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Gerald W. Bowes, Ph.D.
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Office of Research, Planning and Performance
State Water Resources Control Board
1001 I Street
Sacramento, CA 95814

5 February 2014

Re: Scientific Review of "Volume Depletion Approach Study - Protectiveness of Alternative Guidelines in North Coast Instream Flow Policy Section A.1.8.3

Dear Mr. Bowes,

I am pleased to provide my evaluation of the Volume Depletion Approach Study (VDAS) described in Policy section A.1.8.3. The purpose of the VDAS is to provide a scientific evaluation of the protectiveness of alternate criteria to the State Water Board Policy for Maintaining Instream Flows in Northern California Coastal Streams regional criteria for season of diversion, minimum bypass flow and maximum cumulative diversion. It is my responsibility to determine whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices. I provide an evaluation of each section of the VDAS below. Please let me know if you have any questions.

Sincerely,

Julian D. Olden

Scientific Review of "Volume Depletion Approach Study - Protectiveness of Alternative Guidelines in North Coast Instream Flow Policy Section A.1.8.3"

Prepared by:
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5 February 2014

Below is my (Julian D. Olden) evaluation of the Volume Depletion Approach Study (VDAS) described in Policy section A.1.8.3. The purpose of the VDAS is to provide a scientific evaluation of the protectiveness of alternate criteria to the State Water Board Policy for Maintaining Instream Flows in Northern California Coastal Streams regional criteria for season of diversion, minimum bypass flow and maximum cumulative diversion. It is my responsibility to determine whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices. I review each section of the VDAS below.

Study Plan and Approach to Analysis

The VDAS selected three regionally representative study basins, collated habitat and hydrology data, developed hydrologic models, and performed a series of protectiveness investigations according to habitat flow curves and salmon passage, spawning and rearing habitat requirements. The selection of study basins (2.1) followed a defensible protocol that adequately balanced existing data availability and feasibility associated with new field surveys. Next, stream sites were classified as those occurring above the limit of salmon anadromy with benthic macroinvertebrates present and those occurring above the limit of salmon anadromy without benthic macroinvertebrates present (2.2). Unimpaired flows were modeled for points-of-interest in the two stream classifications using the Hydrologic Simulation Program – Fortran (HSPF) (2.3), which given available data and requirements for the VDAS, is considered an appropriate methodology. HSPF is commonly recognized as among the most complete process-based watershed model for quantifying runoff and addressing water quality impairments associated with combined point and nonpoint sources. Since its initial development nearly twenty years ago, the HSPF model as proven useful for long-term continuous simulations and assessments of hydrological changes and watershed management practices, especially agricultural practices. For these reasons, I agree that it is an appropriate model choice and has several advantages over the dozens of other watershed-scale hydrologic models currently being used (reviewed in: Borah, D.K., and M. Bera. 2003. Watershed-scale hydrologic and nonpoint-source pollution models: review of mathematical bases. Transactions of the American Society of Agricultural Engineers 46: 1553-1566).

Anadromous Salmonid Habitat Flow Needs

The protectiveness analysis completed for the VDAS involved three key elements of anadromous habitat: upstream passage, spawning and natural flow variability. As stated on Page 2-11 "The suitability criteria for evaluating effects in the VDAS were the same as established for the original Policy development, and are consistent with those developed in the report titled, *North Coast Instream Flow Policy: Scientific Basis and Development of Alternatives* (Stetson and R2, 2008) and subsequently modified as a result of sensitivity analyses of effects of reducing the lower spawning depth limit (Stetson and R2, 2009)". For this reason, I have no comments on this section of the VDAS. The VDAS then describes how critical minimum instream flow thresholds were defined for upstream passage and spawning, and how unimpaired and impaired flow time series were compared to assess impacts of diversions (3.2).

A protective minimum spawning flow was determined for each site in two steps. "First, the composite habitat flow curves were used to define a minimum spawning flow at each redd. The minimum flow was identified on each redd-specific curve corresponding to a minimum WUA value of 2000 ft2/1000 ft of stream (i.e., a minimum redd width of 2 ft, consistent with the original Policy development). The redd with the lowest resulting spawning flow then defined the lowest flow for each transect below which spawning habitat would disappear. As a balance towards then increasing protectiveness, the minimum spawning flow for the site was then taken to be the transect with the highest minimum spawning flow (Table 3-3). This flow represents the estimated minimum flow required to support some spawning at all transects in a site."

If I understand correctly, then I have concerns that this approach, which is essentially taking the maximum (across transects within a site) of a minimum flow (across redds within a transect), is over-stating the perceived protectiveness of a site. In other words, protectiveness of spawning flows is being based on a single redd (per transect) that demonstrates the lowest flow, despite the fact that the maximum is calculated across transects. This is truly the best-case scenario. A better and more robust approach is to evaluate a range of scenarios based on the maximum (across transects) of: (1) the first-quartile flow (across redds), (2) the median flow (across redds), (3) the third-quartile flow (across redds), and (4) the maximum flow (across redds). I believe this analysis would better achieve the desired outcome of a balance towards "increasing protectiveness" as stated in the VDAS.

Channel and Riparian Maintenance Flow Needs

Effects of diversions were evaluated in terms of changes in the 1.5 year flood magnitude at the habitat sites, and the corresponding changes in substrate mobility conditions at that flood level. Although it should be noted that substrate size (D50) is just one of many potential channel responses to changes in flood regimes, I believe this analysis is adequate for the purposes of the VDAS.

