the method for estimating minimum passage flow, would be potentially significant downstream of the Davis Road site.

Flow reductions during the dry season (June-September) exceed 10% across the majority of the range of flows simulated at Davis Road and Castroville (Figures 12 and 13). Flow reductions from Case 4 result in the minimum bypass flow of 1 cfs at both the Davis Road and Castroville locations occurring virtually the entire time (Figures 12 and 13). As in Cases 1, 2, and 3, flow reduction at the level that would occur for Case 4 would have less than significant effect on fish species potentially present in the Reclamation Ditch and Tembladero Slough during the dry season.

1.3.4.5 Conclusion

Case 1 and Case 3 have identical diversion profiles but differ in the minimum bypass amounts. Similarly, Case 2 and Case 4 have identical diversion profiles but feature higher diversions at Davis Road than Cases 1 and 3 (6 cfs vs. 2.99 cfs). All four cases have potentially significant effects on adult steelhead migration although Cases 2 and 4 have greater effect than Cases 1 and 3. The different minimum bypass provisions have no effect on steelhead migration since they are well below the minimum flows required for either smolts or adults. For adult migration it is estimated that there would be reductions of 0% to 20% (average 8%) in the number of days annually meeting the minimum migration threshold for both Case 1 and 3. For both Cases 2 and 4 average annual reduction in the number of days meeting the adult migration threshold would be 13%. During the hydrologic period examined, there would be a 10% or larger reduction in the number of days with flow meeting the migration threshold in 4 years out of 11 for Cases 1 and 3 and in 8 years out of 11 for Cases 2 and 4. Given steelheads status as a threatened species, a change in flow of this magnitude is potentially significant for migrating adult steelhead.

During the potential migration period for steelhead smolts, only Cases 2 and 4 would result in a significant reduction in the number of days meeting migration criteria, while

Cases 1 and 3 would have a less than significant effect. The number of days meeting migration criteria would be reduced in only two years under Cases 1 and 3 and the reduction would be less than 10% in both years. For Cases 2 and 4, the number of days meeting migration criteria would be reduced in 4 years out of 11 with 2 of those years having a reduction greater than 10%. Flow alterations of the magnitude occurring during the smolt migration period under Cases 2 and 4 would be potentially significant downstream of the Davis Road site, particularly given the sensitivity of smolts migrating through this degraded habitat, and considering the low accuracy of the method for estimating minimum passage flow.

Flow reductions during the dry season (June-September) exceed 10% across nearly the full range of baseline flows. However, special status species are not expected to be present in the Reclamation Ditch downstream of the Davis Road proposed project site. Steelhead use these reaches only for migration, during the winter and spring, and potential dry season rearing habitat exists only in headwater reaches. There is a limited potential for tidewater goby near or downstream of the Castroville project site. Since goby prefer quiescent conditions, and since the channel is tidally backwatered in this reach, flow reductions would not be expected to have a detrimental effect on them, should they be present. Native and introduced warmwater species likely to be present are not migrating during this period. Habitat in the Reclamation Ditch and Tembladero Slough are highly degraded in terms of channel structure, riparian vegetation, and water quality. The minimum bypass flows of 0.69 cfs (Cases 1 and 2) or 1 cfs (Cases 3 and 4) downstream of Davis Road maintain base habitat conditions for species likely to be present. Flow changes during the dry season for both cases would have a less than significant effect.

Overall, Cases 1 and 3 would have slightly less effect on steelhead migration than Cases 2 and 4 due to the lower diversion rates at Davis Road. Case 3 would have slightly more flow below Davis Road due to the higher bypass flow during the dry season but the effect is less than significant.

1.4 MITIGATION MEASURES

Potential significant effects on migrating adult steelhead and steelhead smolts could be mitigated by operating diversions to maintain flow within suitable windows for migration during periods when steelhead may be migrating. Steelhead adults migrate during December through April and require a flow of at least 78 cfs to pass over the weir at San Jon Road. If the diversion is operated to avoid dropping flow below this level, negative effects to migrating steelhead adults could be avoided. Steelhead smolts migrate primarily during March through May and require a flow of at least 31 cfs to meet passage criteria at the San Jon Road weir. Operating the diversion during March through May to avoid reducing flow below this level would avoid potentially significant effects on steelhead smolt migration.

When natural flow (without diversion) drops below these thresholds, presumably steelhead would no longer be able to migrate and diversions could be resumed. Since there is some uncertainty in the conditions required by steelhead to migrate and in estimating the flow level that meets those criteria, it is prudent do define a window for the migration flow threshold rather than to use a single numeric value. For example, it is assumed that adult steelhead need a depth of 0.7 feet to migrate but in fact they may be able to pass an obstacle with only 0.5 feet of depth. In addition, there is likely a minimum of at least 10% error in estimation of the flow that provides a depth of 0.7 feet. Given this potential for error it is not unreasonable to assume an error of +/- 30% in our estimate of the migration threshold (HES 2015). Therefore, a reasonable flow window for protection of adult steelhead migration would be 55 to 101 cfs. Similarly, a reasonable window for smolt migration would be 22 to 40 cfs. Operation of the diversion such that it would not cause flows to drop below the upper migration limit and would be resumed when flows drop below the lower migration threshold would avoid significant impacts to steelhead migration (Table 7).

Table 7: Diversion schedule to avoid significant effects to migrating steelhead (flow measured at San Jon Road gage).

Migration Period	Operate Diversion only when flow is below (cfs):	Operate Diversion only when flow is above (cfs):
December	55	101
January	55	101
February	55	101
March	22	101
April	22	101
May	22	40

Modification of the San Jon Road stream gage weir to allow passage of steelhead at lower flows could expand the range of flows when the diversion could be operated and would greatly increase the amount of time available for steelhead migration in the Reclamation Ditch watershed. For example, if the weir could be modified to allow passage at flows similar to the Boronda Road passage site then the migration threshold would be 32 cfs for adult steelhead and 11 for steelhead smolts. This would be approximately equivalent to flows of 34 cfs and 12 cfs at the San Jon Road gage[3]. The window for migration, calculated in the same way as for the San Jon Road site, would be 22 to 42 for adult steelhead and 8 to 14 for steelhead smolts. An operation schedule as in Table 8 would avoid significant effects on steelhead migration if the San Jon Road weir were modified to achieve passage at flows comparable to the Boronda Road site.

Table 8: Diversion schedule to avoid significant effects to migrating steelhead if the San Jon Road weir were improved for steelhead passage (flow measured at San Jon Road gage).

Migration Period	Operate Diversion only when flow is below (cfs):	Operate Diversion only when flow is above (cfs):
December	22	42
January	22	42
February	22	42
March	8	42
April	8	42
May	8	14

[3] Flow at Boronda Road is similar to the diversion site and is 93.7% of the flow at San Jon Road based on drainage area (Schaaf and Wheeler 2014)

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Appendix G2

Memorandum Regarding Reclamation Ditch Steelhead Migration Passage Assessment

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TECHNICAL MEMORANDUM

TO: Denise Duffy
Denise Duffy and Associates

FROM: Jeff Hagar
Hagar Environmental Science

DATE: February 27, 2015

PROJECT: Pure Water Monterey Groundwater Replenishment (GWR) Project – Estimation of Minimum Flows for Migration of Steelhead in the Reclamation Ditch

The Monterey Regional Water Pollution Control Agency (MRWPCA) is preparing an Environmental Impact Report (EIR) for the proposed Pure Water Monterey Groundwater Replenishment Project (GWR Project). The project will develop high quality replacement water for existing urban supplies; and an enhanced agricultural irrigation (Crop Irrigation) component that will increase the amount of recycled water available to the existing Castroville Seawater Intrusion Project in northern Monterey County. The project could involve diversion of flows from the Reclamation Ditch watershed at a site near Davis Road and a site in Castroville on Tembladero Slough (Figure 1). The reclamation ditch watershed has the potential to support steelhead trout (*Oncorhynchus mykiss*). Potential salmonid habitat exists upstream of the project site, although the extent and quality of such habitat has not been well quantified. Diversion of flow from the Reclamation Ditch has the potential to affect steelhead during periods when they are migrating, either upstream as adults or downstream as smolts.

Steelhead trout are listed as a threatened species under the Federal Endangered Species Act (ESA). Full levels of production for anadromous salmonids in Central California coastal streams rely on the ability of adult steelhead to enter the streams and easily access spawning and rearing habitat in the upper reaches and for smolts to return to the ocean. Unlike other Pacific salmon, some steelhead survive after spawning and return downstream to the ocean. As many as 20% of adult steelhead spawners may be repeat spawners and some fish may return to spawn up to 3 or 4 times (Shapovalov and Taft 1954). Even obstacles that are not complete barriers can impair populations by delaying migration rates and exposing fish to potential predation or poaching.

The purpose of the work described here was to identify fish passage obstacles between the Davis Road project site and the Tembladero Slough proposed diversion site and determine the minimum amount of flow necessary for steelhead migration through the reach. Passage in Tembladero Slough is not expected to be influenced by a diversion near Castroville since

Tembladero Slough is tidal up to this area and backwatering of the channel prevents formation of critical riffles or other shallow locations. The accepted methodology for minimum passage flow assessment involves measurement of stage and flow at a range of flows bracketing the minimum passage flow (CDFW 2013). The time frame for completion of the environmental documents did not provide opportunity to wait for winter flow conditions to collect the necessary data. Instead, HES used an alternative method using channel geometry measurements and the Manning equation to make an approximation of minimum passage flow needs. This method gives an “order-of-magnitude” approximation for planning level application only. This information was collected on October 20, 2014 during a site visit with representatives of HES, Monterey Peninsula Water Management District, Schaaf & Wheeler, and Denise Duffy & Associates.

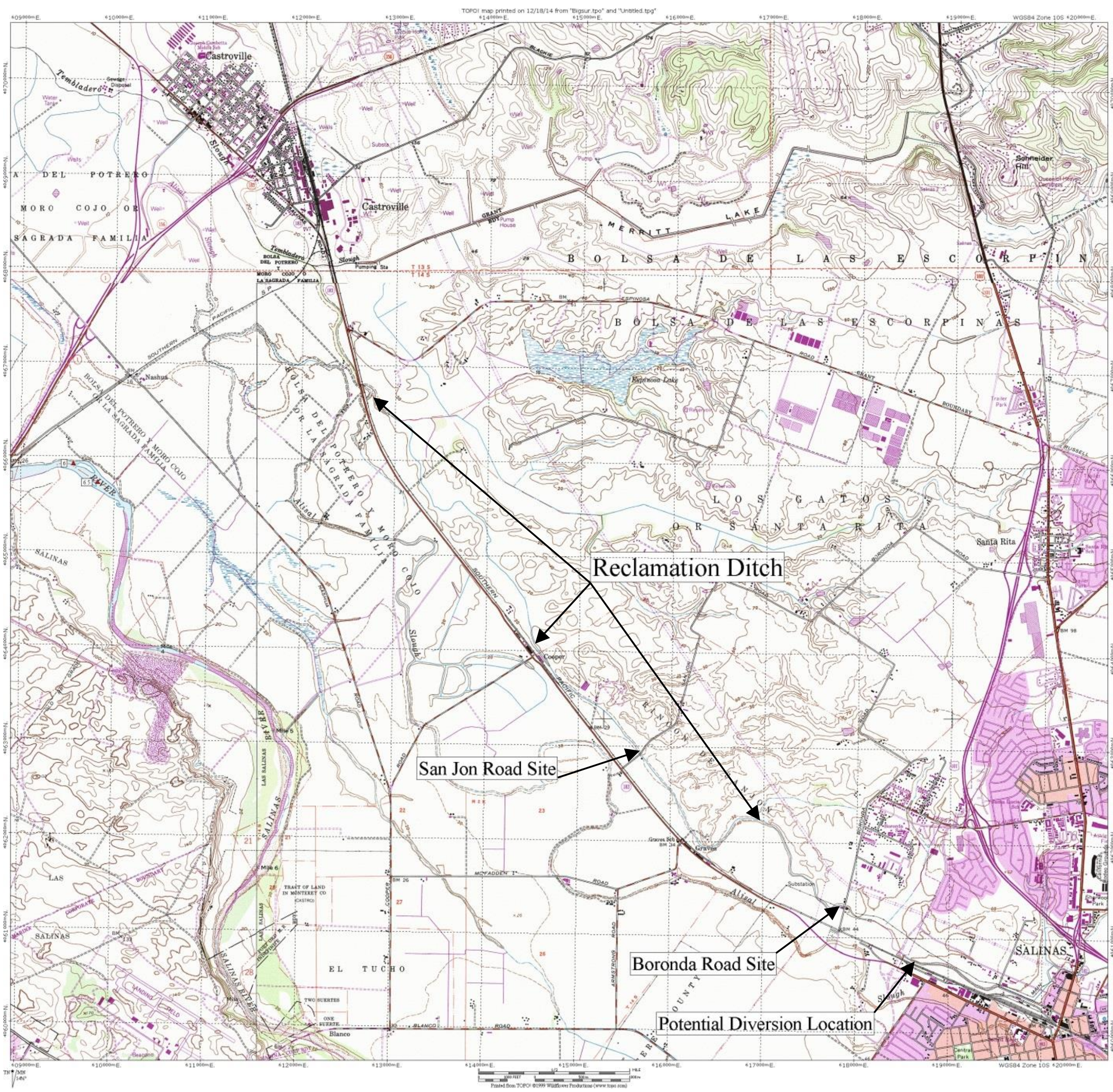

Figure 1. Study area.

During the October 20 site visit several road crossings of the Reclamation Ditch between Castroville and Salinas were evaluated for passage conditions. Two sites, San Jon Road and Boronda Road (Figure 1), were selected for assessment based on judged severity of passage conditions and access issues.

The San Jon site has a USGS stream gage installation with a trapezoidal concrete channel section and gaging weir (Figure 2). There are two elements that produce difficult passage at this site. First is the concrete lip at the lower edge of the apron. This presents a jumping obstacle at low flows without a pool at the base. The second is the concrete apron itself which presents uniformly very shallow flow. The concrete lip is probably not a problem for upstream migrating adults when there is sufficient flow for passage over the apron. The lip is also not a problem for downstream migrating smolts or adults. The Boronda Road site has rock rip-rap fill in the channel downstream of the road bridge creating a critical passage riffle (Figure 3). This presents shallow water depth at lower flow levels without any other passage issues.

Figure 2. San Jon Road critical passage site.

Channel characteristics were measured at each of these sites for use in hydraulic modeling. Data collection included a channel cross-section at each site detailing bed elevation and water surface; a longitudinal profile of the thalweg through the site detailing bed elevation and water surface; and an estimate for Manning resistance coefficient (n). At the San Jon Road site, stage discharge data for the USGS gage were also available online (http://waterdata.usgs.gov/nwisweb/get_ratings?site_no=11152650&file_type=exsa). This information was used to develop an approximation of minimum passage flow estimates for migrating adult steelhead and steelhead smolts. Use of the Manning equation to estimate flow under these conditions is subject to substantial potential error. This information is used for project planning purposes only and is not a substitute for more rigorous methods such as the CDFW methodology (CDFW 2013). Passage flow estimates presented here should be verified by on-site observations during higher flow conditions.

Figure 3. Boronda Road critical passage site.

Methodology

The migration passage flow assessment is based on standards developed in the fisheries literature. These standards assume that there must be sufficient depth over the shallowest riffles for the target species to swim upstream with its body completely covered. Specifically, the critical depth must occur across 25% of the wetted channel width and across a contiguous section comprising 10% of the wetted channel width (Thompson 1972, Bjornn and Reiser 1991, CDFW 2013). The critical depths used in this analysis are 0.7 feet for adult steelhead and 0.4

feet for steelhead smolts. Although shallower critical depths are often justifiable (e.g. 0.6 feet for adults and 0.3 feet for smolts), these values were used in order to be consistent with the standards used by CDFW (CDFW 2013).

Flow velocity is also a consideration for migrating steelhead. Steelhead have strong swimming and leaping abilities that allow them to ascend streams into small tributary and headwater reaches. Steelhead can swim at rates of up to 4.5 feet per second (fps) for extended periods of time and can achieve burst speeds of 14 to 26 fps during passage through difficult areas (Bell 1986).

Critical passage flows are estimated through application of the Manning equation. The Manning equation is an empirical formula (based on observation rather than theory) that estimates the average velocity of a liquid flowing in an open channel (i.e., a conduit that does not completely enclose the liquid) (Gauckler 1867, Manning 1891).

The equation is given as:

$$V = k/n \; R_h^{\;2/3} \; S^{\;1/2}$$

where:

- *V* is the cross-sectional average velocity (ft/s in this application);
- *k* is a conversion factor of 1.4859 $ft^{1/3}/s$;
- *n* is the Manning coefficient (unitless);
- R_h is the hydraulic radius (ft), also given by A/P where A is the cross-sectional area of flow (ft^2); and P is the wetted perimeter;
- *S* is the slope of the hydraulic grade line or the linear hydraulic head loss (ft./ft.), which is the same as the channel bed slope when the water depth is constant.

Since flow (Q) is equal to VA the equation can be rewritten to solve for flow as:

$$Q = k/n \; A \; R_h^{\;2/3} \; S^{\;1/2}$$

This equation can be solved for any given flow stage with the channel geometry parameters: area, wetted perimeter, channel slope, and an estimate of the Manning coefficient.

At each passage study site, a critical cross-section was selected where the depth of flow was at a minimum across the channel width. Cross-sections incorporated the shallowest portion on the probable route a migrating salmonid would follow. A fiberglass survey tape was stretched across the channel and streambed and water surface elevations were measured at regular intervals along the tape using plane surveying techniques. A site benchmark was also established and surveyed. Conditions at each passage site were documented with photographs when measurements were made. Time was recorded at the beginning of each cross-section and at intervals across the channel. At the San Jon Road site, stage and time were recorded from the permanent staff plate at the station. Flow at the time of the survey was estimated from the 15-minute gage record at the San Jon Road site maintained by the USGS (http://waterdata.usgs.gov/usa/nwis/uv?site_no=11152650). Parameters used in the analysis and resulting flow and mean velocity estimates are presented in Table 1.

Cross-section data were entered in a spreadsheet configured to allow determination of the critical water surface elevation at which depth criteria were met. The cross-sectional area of flow is calculated from the channel bed elevation cross-section and measured or projected water surface elevation. Each point on the cross-section represents a cell with boundaries extending halfway to both adjacent measurement points and depth equal to the difference between the bed elevation and the water surface elevation. Cell width and depth are multiplied to give area and individual cell areas are summed across the cross-section. The wetted perimeter is the portion of the cross-section's perimeter that is "wet" and is also calculated by adding the length of bed for each cross-section cell. The channel slope was approximated from the USGS 1:24,000 topographical map for the area. Chow (1959) gives values for Manning coefficient based on channel condition. We used a value of 0.037 for both sites; this value is intermediate between an excavated or dredged channel, of earth, straight, uniform, with short grass and few weeds and an excavated or dredged channel, of earth, winding and sluggish, with stony bottom and weedy banks (Chow 1959).

For each depth criteria (0.4 or 0.7 feet) a stage was set for which 25% of the wetted channel width and a contiguous portion totaling at least 10% of the wetted width had a depth equal to or greater than the criteria value. Cross-section area and wetted perimeter were calculated and entered in the Manning equation to give an estimate of flow.

As a check on parameter value specification and overall performance of the analysis, the calculated flow values associated with target flow depths were compared to the rating curve for the San Jon Road stream gage site (Appendix A). The gage reads water levels a few feet upstream of the critical passage cross-section used in this analysis. On the October 20 survey date, the on-site staff plate read 0.72 at the time channel and water surface measurements were collected. This corresponds to a reported flow of 1.3 ft^3/s (cfs) during that period. Use of the Manning equation resulted in a flow estimate of 2 cfs. The difference may be related to the very shallow flow across the apron at the time of the survey and the difficulty of getting accurate water surface elevations. An additional data point was available from observations made by Schaaf and Wheeler on February 9, 2015 (Andrew Sterbenz, personal communication, February 24, 2015). The depth of flow measured at 9:00 am on that date was 0.3 feet and the corresponding flow from the USGS gage was 18 cfs. Using a Manning coefficient value of 0.37 gives a flow estimate of 19 cfs. This description applies to the ditch in the near vicinity of the gage installation.

As can be seen, the San Jon Road site results in significantly higher minimum passage flow requirements than the less altered Boronda Road site (Table 1). The Boronda Road site is probably representative of other critical passage sections in the Reclamation Ditch downstream of the potential diversion location (e.g., the farm access road downstream of the San Jon Road site). Potential for steelhead migration success through the Reclamation Ditch could be dramatically improved by altering the San Jon Road site to a more passage friendly configuration.

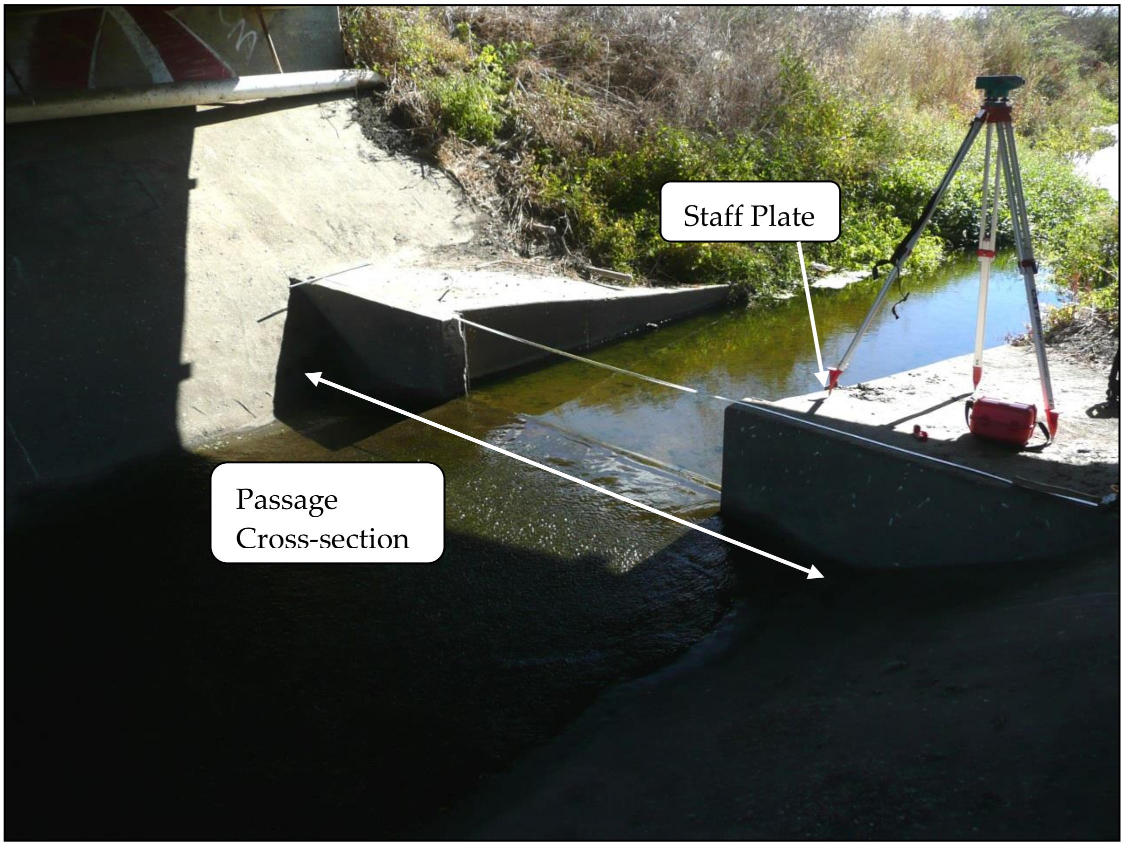

Figure 4. San Jon Road site.

This method gives an "order-of-magnitude" approximation of minimum flows for steelhead migration for planning level application only. There are numerous sources of error in the method including, estimation of parameter values, measurement of flow and associated rating curve, measurement of channel features and placement of cross-sections, and assumptions about depth required for steelhead passage. For example, it is assumed that adult steelhead need a depth of 0.7 feet to migrate but in fact they may be able to pass an obstacle with only 0.5 feet of depth. In addition, there is likely a minimum of at least 5-10% error in estimation of the flow that provides a depth of 0.7 feet. In addition, the Manning equation is an empirical equation for flow in uniform open channels. Uniform open channel flow takes place whenever there is a constant volumetric flow rate of liquid through a section of channel that has a constant bottom slope, constant hydraulic radius (that is constant channel size and shape), and constant channel surface roughness (constant Manning roughness coefficient). Under these conditions, the liquid will flow at a constant depth, often called the normal depth for the given channel and volumetric flow rate. Observations at the San Jon Road site indicate that the assumption of uniform flow may be problematic at some flows (Andrew Sterbenz, personal communication, February 2015). Given this potential for error it is not unreasonable to assume an error of +/- 30% in our estimate of the migration threshold.

Table 1: Channel geometry parameters for critical passage sites in the Reclamation Ditch with associated minimum passage flow estimates.

	San Jon Road			Boronda Road		
Parameter	October 20	Depth Criterion= 0.4 ft.	Depth Criterion= 0.7 ft.	October 20	Depth Criterion= 0.4 ft.	Depth Criterion= 0.7 ft.
n Manning coefficient	0.037	0.037	0.037	0.037	0.037	0.037
S Hydraulic slope	0.070	0.070	0.070	0.0280	0.0280	0.0280
A Cross-sectional area (ft^2)	1.0949	5.5281	10.2636	1.3970	3.5157	6.8266
P Wetted perimeter (ft.)	13.5651	14.8049	16.8706	9.0279	10.8492	11.8447
R = A/P hydraulic radius (ft.)	0.0807	0.3734	0.6084	0.1547	0.3240	0.5763
Q Estimated Flow (ft^3/s)	2.2	30.5	78.5	2.7	11.2	31.9
V Estimated velocity (f/s)	2.0	5.5	7.6	1.9	3.2	4.7

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Appendix A

Rating Curve for USGS Reclamation Ditch at San Jon Road Gage (11152650)

for October 20, 2014

Stage	Shift	Discharge	Stage	Shift	Discharge	Stage	Shift	Discharge
0.56	0.00	0.00	0.95	0.00	5.15	1.34	0.00	16.11
0.57	0.00	0.04	0.96	0.00	5.36	1.35	0.00	16.46
0.58	0.00	0.06	0.97	0.00	5.57	1.36	0.00	16.82
0.59	0.00	0.08	0.98	0.00	5.79	1.37	0.00	17.18
0.60	0.00	0.11	0.99	0.00	6.02	1.38	0.00	17.54
0.61	0.00	0.15	1.00	0.00	6.24	1.39	0.00	17.91
0.62	0.00	0.20	1.01	0.00	6.47	1.40	0.00	18.28
0.63	0.00	0.25	1.02	0.00	6.71	1.41	0.00	18.65
0.64	0.00	0.31	1.03	0.00	6.94	1.42	0.00	19.03
0.65	0.00	0.38	1.04	0.00	7.18	1.43	0.00	19.41
0.66	0.00	0.46	1.05	0.00	7.43	1.44	0.00	19.79
0.67	0.00	0.55	1.06	0.00	7.68	1.45	0.00	20.18
0.68	0.00	0.65	1.07	0.00	7.93	1.46	0.00	20.57
0.69	0.00	0.76	1.08	0.00	8.19	1.47	0.00	20.96
0.70	0.00	0.87	1.09	0.00	8.45	1.48	0.00	21.36
0.71	0.00	1.00	1.10	0.00	8.71	1.49	0.00	21.76
0.72	0.00	1.13	1.11	0.00	8.98	1.50	0.00	22.16
0.73	0.00	1.26	1.12	0.00	9.25	1.51	0.00	22.57
0.74	0.00	1.40	1.13	0.00	9.52	1.52	0.00	22.98
0.75	0.00	1.54	1.14	0.00	9.80	1.53	0.00	23.39
0.76	0.00	1.70	1.15	0.00	10.08	1.54	0.00	23.81
0.77	0.00	1.85	1.16	0.00	10.37	1.55	0.00	24.23
0.78	0.00	2.01	1.17	0.00	10.66	1.56	0.00	24.65
0.79	0.00	2.18	1.18	0.00	10.95	1.57	0.00	25.08
0.80	0.00	2.35	1.19	0.00	11.25	1.58	0.00	25.51
0.81	0.00	2.52	1.20	0.00	11.55	1.59	0.00	25.94
0.82	0.00	2.69	1.21	0.00	11.85	1.60	0.00	26.38
0.83	0.00	2.87	1.22	0.00	12.16	1.61	0.00	26.82
0.84	0.00	3.05	1.23	0.00	12.47	1.62	0.00	27.26
0.85	0.00	3.23	1.24	0.00	12.78	1.63	0.00	27.71
0.86	0.00	3.41	1.25	0.00	13.10	1.64	0.00	28.16
0.87	0.00	3.60	1.26	0.00	13.42	1.65	0.00	28.61
0.88	0.00	3.78	1.27	0.00	13.74	1.66	0.00	29.06
0.89	0.00	3.96	1.28	0.00	14.07	1.67	0.00	29.52
0.90	0.00	4.15	1.29	0.00	14.40	1.68	0.00	29.99
0.91	0.00	4.34	1.30	0.00	14.74	1.69	0.00	30.45
0.92	0.00	4.54	1.31	0.00	15.08	1.70	0.00	30.92
0.93	0.00	4.74	1.32	0.00	15.42	1.71	0.00	31.39
0.94	0.00	4.94	1.33	0.00	15.76	1.72	0.00	31.87
Stage	Shift	Discharge	Stage	Shift	Discharge	Stage	Shift	Discharge

1.73	0.00	32.35	2.12	0.00	53.52	2.51	0.00	79.38
1.74	0.00	32.83	2.13	0.00	54.12	2.52	0.00	80.11
1.75	0.00	33.32	2.14	0.00	54.73	2.53	0.00	80.83
1.76	0.00	33.81	2.15	0.00	55.34	2.54	0.00	81.56
1.77	0.00	34.30	2.16	0.00	55.96	2.55	0.00	82.29
1.78	0.00	34.79	2.17	0.00	56.58	2.56	0.00	83.03
1.79	0.00	35.29	2.18	0.00	57.20	2.57	0.00	83.77
1.80	0.00	35.79	2.19	0.00	57.82	2.58	0.00	84.51
1.81	0.00	36.30	2.20	0.00	58.45	2.59	0.00	85.25
1.82	0.00	36.81	2.21	0.00	59.08	2.60	0.00	86.00
1.83	0.00	37.32	2.22	0.00	59.71	2.61	0.00	86.90
1.84	0.00	37.83	2.23	0.00	60.35	2.62	0.00	87.81
1.85	0.00	38.35	2.24	0.00	60.98	2.63	0.00	88.72
1.86	0.00	38.87	2.25	0.00	61.63	2.64	0.00	89.65
1.87	0.00	39.40	2.26	0.00	62.27	2.65	0.00	90.58
1.88	0.00	39.92	2.27	0.00	62.92	2.66	0.00	91.52
1.89	0.00	40.45	2.28	0.00	63.57	2.67	0.00	92.47
1.90	0.00	40.99	2.29	0.00	64.23	2.68	0.00	93.43
1.91	0.00	41.52	2.30	0.00	64.88	2.69	0.00	94.40
1.92	0.00	42.06	2.31	0.00	65.54	2.70	0.00	95.37
1.93	0.00	42.61	2.32	0.00	66.21	2.71	0.00	96.36
1.94	0.00	43.15	2.33	0.00	66.87	2.72	0.00	97.35
1.95	0.00	43.70	2.34	0.00	67.54	2.73	0.00	98.35
1.96	0.00	44.25	2.35	0.00	68.22	2.74	0.00	99.36
1.97	0.00	44.81	2.36	0.00	68.89	2.75	0.00	100.38
1.98	0.00	45.37	2.37	0.00	69.57	2.76	0.00	101.41
1.99	0.00	45.93	2.38	0.00	70.25	2.77	0.00	102.45
2.00	0.00	46.49	2.39	0.00	70.94	2.78	0.00	103.50
2.01	0.00	47.06	2.40	0.00	71.62	2.79	0.00	104.56
2.02	0.00	47.63	2.41	0.00	72.31	2.80	0.00	105.62
2.03	0.00	48.21	2.42	0.00	73.01	2.81	0.00	106.70
2.04	0.00	48.79	2.43	0.00	73.70	2.82	0.00	107.79
2.05	0.00	49.37	2.44	0.00	74.40	2.83	0.00	108.88
2.06	0.00	49.95	2.45	0.00	75.11	2.84	0.00	109.99
2.07	0.00	50.54	2.46	0.00	75.81	2.85	0.00	111.10
2.08	0.00	51.13	2.47	0.00	76.52	2.86	0.00	112.23
2.09	0.00	51.72	2.48	0.00	77.23	2.87	0.00	113.36
2.10	0.00	52.32	2.49	0.00	77.95	2.88	0.00	114.51
2.11	0.00	52.92	2.50	0.00	78.66	2.89	0.00	115.66

Stage	Shift	Discharge	Stage	Shift	Discharge	Stage	Shift	Discharge
2.90	0.00	116.83	3.29	0.00	171.05	3.68	0.00	246.10
2.91	0.00	118.00	3.30	0.00	172.69	3.69	0.00	248.35
2.92	0.00	119.19	3.31	0.00	174.35	3.70	0.00	250.62
2.93	0.00	120.38	3.32	0.00	176.01	3.71	0.00	252.91
2.94	0.00	121.59	3.33	0.00	177.69	3.72	0.00	255.22
2.95	0.00	122.81	3.34	0.00	179.39	3.73	0.00	257.54
2.96	0.00	124.03	3.35	0.00	181.10	3.74	0.00	259.88
2.97	0.00	125.27	3.36	0.00	182.82	3.75	0.00	262.25
2.98	0.00	126.52	3.37	0.00	184.56	3.76	0.00	264.63
2.99	0.00	127.78	3.38	0.00	186.31	3.77	0.00	267.03
3.00	0.00	129.05	3.39	0.00	188.08	3.78	0.00	269.45
3.01	0.00	130.33	3.40	0.00	189.86	3.79	0.00	271.88
3.02	0.00	131.63	3.41	0.00	191.65	3.80	0.00	274.34
3.03	0.00	132.93	3.42	0.00	193.46	3.81	0.00	276.82
3.04	0.00	134.25	3.43	0.00	195.29	3.82	0.00	279.31
3.05	0.00	135.57	3.44	0.00	197.13	3.83	0.00	281.83
3.06	0.00	136.91	3.45	0.00	198.99	3.84	0.00	284.37
3.07	0.00	138.26	3.46	0.00	200.86	3.85	0.00	286.92
3.08	0.00	139.62	3.47	0.00	202.74	3.86	0.00	289.50
3.09	0.00	141.00	3.48	0.00	204.65	3.87	0.00	292.09
3.10	0.00	142.38	3.49	0.00	206.56	3.88	0.00	294.71
3.11	0.00	143.78	3.50	0.00	208.50	3.89	0.00	297.34
3.12	0.00	145.19	3.51	0.00	210.44	3.90	0.00	300.00
3.13	0.00	146.61	3.52	0.00	212.41	3.91	0.00	302.67
3.14	0.00	148.04	3.53	0.00	214.39	3.92	0.00	305.37
3.15	0.00	149.49	3.54	0.00	216.39	3.93	0.00	308.08
3.16	0.00	150.94	3.55	0.00	218.40	3.94	0.00	310.82
3.17	0.00	152.41	3.56	0.00	220.43	3.95	0.00	313.58
3.18	0.00	153.90	3.57	0.00	222.47	3.96	0.00	316.36
3.19	0.00	155.39	3.58	0.00	224.54	3.97	0.00	319.16
3.20	0.00	156.90	3.59	0.00	226.62	3.98	0.00	321.98
3.21	0.00	158.42	3.60	0.00	228.71	3.99	0.00	324.82
3.22	0.00	159.95	3.61	0.00	230.83	4.00	0.00	327.69
3.23	0.00	161.50	3.62	0.00	232.95	4.01	0.00	330.58
3.24	0.00	163.06	3.63	0.00	235.10	4.02	0.00	333.49
3.25	0.00	164.63	3.64	0.00	237.27	4.03	0.00	336.42
3.26	0.00	166.22	3.65	0.00	239.45	4.04	0.00	339.38
3.27	0.00	167.81	3.66	0.00	241.65	4.05	0.00	342.35
3.28	0.00	169.43	3.67	0.00	243.86	4.06	0.00	345.36

Stage	Shift	Discharge	Stage	Shift	Discharge	Stage	Shift	Discharge
4.07	0.00	348.38	4.46	0.00	487.44			
4.08	0.00	351.43	4.47	0.00	491.60			
4.09	0.00	354.50	4.48	0.00	495.78			
4.10	0.00	357.59	4.49	0.00	500.00			
4.11	0.00	360.71						
4.12	0.00	363.85						
4.13	0.00	367.01						
4.14	0.00	370.20						
4.15	0.00	373.41						
4.16	0.00	376.65						
4.17	0.00	379.91						
4.18	0.00	383.20						
4.19	0.00	386.51						
4.20	0.00	389.84						
4.21	0.00	393.20						
4.22	0.00	396.59						
4.23	0.00	400.00						
4.24	0.00	403.49						
4.25	0.00	407.02						
4.26	0.00	410.56						
4.27	0.00	414.14						
4.28	0.00	417.74						
4.29	0.00	421.37						
4.30	0.00	425.03						
4.31	0.00	428.71						
4.32	0.00	432.43						
4.33	0.00	436.17						
4.34	0.00	439.94						
4.35	0.00	443.73						
4.36	0.00	447.56						
4.37	0.00	451.42						
4.38	0.00	455.30						
4.39	0.00	459.21						
4.40	0.00	463.16						
4.41	0.00	467.13						
4.42	0.00	471.13						
4.43	0.00	475.16						
4.44	0.00	479.23						
4.45	0.00	483.32						