TODD GROUNDWATER

June 16, 2022

MEMORANDUM DRAFT

To: John Weigold, Cambria Community Services District

From: Gus Yates, Senior Hydrologist

Re: **Technical Review of California Coastal Commission Notice of Violation Issued to Cambria Community Services District in April 2022**

INTRODUCTION

The Notice of Violation (NOV) dated April 19, 2022 issued by the California Coastal Commission to Cambria Community Services District (CCSD) included assertions that CCSD pumping has adversely impacted aquatic and riparian habitat along Santa Rosa and San Simeon Creeks. These statements were not accompanied by evidence presented in the NOV but rather by references to four previous studies. This memorandum presents a detailed technical review of those studies as well as key prior publications cited in the studies. The purpose of the review is to determine whether the statements in the NOV were in fact substantiated by data and analysis in the four studies and their predecessors.

The four studies cited in the NOV are the following:

- San Luis Obispo County Regional Instream Flow Assessment (Stillwater Sciences, 2014)
- South-Central California Steelhead Recovery Plan (National Marine Fisheries Service [NMFS], 2013)
- Santa Rosa Creek Watershed Management Plan (Greenspace, 2010)
- Santa Rosa Creek Steelhead Habitat and Population Survey (Nelson, et al., 2005)

This memorandum is necessarily technical and detailed because the issues with the four studies have to do with lack of scientific rigor that is often only evident in the details. This review has found that the four studies and their predecessors were flawed due to the following types of weaknesses:

- Inappropriate use of the environmental water demand (EWD) concept
- Failure to account for stream reaches that are naturally intermittent
- Internal inconsistencies within some studies
- Findings unsupported by data and presented without limitations

This memorandum documents where those weaknesses occurred and the resulting lack of justification for key statements in the NOV.

KEY ASSERTIONS IN NOV

Key assertions in the NOV that were found not to be substantiated include the following:

- "Recent studies indicate that water extractions regularly exceed that which is necessary to maintain water levels and sustain stream flow as required. As a result, impacts to fisheries and riparian habitat have occurred and are ongoing" (NOV p. 2)
- "Several studies have demonstrated that adverse impacts to creek flows, riparian habitat, and fisheries are occurring in both creeks" (NOV p. 4)
- "CCSD's extractions are leading directly to adverse impacts to the creeks" (NOV p. 6)
- "The discontinuance of the use of the Santa Rosa Creek wells would increase the stream flows and enhance the coastal fishery resources." (NOV p.3)

Of the four studies referenced by the NOV, only the 2014 regional instream flow assessment was cited in detail. However, all four studies were reviewed for this memorandum to verify whether they presented information substantiating the assertions in the NOV. Each study is reviewed below.

REVIEW OF SAN LUIS OBISPO COUNTY REGIONAL INSTREAM FLOW ASSESSMENT (2014)

Inappropriate Use of Environmental Water Demand

The NOV referenced the environmental water demand (EWD) analysis in the Regional Instream Flow Assessment as follows: "A 2014 study looked at instream flows for creeks across San Luis Obispo County compared to estimated environmental water demand (EWD) (where the EWD metric represented a minimum threshold as opposed to an optimum or sustainable level of water flow). That report documented such instream flows in 2013, showing that San Simeon Creek instream flow was below the EWD, and Santa Rosa Creek was below the EWD in the spring, and completely dry in the summer, providing no habitat whatsoever." (NOV pp. 4-5)

A closer look at EWD methodology shows that it cannot reasonably be applied to naturally intermittent streams. The Regional Instream Flow Assessment should not have used it; but having done so, it opened the door for the Coastal Commission to carry incorrect conclusions forward to the NOV.

The EWD concept is not applicable to seasonally intermittent streams, which are common in San Luis Obispo County. The common occurrence of intermittent streams in the central coast region was actually noted in the Regional Instream Flow Assessment (and in other studies), and it can clearly be seen in the flow duration curves for four stream gages in the area shown in Figure 1.

All of these gages are located upstream of the groundwater basins that underlie the lower reaches of the respective streams and hence are not impacted by pumping from those basins.

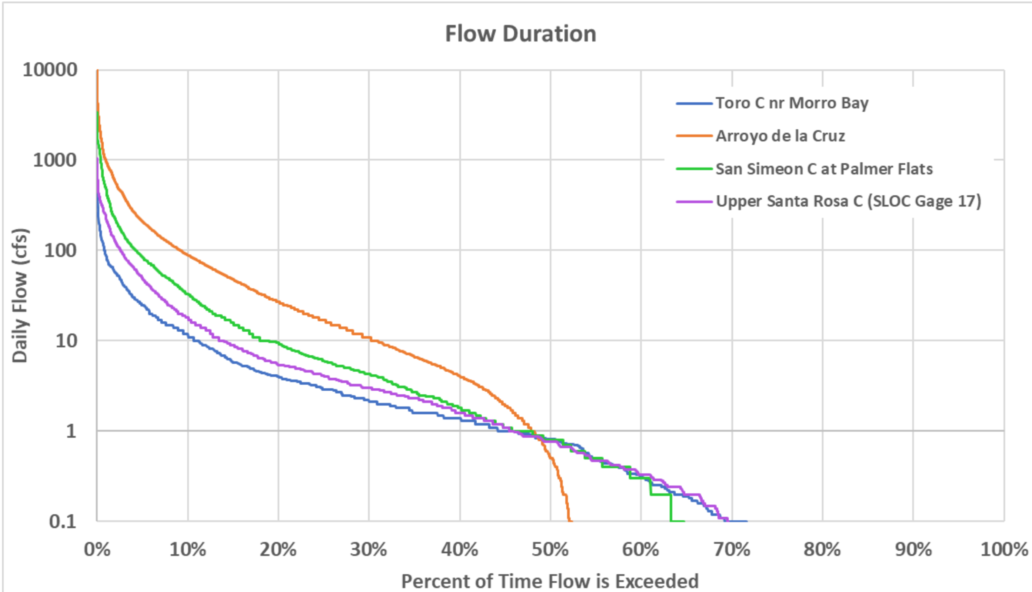


Figure 1. Flow Duration Curves for Four Gages

If the streams were perennial, the curves would continue across the entire width of the graph ending with a non-zero flow exceeded 100 percent of the time. Instead, the curves bend down to the X axis, showing that flow at the gage sites is present only 53-78 percent of the time. This means that there is no flow 22-37 percent of the time. No-flow conditions typically occur in late summer and fall.

The EWD concept is flawed for seasonally intermittent streams because the equations used to calculate it are based on mean annual discharge, and the equations will never return a value of zero. That is, even if the analysis is focused on flows during late summer and fall, it will produce a non-zero result that inherently presumes that water should be present at that time of year. It is worth noting that even a desert stream with one day of runoff during the year has a mean annual discharge greater than zero. The EWD calculation for that stream will indicate that flow should always be present, even though it obviously isn’t.

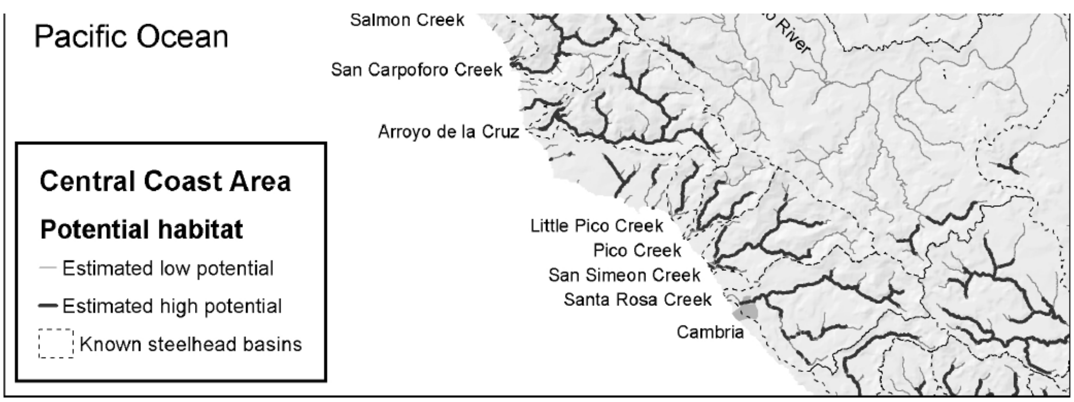
The Regional Instream Flow Assessment initially acknowledged the methodological flaw in applying EWD to intermittent streams:

> “Portions of many County rivers are naturally dry each summer. We recognize that there is no value in predicting summer flow requirements for steelhead in the portion of a creek that is naturally dry during part of the year” (RIFA p. v).

However, the study applied the EWD despite the fact that it would always indicate a "demand" for flow greater than zero. This is an internal inconsistency in the report that leads to conclusions unsupported by evidence.

Part of the justification was to cite a NOAA study that mapped streams as having a "high potential for steelhead rearing" in the central coast region, whether or not the streams were intermittent or ever supported steelhead rearing (Boughton and Goslin, 2006). However, the Boughton and Goslin (2006) report included similar misuse of EWD and internal inconsistencies. The report admitted "Low summertime flows are probably an important limiting factor in Southern California, given the prevalence of intermittent streams in the region (Spina et al. 2005)" (p. 2). However, this important fact was disregarded.

It is noteworthy that Boughton and Goslin (2006) identified several adjustments to make the EWD concept applicable to semi-arid regions. Specifically, they added "three additional predictors to the model: "absence of alluvial substrate, mean August air temperature as an index of stream temperature; and mean August-September discharge as a substitute for mean annual discharge." Alluvial substrate refers to stream reaches underlain by groundwater basins. However, these basin reaches were not excluded from the analysis. Although acknowledging that "channel positions in low-relief areas are likely to be inaccurate" and "many of the stream reaches assigned low values for summer discharge in reality have no surface discharge during the summer" (p.8), those reaches were included inappropriately as potential habitat. The final map of streams with "estimated high potential" for steelhead rearing included essentially all reaches of major streams, including the ones overlying groundwater basins that are most likely to be naturally intermittent. This included the groundwater basin reaches of San Simeon and Santa Rosa Creeks, as shown in Figure 2. The inclusion of intermittent reaches overlying alluvium in the map is an internal inconsistency of the Boughton and Goslin report and most importantly, is inappropriate for mapping potential steelhead habitat.



Omitted for clarity are reservoirs and channels predicted to have Q89 < 0.5 cfs. Note that channel positions in low-relief areas are likely to be inaccurate, due to model assumptions.

Figure 2. Map of Central Coast Streams with Steelhead Habitat Potential (Boughton and Goslin, 2006)

Furthermore, by focusing on the *potential* for steelhead rearing habitat, Boughton and Goslin (2006) did not establish if rearing habitat were currently or even historically present. "Though many such reaches are probably dry channels in Southern California, we did not wish to make assumptions, preferring instead to let the model-fitting process make the determination of whether they comprise potential habitat." (p. 6). In other words, the results of a model-fitting process were presented despite being at odds with verifiable facts. This led to conclusions not supported by evidence.

The EWD equation developed by Boughton and Goslin is also inappropriate for intermittent streams because it will never return an environmental water demand of zero: The regression equation for mean discharge in August-September (p. 6) is: Q_{89} = exp[-34.02 + 3.400ln(MAP) + 0.670ln(CA), where MAP is mean annual precipitation and CA is contributing drainage area. The exponential function is undefined at zero. Therefore, all stream reaches will be expected to have non-zero flow in August and September. By simple inspection of the equation, it can also be seen that if mean annual precipitation (mm) and contributing area (ha) are both zero, the equation still predicts an August-September EWD of 1.68 m^3/s. Obviously, flow could not be present in a watershed with no contributing area and no precipitation.

The discrepancy between calculated EWD and the actual flow regimes of the streams is acknowledged: "When interpreting these maps, please note that the algorithm for estimating the stream networks performed poorly in areas of low-relief… In general, channels in these areas have gradients too low to qualify as potential habitat under our model, or are disqualified due to alluvial substrate" (p.10). While acknowledged, the discrepancy was not actually addressed and the map does not show any reaches disqualified due to alluvial substrate; all these reaches were included inappropriately.

The 2014 Regional Instream Flow Assessment carried forward the potential habitat maps, but did not acknowledge the caveats and limitations provided in Boughton and Goslin's text, which are necessary to interpret the maps.

Limitations of the EWD concept and methodology can be traced back even further. Boughton and Goslin (2006) stated that the starting point for their EWD analysis was the methodology presented by Burnett *et al.* (2003). That study developed a flow-habitat relationship based on two large watersheds in northwestern Oregon, where streams are perennial. The authors clearly stated that their methods and analysis are for the Pacific Northwest. Mean annual discharge was selected as the flow parameter without justification or presentation of alternatives. The method consisted of a GIS screening process based on topography, flow and land ownership as factors to calculate "intrinsic potential" of salmonid habitat. There is no discussion of seasonal variations in flow, much less intermittent streams.

The 2014 Regional Instream Flow Assessment cited a previous study by Hatfield and Bruce (2000) as the basis for the EWD methodology. Hatfield and Bruce are both from British Columbia, where essentially all streams with fisheries are perennial. Their objective was to relate salmonid habitat to flow. They selected mean annual discharge as the flow metric not because it is particularly relevant to fish life history but because it was the only metric they could consistently obtain for a large number of stations. Seasonally intermittent stream flow is not an issue in British Columbia, so a method that assumes perennial flow appeared reasonable for their purposes. "Many of the reports lacked flow data, so we restricted our analysis to one measure of flow, mean annual discharge (MAD), rather than more complicated but potentially more informative measures such as stream power or flood return times" (p. 1006). They further referenced a previous report by Tennant (1976) that also used MAD to represent the flow regime, but that work was in the midwestern United States where perennial streams are also the norm.

Hatfield and Bruce (2000) selected the term "optimum" to indicate an inflection point on the flow-habitat curves, creating the misleading impression that nature "optimizes" conditions for any species. They note that use of this term "ignores many vital ecological and geomorphic processes" but the term is used anyway (p. 1005). This might have contributed to the apparent assumption in subsequent studies that EWD refers to flow that *should* be in a stream rather than flow that *actually is* in a stream.

Hatfield and Bruce (2000) fitted mathematical functions to 1,500 Physical Habitat Simulation (PHABSIM) flow-habitat curves and arrived at functions relating ln(PHABSIM-determined optimum flow) to ln(MAD). In all of the examples, the minimum MAD value was non-zero (4.1 cfs; see Table 2). In fact, the natural logarithm of zero is undefined. Therefore, the method of Hatfield and Bruce cannot be applied to seasonally intermittent streams. It will always predict an "optimum" flow greater than zero at locations and seasons where flow is naturally zero.

Lack of Foundation for Asserted Facts

Another statement in the NOV that references the Regional Instream Flow Assessment is: "That same 2014 study states that, "[i]n Santa Rosa Creek, it has also been observed that lagoon conditions are worsened by low stream flows resulting from excessive groundwater pumping and diversions. Reduced freshwater inflows result in water temperatures and dissolved oxygen levels in the lagoon, particularly at the bottom, that can frequently exceed lethal limits for steelhead in the summer and fall" (RIFA page 31; cited on NOV p. 5).

This statement contains two unfounded assertions: 1) that groundwater pumping significantly diminishes lagoon inflow, and 2) that lagoon inflow significantly affects water temperatures and dissolved oxygen.

Depending on a well's location, groundwater pumping upstream of a lagoon can be supplied by local depletion of aquifer storage that is replenished by high stream flows the following winter, with no impact on lagoon inflow. In the relatively small San Simeon and Santa Rosa Creek basins, dry-season groundwater pumping is probably supplied by a combination of storage depletion and intercepted lagoon inflow in some proportion, but the Regional Instream Flow Assessment ignored this physical characteristic of these coastal basins. I have seen this type of partitioning between storage depletion and stream flow depletion in my groundwater modeling studies of other basins.

Lagoon water levels are dominated by tides and waves overwashing the beach barrier berm. Figure 3 shows San Simeon Creek lagoon water levels recorded every 15 minutes during the dry season of 2018. The data are from a monitoring station operated by the Central Coast Wetlands Group (O'Connor, 2021). Tidal fluctuations on the ocean side of the beach berm cause daily lagoon level fluctuations of up to 0.4 foot. The upward spikes of 1-2 feet in May, June and August probably resulted from wave overwash events that take about a week to dissipate. Lagoon water temperatures are controlled by solar radiation and air temperature, not groundwater inflow. Low dissolved oxygen concentrations typically occur at the bottom of the lagoon near the beach berm, where microbes decompose organic matter. At high tide, the oxygen-depleted water remains trapped in the lagoon because there is no outflow through the beach berm. When a seaward hydraulic gradient through the berm is reestablished at lower tide levels, the water is flushed out. It is unlikely that groundwater inflow plays more than a small role in determining any of these important habitat parameters.

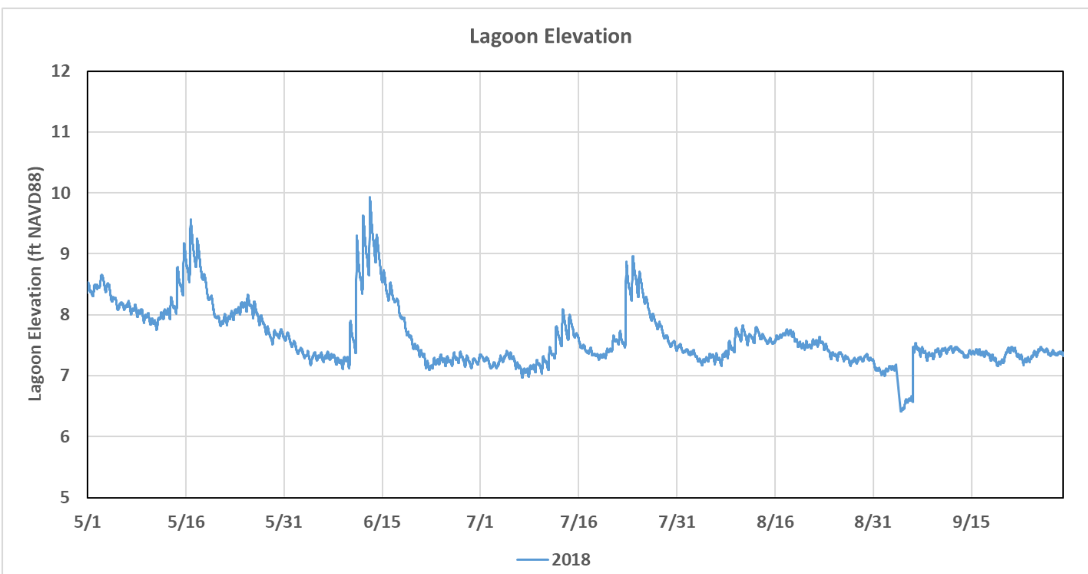


Figure 3. San Simeon Creek Lagoon Water Levels, May-September 2018

Lack of Foundation for Asserting that Pumping Causes Impacts

A third statement in the NOV attributed to the Regional Instream Flow Study is: "Additionally, another such Santa Rosa Creek steelhead habitat and population survey found that, "during the fall and summer months stream flow at approximately stream mile 6.7 … goes subsurface leaving a portion of Santa Rosa Creek dry for a part of the year. This section of dry creek severs the upper watershed from the lower watershed and can delay or prevent upstream migration of adult steelhead and downstream migration of smolts during drier years" (RIFA page 25; cited on NOV p. 5).

Importantly, this statement does not assert that groundwater pumping is the cause of seasonally intermittent flow at the upstream end of the groundwater basin. Intermittent flow is consistent with the natural process of flow recession during the dry season, where surface flow ceases when it recedes to a level smaller than the capacity of the basin to convey water down the valley via the subsurface.

However, the statement implies that the absence of flow during the dry season affects upstream and downstream fish migration. Groundwater depletion does not significantly delay upstream migration, given the pattern of early winter streamflow. Winter stream flow events typically start with a sudden peak that greatly exceeds the percolation capacity of the creek, then recede over a few days to weeks. Both the Santa Rosa and San Simeon basins typically refill almost completely within 2 weeks of the onset of stream flow, as can be seen in the hydrograph for well 11C1 at the upper end of the San Simeon Basin (Figure 4). Once the basin is full, concurrent pumping depletion by CCSD is negligible (0.3-0.5 cfs in winter for San Simeon Creek; less for Santa Rosa Creek).

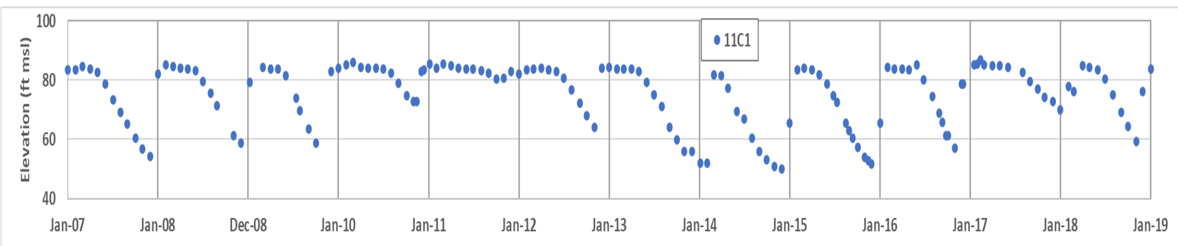


Figure 4. Hydrograph of Water Levels in San Simeon Basin Well 11C1

Stream flow depletion by pumping could theoretically decrease downstream passage opportunity for smolts, yearlings and young-of-year (YOY) in spring, which typically is during April-May. However, no data were presented to determine whether CCSD pumping materially affects passage opportunity. To fill that analysis gap, Figure 5 shows the potential impact of CCSD pumping on smolt/yearling/YOY passage opportunity based on the 1971-1995 period of record for the San Simeon Creek gage at Palmer Flats. This analysis assumes: 1) the passage season is April-May, 2) the minimum flow required to pass the critical "bunkhouse" and "woodrat" riffles near the CCSD well field is 11 cfs (D.W. Alley & Associates, 1992), 3) percolation loss between Palmer Flats and the critical riffle is 2 cfs at that time of year, so that the minimum passage flow at Palmer Flats is 13 cfs, 4) CCSD pumping in April-May is 31 AF/mo (equals 0.51 cfs), 5) 100 percent of CCSD pumping at that time of year derives from concurrent stream flow depletion (conservatively high), and 6) irrigation pumping by the upstream grower did not already dewater the critical riffle. Of the 23 years with data, passage opportunity was zero in 8 years (35 percent) due to low rainfall during the previous winter. Depletion impacts were negligible in the four wet years with greater than 35 days of passage opportunity, because opportunity was ample with or without depletion. This focuses the issue on the 11 years with low but non-zero passage opportunity (1-20 days). During these years, the average passage opportunity was decreased by 0.3 days (6.3 percent). The relevant question is whether that magnitude and frequency of reduction in smolt/yearling/YOY passage opportunity is significant from a population trend standpoint. Such a specifc analysis is the kind of evaluation needed to substantiate the NOV.

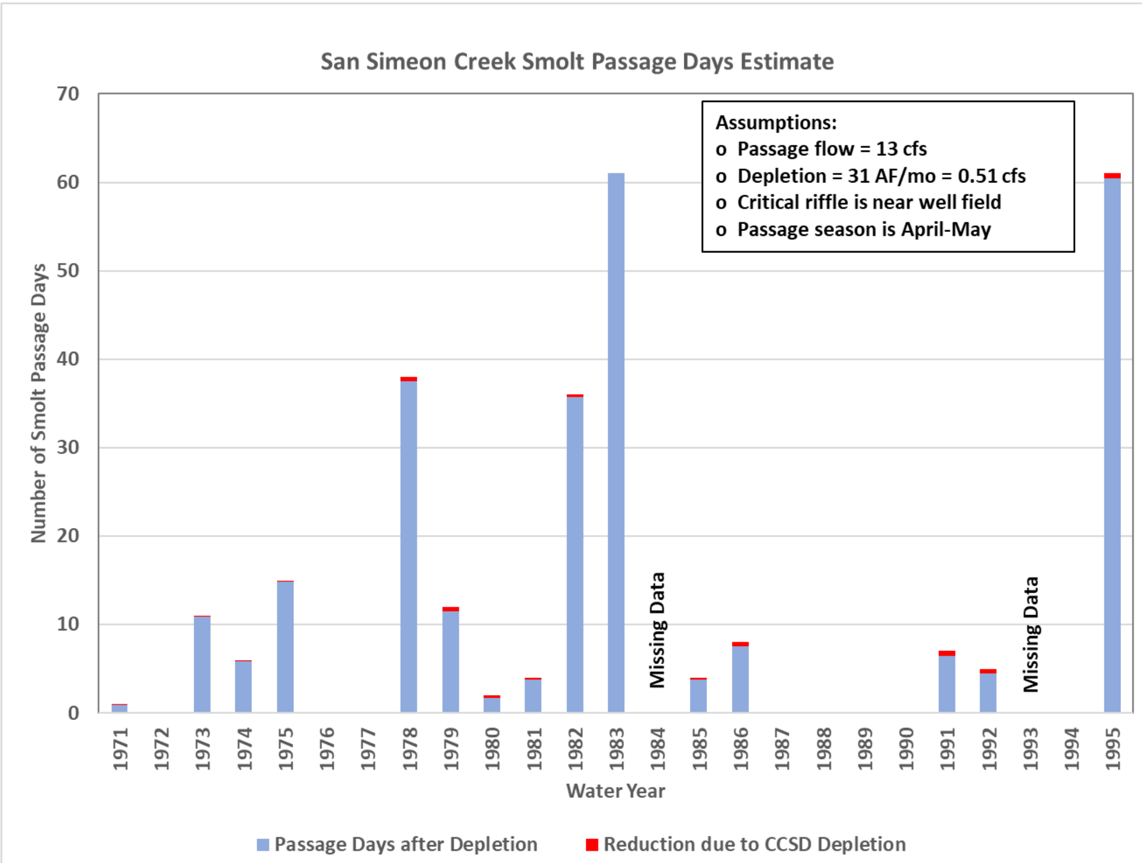


Figure 5. Pumping Impacts on Smolt/Yearling/YOY Passage Opportunity in San Simeon Creek

REVIEW OF SOUTH-CENTRAL CALIFORNIA STEELHEAD RECOVERY PLAN (2013)

This study affirmed the widespread occurrence of seasonally intermittent streams in the South-Central California Coast region: “Many rivers and streams naturally exhibit interrupted baseflow patterns (alternating channel reaches with and without perennial surface flow) controlled by geological formations, and a strongly seasonal precipitation pattern characteristic of a Mediterranean climate” (p. 2-16).

The report also states that “steelhead run sizes are sharply reduced” relative to “historical” conditions. However, the discussion of factors affecting population declines does not specifically mention flow depletion by groundwater pumping. It focuses more on dams, diversions and other factors: "Water storage, withdrawal, conveyance, and diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat. Modification of natural flow regimes by dams and other water control structures have resulted in increased water temperatures, changes in fish community structures, depleted flow necessary for migration, spawning, rearing" (p. 3-2). A later section of the plan mentions groundwater extraction more explicitly as a factor that decreases flows needed for passage, but the text does not present any quantitative information (Section 4.2.1; p. 4-4).

REVIEW OF SANTA ROSA CREEK WATERSHED MANAGEMENT PLAN (2012)

The Santa Rosa Creek Watershed Management Plan (WMP) opposes future increases in groundwater pumping but does not indicate that groundwater pumping is a major cause of stream intermittency. The WMP also does not provide the consistent or substantive evaluation of pumping impacts on local stream systems.

In fact, the WMP acknowledges that the reach of Santa Rosa Creek at the upstream end of the groundwater basin is seasonally intermittent: "In summer and fall, monthly average flows are often less than 5 cfs (0.14 m3 s-1), leaving many stream reaches dry, such as immediately downstream of Mammoth Rock where any surface water delivered from upstream reaches seeps down to the groundwater table (Figure 2-9)" (p. 43). Nonetheless, depletion by groundwater pumping is listed as one of seven factors that have affected ecological conditions in the watershed, and one of the eight recommendations to improve fish habitat conditions is to "increase summer and fall instream flows" (p. 110).

The WMP provides a comparison of aerial photographs of the creek from 1937 and 2009 and found that "Aerial photography taken in 2009 reveals a considerable increase in riparian vegetation extent and density compared with 1937 (Figure 2-25)" (p. 83). This is noteworthy relative to groundwater pumping impacts on stream flow depletion, because pumping would necessarily lower the water table near the creek and tend to adversely impact riparian vegetation. Thus, this evidence provided by the WMP does not support a conclusion of adverse impact due to groundwater pumping.

The WMP does not present any new analysis of flow or pumping data. Instead, it presents citations of several previous studies, each of which is problematic. The citations and source documents are described below.

First, the WMP states that "Flows into the lagoon during summer and fall are likely worsened by low stream flows resulting from excessive groundwater pumping and diversions (Rathbun et al. 1991, Yates and Van Konyenburg 1998, D. W. Alley & Associates 2006, 2008)" (p. 50). In this statement the report by Yates and Van Konyenburg (1998) is misrepresented. Those authors never characterized pumping as "excessive".

The WMP also cites D.W. Alley & Associates (2006), which describes the results of fish monitoring in San Simeon and Santa Rosa Creeks in 2004-2005. The report asserted that “lagoon water depth was predominantly controlled by streamflow and that tidal overwash and through-flow (i.e., subsurface flow through the sandbar) had a minimal effect.” (p. 49). This conflicts with the data presented above (see Figure 3) that showed large effects of tides and wave overwash events. Furthermore, this conflicts with the hydraulics of flow through the sand berm, which by Darcy’s Law is proportional to the water-level difference between the lagoon and ocean as well as the width of the sand berm. Historical aerial photography shows that the width of the sand berm is variable from year to year and typically increases gradually during the dry season. Thus, the statement asserting that stream inflow is the dominant factor controlling lagoon elevation is not supported by data or the governing equation of groundwater flow.

WMP Figure 2-26 (copied from the D.W. Alley report) shows a decline in young-of-year steelhead counts from 1998-2006. However, WMP Figure 2-28 (also from D.W. Alley) shows that the decline occurred in the upper creek reaches and that fish counts in the “lower reaches” exhibited no trend. WMP Figures 2-27 and 2-29 show the same pattern for age 1+/2+ juvenile steelhead. The absence of a population trend in the lower reaches does not support a conclusion that CCSD pumping (which is located next to the lower reaches) has adversely impacted young-of-year populations during that period.

D.W. Alley & Associates (2006) and Nelson *et al.* (2005) both concluded that annual rainfall has the strongest correlation with reproductive success (WMP p. 103). In other words, any impacts of groundwater pumping occur in a context of variable stream flow and fish populations.

The WMP also cites D.W. Alley & Associates (2008), which was another report summarizing fisheries conditions in Santa Rosa Creek. That report noted that fall young-of-year densities in Santa Rosa Creek were the highest of nine streams surveyed on the Central California Coast in 2006” (WMP p. 106). Like the aforementioned riparian vegetation data, this long-term trend conflicts with the NOV assertion that fisheries have been severely impacted by CCSD operations.

The WMP asserted that groundwater pumping has impacted fish, offering no new flow and pumping data or analysis, but referencing prior studies: “However, due to groundwater pumping and water diversions, summer instream flows are chronically low compared to historic levels and are considered a critical factor limiting juvenile steelhead populations in Santa Rosa Creek (Yates and Van Konyenburg 1998, D. W. Alley & Associates 2008, Nelson et al. 2005)“ (WMP p. 107). This statement misrepresents the work by Yates & Van Konyenburg, which contained no discussion of fish. Also, this topic sentence is unsupported by the rest of the paragraph, which goes on to compare the “wettest” years with “drier” years—which are climatological variations that have nothing to do with groundwater pumping. The text also notes the summer dry reach at the upper end of the groundwater basin but does not attribute it to groundwater pumping. There is certainly no evidence in any of the reports that groundwater pumping is a “critical factor” in limiting juvenile steelhead populations.

On the other hand, the WMP cites several studies that concluded that lack of pools is of greater concern: "poor pool development has been cited as one of the primary limits on rearing habitat in Santa Rosa Creek (Rathbun et al. 1991; Nelson 1994; D. W. Alley & Associates 2007, 2008; Nelson *et al*. 2005)." The paragraph continues: "Although pool filling has been attributed to fine sediment deposition (Nelson *et al*. 2005), the relatively high sediment-transporting capacity of the lower reaches of Santa Rosa Creek (see Section 2.5) suggests that poor pool development is likely due to the lack of large woody debris" (WMP p. 107). In other words, the biggest impact on summer rearing habitat is purportedly poor pool development caused by sedimentation and a lack of large woody debris, neither of which have anything to do with groundwater pumping. This discussion further undermines the report's recommendation to protest future increases in diversions or groundwater pumping.