Protectiveness Analysis

A protectiveness analysis was completed to compare impairments made under the Policy Section A.1.8.3 guidelines to unimpaired conditions. Passage and spawning days were computed for the unimpaired conditions and then for multiple diversion scenarios. Four watershed diversion scenarios were proposed to describe different spatial distributions of potential points of diversion across the watershed. I believe that these scenarios adequately capture the range of potential diversions and therefore provide realistic insight into the likely implications for salmon passage and spawning. However, the definition of a spawning day is misleading "The limiting spawning flow at a site was the highest spawning flow of all transects at that site" (page 4-1), because transect values are based on minimum values across redds (see my previous comment).

Protectiveness of Guidelines in Policy Section A.1.8.3

Overall, I found the evaluation of the alternative scenarios and policy guidelines to be robust. Predictions of reductions in salmon spawning and passage, changes in 1.5-year flood return magnitude and reductions in grain size in response to flow scenarios D1 and D3 all appear valid and conform to my expectations.

Despite this, some general conclusions in this section are overly generalized and thus require revision. For example, "For the above reasons, the reductions in 1.5-year flood magnitude seen in Scenario D1 are within acceptable limits for impacts to natural flow variability. The guidelines in A.1.8.3 for Class III streams with maximum cumulative volume depletion no greater than 5% are protective of natural flow variability. For Class

III streams with a maximum cumulative volume depletion greater than 5% but no more than 10%, the guidelines in A.1.8.3 are also protective and no additional conditions are necessary to protect natural flow variability." (page 5-21). Equating 1.5 year flood magnitude to natural flow variability is overly simplistic – as noted previously in the VDAS (section 3.3). It is worth restating here that flood magnitude is just one of many dimensions of flow variability (reviewed in: Naiman, R.J., Latterell, J.J., Pettit, N.E., and J.D. Olden. 2008. Flow variability and the vitality of river systems. Comptes Rendus Geoscience 340: 629-643.)

In another example, "The results of the hydrologic models prepared for this Study show that flow at the ULA, which is generally the downstream limit of Class II streams, is primarily composed of runoff to the Class II stream with relatively small flow contribution from upstream Class III streams… The contribution from the headwaters represents only about 8% of the annual flow at the ULA." (page 5-22). This may be true, but does the contribution by Class III streams vary seasonally? That is, the contribution may be 8% according to mean annual flow, but be greater during certain times of the year that coincide with critical spawning and passage requires of salmon.

In another example, "Therefore, dewatering of a Class II stream could only occur under the guidelines in Policy Section A.1.8.3 under a highly specific and unlikely diversion scenario, with potential dewatering occurring over a short time period and limited reach length. Because of this, potential impacts related to stream dewatering are not significant." (page 5-22). Note the model outputs contained the VDAS are predictions and subject to error. Therefore, this text should be revised to state that "models predictions suggest that dewatering of a Class II stream may only occur …".

I was pleased to see a discussion of the importance of diversions to re-fill reservoirs for frost protection, and the need for additional research to elucidate the potential impacts on downstream migration of salmon. The VDAS correctly notes that large uncertainties exist regarding how to define suitable and defendable baseflow conditions (magnitude and timing of pulse events) and thermal regimes during March – May to support salmon persistence. VDAS hypothesizes that the Policy may require higher magnitude base flows.

Protective Conditions for Class III and II Streams

I find the recommendations for Class II streams with maximum cumulative volume depletion greater than 5% but no more than 10% to be supported by adequate scientific information. The investigation of Policy elements in addition to the February median base flows is warranted and described more below.

The VDAS reported that “adding a diversion season policy element (Scenario A1) protects sensitive passage and spawning in October and November and shifts the impacts to December and January when there are substantially more days with flow conditions conducive to each habitat need such that reductions in flow due to diversions have less biological significance with respect to protecting diversity in life history strategies. For example, losing one day in October out of two or three passage days total is more biologically significant than losing one day in December out of 10 or more passage days. In the latter case, there should be enough opportunities for steelhead to migrate upstream and spawn that losing one day is unlikely to have a lasting effect on population viability, whereas earlier in the season, every limited opportunity may be important for maintaining viability of coho salmon and early season steelhead upstream migrants.” (page 6-4). Although I agree with the numerical result I do not necessarily support the biological interpretation that assumes ecological equivalence of a “day” in October-November vs. December-January. No evidence and reference to the peer-reviewed literature is provided to support this statement; instead it contains vague wording such as “should be enough”, “lasting effect on population viability”, and “may be important”. This section is far too speculative and requires the inclusion of references to peer-reviewed papers.

I highly support the finding that Scenario A1-A3 are not sufficient to protect salmon (page 6-2) and that adding additional Policy Elements that include diversion season and regionally-referenced base flows are required. I agree with the recommendation that no additional conditions are necessary to ensure protectiveness for Class III streams and that additional conditions of the regionally protective MBF and February median MCD are required for Class II streams.

If the State Water Board revises the Policy in the future, then I agree with the VDAS that additional conditions be applied to Class II applications with no more than 5% maximum cumulative volume depletion. In these cases, adding an MCD equal to the February median flow would be the first step towards protecting natural flow variability.

Furthermore, I concur with the VDAS finding that for Class II streams with maximum cumulative volume depletions greater than 5% but no more than 10%, the A.1.8.3 guidelines are clearly not protective. Specifically, I support the scientific basis upon which it is recommended “that both the regionally protective minimum bypass flow from Policy Section 2.2.1.2 and an maximum cumulative diversion rate equal to the February median unimpaired flow are required as additional conditions under Option 3 of the A.1.8.3 Class II guidelines” (page 6-15).

In summary, with the exceptions noted above in my review, I believe that the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices.