APPENDIX G

FISHERIES RESOURCES OF THE LOWER PAJARO RIVER AND ITS TRIBUTARIES

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INTRODUCTION

This report is an assessment of existing conditions for fisheries resources, particularly for Central Coast steelhead (*Onchorhynchus mykiss*) and the tidewater goby (*Eucyclogobius newberryi*), in the lower Pajaro River and its tributary watershed of Salsipuedes Creek. Tidewater gobies are found only in the lowest one mile of the Pajaro River and in Watsonville Slough, while the steelhead migrates to the upper portions of these watersheds to spawn. The purpose of this report is to present sufficient information to assess the potential effects of development of the Pajaro Valley Water Management Agency's proposed import and local distribution pipeline projects on fishery resources.

Inventories of riffle conditions were carried out in two areas critical for steelhead passage, the Pajaro River at Murphy Crossing, and Corralitos and Salsipuedes creeks near College Lake. Recommendations to reduce adverse impacts to steelhead are included as well.

EXISTING CONDITIONS: FISHERIES

Pajaro River and the Eastern Watershed

The Pajaro River serves as a migration pathway for adult steelhead (*Oncorhynchus mykiss*) migrating to spawning and nursery habitat in the upper watershed and for steelhead smolts (1-2 year old juveniles) migrating from that habitat to the ocean. In the upper watershed Pescadero, Uvas, Llagas and Pacheco creeks, and their tributaries, provide potential spawning and rearing habitat. Pescadero and Uvas creeks provide access, spawning and rearing in all but extreme drought years. Use of Llagas and Pacheco creeks by steelhead is less frequent and less extensive. Coho salmon (*O. kisutch)* have not been present in the Pajaro River system since at least the late 1960's, and occasional sightings in the 1960s may have been due to hatchery strays from the San Lorenzo River. Scarcity of suitable cool, low gradient rearing habitat and lack of regular access preclude sustaining runs of coho in the watershed.

Chesbro Reservoir on Llagas Creek and Uvas Reservoir on Uvas Creek, which are operated by the Santa Clara Valley Water District, regulate late spring through fall stream flows in those two streams. Normally, reservoir releases are adjusted to the percolation capacity of the middle reaches of the two streams, and steelhead passage through the lower reaches is blocked by dry streambeds by May to early June (with flows persisting longer in Uvas Creek than in Llagas Creek). Flows in Pacheco Creek are partially regulated by a dam on the North Fork of Pacheco Creek (operated by the Pacheco Water District). Flow regulation by the dam, and the generally dry nature of the watershed, usually block smolt outmigration by late April to May. Storage capacity of the reservoirs in the upper watershed is relatively low compared to average annual runoff, and unregulated tributaries are present in the Llagas Creek, Uvas Creek and Pacheco Creek watersheds. Except in severe drought years, adult upstream access is provided by reservoir spill and tributary runoff during the winter storms of January through March or April.

No studies of adult and smolt steelhead migration timing have been conducted for the Pajaro River system, but, despite drier watershed conditions in the Pajaro, migration periods are probably similar to those of streams in Santa Cruz County. Adult steelhead upmigration in Waddell Creek (Shapovalov and Taft 1954) and the San Lorenzo River (Monterey Bay Salmon and Trout Project trapping records) is in late December through early April, with most of the run occurring in January through March. The migration of waiting adults can be triggered by storms, and even in drier years the majority of adults may be able to migrate during the infrequent storms. Smolt outmigration in Waddell Creek (Shapovalov and Taft 1954; Smith unpublished trapping records from 1992-4) and the San Lorenzo River (Smith, unpublished trapping records for 1987-89) is primarily during late March through the end of May. Three characteristics of smolt migration make it more precarious than adult migration: 1) it occurs in late spring, when streamflows are naturally low and declining, rather than during the high flows of winter; 2) it does not appear to occur much earlier in dry years, despite the more rapid decline in spring streamflows; and 3) it is a more continuous, prolonged migration, rather than an episodic dash. The relatively fixed, prolonged migration period is apparently due to the importance of size of emigrating smolts; larger juveniles migrate earlier, and many later fish apparently require spring growth to achieve a size sufficient to successfully enter the ocean. The relatively fixed late spring migration means that in dry years a large portion of late-migrating steelhead smolts may be blocked from migration. Avoiding predation is also apparently an important factor in smolt migration, as almost all migration occurs at night (Smith, unpublished San Lorenzo River trapping results).

During periods of lower flows in late spring the water temperatures of streams increase. Part of this increase is due to the seasonal increase in day length and air temperatures, and part is due to the reduced temperature buffering provided by the reduced streamflows. Since smolts travel mostly at night, when water temperatures are cooler, the temperature problem is probably minor for short migrations. Migrating smolts travel relatively quickly, and the distance from Murphy Crossing to Salsipuedes Creek is short

(6 miles); temperature is probably not a problem at times when the flows are sufficient to allow easy passage through riffles.

No steelhead spawning or rearing occur in the Pajaro River downstream of Murphy Crossing. Other fish species are present in the Pajaro River downstream of Murphy Crossing and in Salsipuedes Creek, including Sacramento sucker (*Catostomus occidentalis*), Sacramento squawfish (*Ptychochielus grandis*), hitch (*Lavinia exilicauda*), Sacramento blackfish *(Orthodon microlepidotus*), prickly sculpin (*Cottus asper)* and threespine stickleback (*Gasterosteus aculeatus*). None of these species require April to June streamflows for passage, spawning or rearing in excess of those required for steelhead smolt passage. Pacific lamprey (*Lampetra tridentata*) is an anadromous fish, which, like the steelhead, migrate into freshwater to spawn and rear and with juveniles which migrate to the ocean to mature. Adult migration times for lamprey tend to occur somewhat later than than the peak of the steelhead adult migration (March and April). However, lamprey adults are able to negotiate relatively shallow riffles. Juvenile lampreys migrate to the ocean with peak winter flows, and rarely suffer migration blockage.

Salsipuedes Creek Watershed

Steelhead regularly use the watershed of Corralitos Creek, which joins Salsipuedes Creek immediately downstream of College Lake. Diversion dams on Corralitos and Browns creeks and wells downstream of their confluence (operated by the City of Watsonville) affect spring streamflows and fish passage in lower Corralitos Creek and in Salsipuedes Creek.

Two tributaries to College Lake and Salsipuedes Creek may also be used by steelhead for spawning and rearing. Adult access is good to Casserly Creek, and fish with smolt coloration were captured in spring 1997, confirming its continued use by steelhead. Passage is more difficult on Green Valley Creek, and size structure of fish in spring 1997 and lack of smolted fish may indicate that a major portion of the "rainbow trout" in the perennial portion of the stream are resident, rather than migratory steelhead in many years. Although no dams or major diversions occur on the two streams, spring streamflows are relatively low, probably blocking late-migrating smolts in average or dry years; on 2 May 1997 streamflows in both streams were insufficient for fish passage to College Lake, even though smolts were still apparently coming down Corralitos Creek.

College Lake is quite turbid in winter and spring, because much of its stored water is turbid storm runoff and because the bare, fine-grained soils of the shallow lake bed are easily stirred up by wind and wave action. The turbid conditions and probable lack of abundant food due to turbid water and the seasonal nature of the lake) indicate that steelhead smolts migrating through the lake from Green Valley or Casserly creeks probably spend little time in the lake (less than 1 week).

College Lake is presently pumped dry in late spring to allow agricultural use of the lake bed. The pumped water provides passage flows for steelhead from College Lake tributaries and also for those from the Corralitos Creek watershed.

The Pajaro River Lagoon

Pajaro River and Salsipuedes Creek streamflows can provide for steelhead passage and also supply fresh water to the Pajaro River estuary. In spring the freshwater inflow provides a surface wedge of lighter fresh water on top of the salt water in the Pajaro River estuary. This freshwater wedge allows steelhead smolts to move up and down in the water column to aid in gradually adjusting to sea water. When flows are sufficient for passage to the estuary the inflows are also probably sufficient to provide a good fresh to saltwater transition zone. Migrating smolts may spend several weeks feeding in the estuary and adjusting to sea water. This transition may not be required, as many central California streams lack good transitional estuaries. However, the transition may improve survival of smolts, especially smaller smolts, upon entering the ocean.

A sand bar forms across the mouth of the Pajaro River in many years. Bar formation is primarily a function of beach-building processes produced by low-energy summer waves. Spring and early summer freshwater inflows are not an important factor in bar formation in a large estuary like that of the Pajaro River (Smith 1990). Tidal flux through the mouth is substantially higher than inflows, and even after the sand bar forms seepage through the large sand bar should be sufficient to prevent overtopping and sand bar breaching.

After sand bar formation freshwater inflows freshen the summer lagoon and may be important to lagoon ecology (Smith 1990). However, at the Pajaro River, even in most years when the sand bar forms, the formation is usually in mid to late summer. This is much later than the period of steelhead smolt passage and estuary adjustment, and is also later than the present practice of pumping water from College Lake. Tidewater gobies (*Eucyclogobius newberryi*), a federally-listed endangered species, are present in the Pajaro River estuary. Sand bar formation is important for providing the calmer lagoon conditions favored by tidewater gobies (Smith 1990), but the salinity of the lagoon is generally not important to goby success. Tidewater gobies in central California maintain large populations in lagoons ranging from fresh water (Soquel Creek in 1988 and Pescadero Creek in 1985) to ocean salinities (Corcoran and Moran Lagoons in 1996) (Smith, unpublished).

STEELHEAD PASSAGE CONDITIONS

Methods

Conditions for steelhead passage are the only fish habitat factor potentially impacted by the proposed water management plans. Passage conditions were evaluated by establishing depth transects in Salsipuedes Creek and in the Pajaro River at shallow riffles that were most likely to impede steelhead upstream or downstream migration.

These same riffles and their configurations may not exist from year to year, but the riffles chosen are probably typical of the worst riffles present in most years.

Transects were established at three riffles on Salsipuedes Creek in April 1997. Depths at one of the riffles (a "typical", rather than a critical/difficult passage riffle) were recorded at 1 foot increments across the riffle 3 times between 25 April and 9 May, at flows of 15.1, 4.7 and 2.0 cubic feet per second (cfs). Depths at 2 other riffles, which represented very difficult "critical" passage were recorded 5 times between 25 April and 29 May, with the above flows and with flows of 0.9 and 0.4 cfs. The last two flows were far below those needed for passage, but provided information on how depth changed with flow and with algal growth. The two critical riffles were the only difficult riffles in the creek in 1997, and both had wide, diagonal gravel bars producing the riffles. The most difficult stretched over 80 feet across a bankfull channel about 30 feet wide. The upstream to downstream length of each riffle was short; the length of difficult passage was less than 5 feet.

Four riffles were transected on the Pajaro River: 1 immediately upstream of Murphy Crossing, 2 within 1.4 miles downstream of the crossing, and one 4.1 miles downstream of the crossing. The 3 upstream riffles were diagonal riffles formed in broad portions of the channel that are usually dry in summer or have very little streamflow. The downstream riffle was the only true riffle in the portion of the channel with regular summer surface water, dense streambed vegetation, and a generally narrower low flow channel (due to the vegetation). Depths were measured at the transects downstream of Murphy Crossing 5 times from 18 April to 12 June, at flows of 65 to 7.6 cfs. Transects were measured twice upstream of Murphy Crossing, on 25 April and 9 May, at flows of 50.5 and 21.7 cfs; construction of the crossing inundated this most critical riffle. Substrates at the riffles were predominantly sand and fine gravel deposited by the high January flows. The configurations were not stable, and the deepest portions of the sandy riffles were gradually scoured deeper over the study period. Because of the channel instability, the transects were not a strict test of the relationship between stream flow and riffle depth; 20 cfs in April would not have provided the passage conditions that 20 cfs in late May would have provided.

Passage Criteria

Steelhead adults can pass through riffles if they can easily find a continuous route through and if that route offers depths and velocities that allow them to easily swim upstream. The length of the shallow portion of the riffle is also a factor for both swimming and route-finding; a very short riffle is more easily passed (with a brief burst of effort) than a long riffle offering similar conditions. Because of the multi-factored nature of fish passage, passage criteria are somewhat of a judgment call. However, passage standards should allow migrating fish to pass through a riffle without repeated attempts or delay and without injury or excessive exertion; they should not be set at levels that "well-motivated" fish can negotiate, with difficulty, most of the time.

Smolts can pass downstream through riffles if there is a continuous route that is deep and wide enough to attract them and allow them swim through. Routes that become too shallow as the fish pass downstream may not only block downstream passage, but may prevent the fish from retreating upstream against the current to seek an alternate route.

In both the Pajaro River and Salsipuedes Creek shallow riffles are infrequent and short, reducing the cumulative effect of riffles on upstream or downstream passage. All riffles were relatively flat, so velocities were relatively slow, and therefore not considered a problem for upstream passage.

For this evaluation routes through riffles were considered minimal passage for upmigrating adult fish if 0.45 feet deep, or about the body and tail depth of a large (2 years in the ocean) steelhead. Such a depth would allow the body and tail to be fully submerged so that tail and body swimming action was efficient; many adult steelhead in the Pajaro River are smaller and could migrate with less depth. At 0.6 feet deep the depth would be more than sufficient to prevent interference from the substrate with the swimming action of a large fish; depth was judged fully passable. The route was considered acceptable if it was in the thalweg or passed 20% of the streamflow or was at the upstream portion of a diagonal riffle (where the diagonal configuration would funnel the fish to the route). Minimum route width was 3 feet and the total width of all routes through the riffle had to be at least 10 percent of riffle width (with at least 1/2 of that at 0.6 feet or deeper) and carry approximately 15% of the flow through the riffle. If the route(s) were much deeper and/or migrating fish were funneled to the route by the riffle configuration or channel thalweg, then less total width or flow was required.

For evaluating smolt downstream passage the minimum depth used was 0.15 feet (as deep as the body depth of large smolts). A depth of 0.2 feet was judged fully passable. Minimum route width was 2 feet, and total width of the route(s) had to equal 25% of the riffle width and normally carry about 50% of the flow through the riffle. As with adult passage, routes that were deeper or likely to funnel fish because of riffle configuration were judged passable with less total route width.

No flow passage requirements were estimated for downstream passage of spent adult steelhead, as most would have outmigrated prior to the late spring smolt migration.

Depth distribution across the Pajaro River riffles changed progressively over the study period, as the deepest portions of the unstable, sandy riffles gradually scoured deeper and carried a greater proportion of the flow. Under those conditions a lesser flow later in the season provided passage conditions equivalent to a much greater flow early in the study. For this evaluation the greater early season flow was judged necessary for passage. This conservative approach guarantees that the flow used will provide passage under the most difficult of conditions throughout the migration period

Results

Adult Passage in the Pajaro River. The 4 Pajaro River riffles were estimated to be passable to adult steelhead at 16 to 45 cfs (see **Table G.1**). The most difficult passage was at the very wide diagonal riffle immediately upstream of Murphy Crossing (riffle 4). However, because the passage route was at the upstream end of the diagonal riffle, upstream migrating fish would be funneled to the route. That riffle was estimated to be passable at about 45 cfs, based upon conditions observed at 50.5 cfs. The other two diagonal riffles (riffles 2 and 3) were estimated to be passable at 25-35 cfs. At riffle 3 passage conditions were similar at 21.7 and 43.0 cfs, due to scour of the route between the sample days. Although the route was at the downstream end of the riffle, the remainder of the riffle was very shallow and migrating fish would be attracted to, or quickly find, the route. The most easily passable riffle (riffle 1) was not a diagonal riffle, most of the channel was relatively deep, and the route was in the thalweg. In general, the stream channel in the portion of the river near riffle 1 had relatively easy passage, because the streamside vegetation (primarily Salix spp.) confined and deepened the low flow channel.

Smolt Passage in the Pajaro River. The 4 riffles on the Pajaro River were judged passable to smolts migrating downstream at 12 to 20 cfs (**Table G.2**). Again, the most difficult riffle for passage was riffle 4, the very wide diagonal riffle at Murphy Crossing. Although the multiple routes occupied about 30% of the riffle width at 21.7 cfs, the largest route was at the upstream end of the diagonal riffle, and some smolts might funnel to the shallower downstream portion of the riffle, even at 20 cfs. Smolts might also have similar problems at Riffle 2.

Smolt Passage in Salsipuedes Creek. Most riffles on this stream were narrow, straight, and easily passable, requiring as little as 1.0 - 2.0 cfs for passage (Riffle 1). However, the two measured diagonal riffles required an estimated 3.0 and 7.5 cfs for passage (**Table G.3**). The configuration of Riffle 3, a wide, diagonal riffle, spread much of the flow across shallow portions of the riffle at 4.7 cfs. Downmigrating smolts would have difficulty "route-finding" and might be trapped in shallower portions; several dead, stranded smolts were observed at 4.7 cfs.

Smolts were observed to have migrated down Corralitos Creek to Salsipuedes Creek at 1 cfs in May 1997 (probably with great difficulty). The flow in Salsipuedes Creek would include flow from Corralitos Creek, as well as from College Lake. The contribution from Corralitos Creek would be at least 1/2 cfs during smolt migration.

TABLE G.1
RIFFLE CONDITIONS AND ADULT PASSAGE REQUIREMENTS FOR 4 RIFFLES IN THE PAJARO RIVER

Riffle Location	Configuration	Route	Route Width % / est. % flow	@Flow	Passage Flow
Riffle 1					
4.1 Miles < Murphy Crossing	straight	thalweg	17% / 25%	21.7	16
Riffle 2					
1.4 Miles < Murphy Crossing	Diagonal	multiple upstream diagonal	25% / 35%	43.0	25
			12% / 20%	21.7	
Riffle 3					
0.7 miles < Murphy Crossing	Diagonal	downstream diagonal	10% / 25%	43.0	35
			10% / 25%	21.7	
Riffle 4					
Above Murphy Crossing	Diagonal	upstream diagonal very wide	9% / 15	50.5	45

TABLE G.2
RIFFLE CONDITIONS AND SMOLT PASSAGE FLOWS FOR 4 RIFFLES IN THE PAJARO RIVER

Riffle	Configuration	Route	Route Width % / est. % flow	@Flow	Passage Flow
Riffle 1	straight	thalweg	21% / 50%	15.1	15
			24% / 57%	7.6	
Riffle 2	diagonal	multiple upstream middle	39% / 60%	15.1	12
			45% / 65%	7.6	
Riffle 3	diagonal	downstream	12% / 60%	21.7	
			85% / 95%	15.1	12
Riffle 4	diagonal wide	upstream multiple	30% / 45%	21.7	20

TABLE G.3
RIFFLE CONDITIONS AND SMOLT PASSAGE FLOWS
FOR 3 RIFFLES IN SALSIPUEDES CREEK

Riffle	Configuration	Route	Route Width % / est. % flow	@Flow	Passage Flow
Riffle 1	straight	thalweg	77% / 95%	2.0	1.0
Riffle 2	diagonal	multiple downstream	31% / 55%	4.7	3.0
		single downstream	25% / 55%	2.0	
Riffle 3	diagonal	multiple	60% / 75%	15.1	7.5
		multiple	12% / 30%	4.7	

MITIGATING PROJECT IMPACTS TO STEELHEAD PASSAGE

Pajaro River

The impact to steelhead passage by diversion of Pajaro River water near Murphy Crossing can be avoided by providing minimum bypass flows during the steelhead migration period. Bypass flows should be:

1 January through 31 March (adult upstream passage): 45 cfs

1 April through 31 May (smolt downstream passage):

20 cfs from 7:00 PM to 7:00 AM (during the nighttime migration period)

12 cfs from 7:00 AM to 7:00 PM (when little migration is likely)

Salsipuedes Creek

Impact to steelhead smolt passage by altering College Lake storage and/or reducing the pumping of College Lake water into Salsipuedes Creek can be avoided by providing minimum bypass flows during the steelhead smolt migration period. Bypass flows should be:

15 March through 31 May: 7.5 cfs in Salsipuedes Creek at its junction with Corralitos Creek, with a minimum of 2 cfs from College Lake to provide passage to the confluence.

1. Only 7 cfs would have to be provided from College Lake water, as Corralitos Creek flow of at least 1/2 cfs would be necessary to allow Corralitos Creek smolts to reach Salsipuedes Creek.

2. From 7:00 AM to 7:00 PM only 4.5 cfs is necessary in Salsipuedes Creek, as few smolts migrate during daylight.

3. After 1 May no Salsipuedes bypass flow would be required if Corralitos Creek is dry at Highway 152.

The reduction of daytime smolt bypass flows in the Pajaro River and in Salsipuedes Creek to 60% of nighttime passage flows is because few smolts apparently migrate in daytime. The few smolts migrating in daytime would also have an easier time route finding and could probably easily pass all but 1 riffle in each stream. The fluctuating flows may also act to speed smolt passage, similar to the effect of small spring storms (Smith, unpublished smolt trapping records for Waddell Creek).

The lack of a requirement for passage flows in Salsipuedes Creek after Corralitos Creek has dried at Highway 152 is because smolts would no longer be coming down Corralitos Creek; smolts would also no longer be coming down Green Valley or Casserly creeks, which tend to dry before Corralitos Creek.

College Lake

If the outlet structure for College Lake is modified to increase the capacity of the lake, the new structure should provide for adult steelhead upstream passage at least equivalent to present conditions.

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