The WMP also cites two studies that supposedly showed that reduced groundwater inflow to a lagoon causes salinity stratification, which in turn causes thermal stratification. "When lagoons are highly saline, or salinity-stratified, they collect heat in the lower saltwater layer, have relatively lower dissolved oxygen levels, and typically have unsuitable conditions for rearing." And "Reduced instream flows limit the extent of lagoon habitat and affect the dynamics of lagoon formation, causing extended periods of saltwater and freshwater stratification that lead to thermal stratification, with warmer temperatures and anoxic conditions along the bottom that lower dissolved oxygen levels and reduce food supplies (Smith 1990, Capelli 1997)" (WMP p. 111). These statements do not fully characterize the salinity and dissolved oxygen (DO) regimes of coastal lagoons. When waves overwash the beach berm—which sometimes happen during full or new moons or when ocean waves are unusually large—a slug of ocean water is introduced into the lagoon. It settles to the bottom, where it gradually seeps back through the beach berm to the ocean over a period of 1-2 weeks. Salinity stratification is not necessarily associated with thermal stratification or with temperatures that are unsuitable for steelhead. Similarly, dissolved oxygen near the bottom of the lagoon is consumed by microbial degradation of organic matter, and the DO concentration can fluctuate widely as the oxygen-depleted water exits via seepage through the beach berm in tidally controlled pulses. These are all natural processes unrelated to groundwater pumping or lagoon inflow. These processes lead to complex, transient, three-dimensional distributions of temperature, salinity and DO to which steelhead are presumably adapted.

REVIEW OF SANTA ROSA CREEK STEELHEAD HABITAT AND POPULATION SURVEY (2005)

As cited in the WMP, the Santa Rosa Creek Steelhead Habitat and Population Survey (Nelson *et al.* 2005) reported that "over one-half of the high-quality spawning locations are located upstream of stream mile 8, downstream of which the creek typically goes seasonally dry. During drier winters, this dry reach may significantly delay or prevent adult steelhead from accessing, and smolts from emigrating from, the upper reaches (Nelson *et al*. 2005)" (WMP p.103). This is yet another study confirming that Santa Rosa Creek flow is seasonally intermittent in the reach overlying the groundwater basin, with no assertion that intermittency is unnatural.

The WMP also cited the following passage from Nelson *et al*. (2005; p. 2): "Historically, Santa Rosa Creek supported one of the largest, self-sustaining populations of steelhead (Oncorhynchus mykiss) in San Luis Obispo County. However, in the past few decades, significant land development in the town of Cambria and adjacent areas and a concurrent increase in the demand for water resources have adversely impacted instream habitat and the steelhead population which resides there." This statement of causality is not supported by any data in the report.

On the contrary, data presented in the Nelson *et al*. (2005) report are consistent with the absence of demonstrable impacts of pumping. Figure 17 of that report showed a hydrograph of measurements of Santa Rosa Creek flow during April-December, 2005 at a location 3,000 ft downstream of Highway 1. Figure 18 of that report showed water temperatures recorded by data logger during the same period. The report did not show groundwater pumping, although the data were available.

Figure 6 below shows the stream flow and temperature hydrographs from the Nelson *et al*. (2005) report along with monthly pumping at CCSD's Santa Rosa Creek wells. The X axes of all three graphs are aligned and scaled so that dates match vertically across all three graphs. The graph of pumping shows that CCSD pumped almost no water during April-July, then abruptly increased to 17-22 AF/mo during August-October. If CCSD pumping were affecting stream flow or temperature, one would expect a deflection in the flow and temperature hydrographs, but no deflections are evident. Flow followed a smooth, logarithmic recession through December. The temperature plot followed a regular seasonal curve with temporary periods of high temperature in late August and late September. Those were likely the result of heat waves after the end of the early-summer fog season. In any case, the plots did not correspond to the pumping time series. Thus, adding pumping data to the analysis failed to reveal a correlation between pumping and stream flow or temperature, undermining if not invalidating the statement that pumping has "adversely impacted instream habitat and the steelhead population". This is an example of conclusions unsupported by evidence. The pumping data were available at the time of the study and should have been included for any meaningful evaluation.

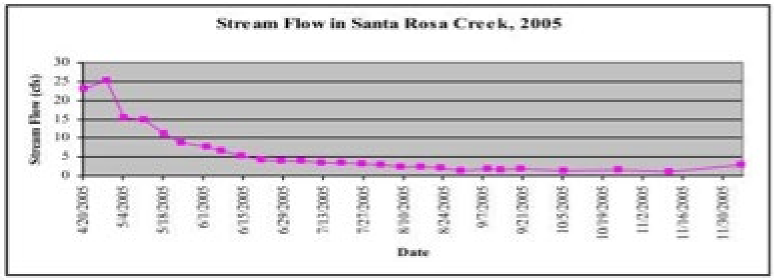


Figure 17. Stream flow results from Santa Rosa Creek, 2005.

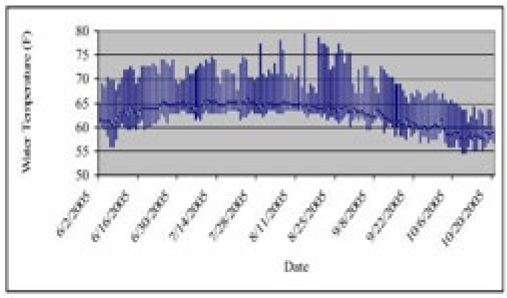


Figure 18. Recorded water temperatures at Site 1 from June 2 through October 20, 2005.

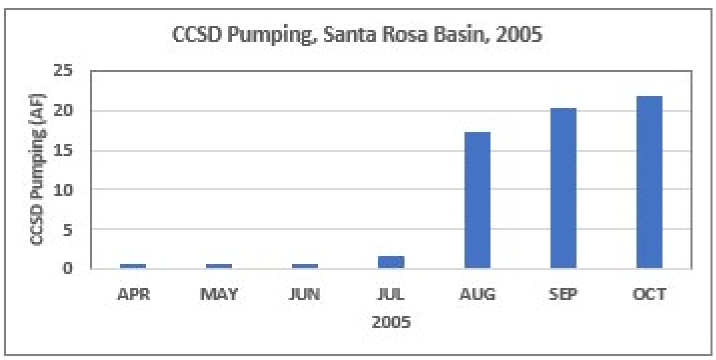


Figure 6. Santa Rosa Creek Flow and Temperature and CCSD Pumping, 2005

One of the recommendations by Nelson *et al*. (2005) is to “protest future water right applications which could jeopardize adult and juvenile passage, summer-fall juvenile rearing, and spawning”, arguing that “reduced summer and fall stream flows have a direct impact on the quantity and quality of rearing space, food production and availability, and water quality” (Nelson *et al*. p. 64). This assertion is followed by generic, conceptual assertions that pumping diminishes flow volume, increases stream temperature and decreases stream dissolved oxygen. However, actual data presented above for Santa Rosa Creek show that other factors control those habitat variables and that pumping impacts are small and in the case of Santa Rosa Creek not apparent.

SUMMARY OF REVIEWS

This review demonstrates that there has been a long history of studies with technical weaknesses that led up to the NOV. Like a game of "telephone", assertions in the NOV do not trace backwards through the sequence of studies to adequate substantiating evidence. Looking at the group of studies as a whole, there were multiple instances of unwarranted persistence in applying a method or conceptual model in spite of study area conditions that render it unsuitable. There were multiple instances of conclusions regarding the effects of groundwater pumping that were unsupported by data or analysis. There were multiple instances where data showed that other habitat factors had a larger impact or that habitat conditions had actually improved over time. There were a few instances where older studies were misrepresented in newer ones, or where weaknesses of prior studies were perpetuated without examination.

Taken together, the four studies cited in the NOV and the antecedent studies on which they were based do not present data or analysis demonstrating that groundwater pumping by CCSD has adversely impacted fisheries in Santa Rosa and San Simeon Creeks.

EFFECTS OF GROUNDWATER PUMPING ON STREAM FLOW, AQUATIC HABITAT AND FISH

This section is an attempt to state what is known about the relationship between CCSD municipal groundwater pumping and steelhead habitat along San Simeon and Santa Rosa Creeks. Some of the statements clearly derive from earlier sections of this memo. Others are essentially professional opinions based on principles of groundwater hydrology and previous studies of these and other streams.

- Flow in San Simeon and Santa Rosa Creeks is seasonally intermittent, like flow in most San Luis Obispo County streams.
- Flow disappears during the dry season along a reach near the upstream end of the groundwater basin (or "alluvial reach") in both watersheds. The duration of the no-flow period and the length of the no-flow reach vary substantially from year to year based on the amount of rainfall the preceding winter.
- At the onset of the winter flow season, creek percolation rapidly refills the groundwater basin, creating a condition of hydraulic connection between groundwater and the creek that persists until surface flow ceases.
- When the creek is hydraulically connected to groundwater, nearby groundwater pumping increases the creek percolation rate by an amount approximately equal to the time-averaged pumping rate.
- During the dry season—when surface flow is not present in the creek—nearby groundwater pumping is supplied by two sources: depletion of local groundwater storage and interception of groundwater flowing down the valley. The proportion of these sources depends on local aquifer characteristics.

- Depending on the location of the well, down-valley subsurface flow that is intercepted by the well might otherwise have reached the lagoon during the dry season. The closer a well is to the lagoon, the greater the likelihood that intercepted subsurface flow would have reached the lagoon.
- During the dry season, steelhead rearing continues to be possible in the lagoon and along reaches upstream of the groundwater basin. The opportunity for rearing along the intermittent groundwater basin reach depends on the length and persistence of the reach that remains flowing during the dry season, as well as habitat quality factors such as pool development, shading, and sedimentation.
- Consumptive use of groundwater pumped from the basin during the dry season would theoretically shorten the length of the flowing reach. Variations in annual rainfall are known to cause a large variation in the length and flow of the dry-season flowing reach. Those variations are not well documented. The extent to which groundwater pumping shortens the flowing reach and decreases its flow is not documented at all. Estimates can be produced by groundwater modeling.
- If groundwater withdrawals are impacting flow and habitat, the relevant variable is net consumptive us of groundwater, not gross pumping. Groundwater applied for irrigation is accompanied by a certain amount of deep percolation that returns to the water table. Similarly, municipal pumping in the San Simeon basin is partially offset by wastewater percolation at a nearby location.
- In general, any conclusions regarding impacts of groundwater pumping apply to all pumpers, not just CCSD. Impacts vary based on the timing, location and magnitude of pumping, not based on the type of use.
- Rare instances where pumping effects can be documented—such as the above analysis of 2005 pumping and flow at the lower end of Santa Rosa Creek—have not revealed a large effect of pumping.
- All biologists appear to agree that steelhead populations in the two creeks are smaller than they were historically.
- Flow and habitat conditions along Santa Rosa Creek is not obviously worse than along other San Luis Obispo County coastal steelhead streams, as evidenced by the relatively large young-of-year populations in Santa Rosa Creek and the long-term (decades) increase in riparian vegetation along the creek.
- Upstream migration of adult steelhead is not significantly impacted by groundwater pumping because the migration opportunity coincides with storm-associated peak flow events with flows that greatly exceed rates of pumping depletion.
- Downstream migration of steelhead smolts in late spring could be impacted by concurrent groundwater pumping, but quantitative analysis of stream flow sequences such as the one presented in this memorandum show that the impact probably amounts to a few percent reduction in passage window duration in a few years.
- Groundwater inflow probably plays a minor role in lagoon habitat quality. Available data indicate that lagoon elevation is dominated by tides, wave overwash and beach berm

width. Water temperatures are controlled by solar radiation. Salinity is dominated by wave overwash events, and dissolved oxygen is controlled by algal photosynthesis/respiration near the surface and by decomposition of benthic organic matter at the bottom.

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