Review of Cal EPA “Biological objectives for the San Diego region”, version February 2019.
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There are three primary considerations and conclusions to be reviewed. I address all three in my review, although with more emphasis on 1 and 3.
1. Conclusion 1 – Numeric Biological Objective Derivation – The underlying method for deriving the numeric biological objectives for streams is scientifically sound and protective of Beneficial Uses.
a. Use of benthic macroinvertebrates and the California Stream Condition Index is scientifically sound
b. Use of a reference approach – the assumptions and methods to define “reference” is scientifically sound
c. Setting of index score threshold – the assumptions and methods to set water quality objectives as a percentile of references using the CA Stream Condition Index is scientifically sound
2. Conclusion 2 – Implementation of Numerical Biological Objective – The underlying methods and assumptions for implementation of the numeric biological objective for perennial and seasonal streams is scientifically sound and protective of Beneficial Uses.
3. Conclusion 3 – Narrative Biological Objective Guidance – The underlying method for deriving narrative guidance to use for the development of future numeric waterbody specific or waterbody-type biological objectives is scientifically sound and protective of Beneficial Uses.

Furthermore, I understand that I am to consider the following “big picture” elements:
(a) Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?
(b) Have we missed anything?

Summary of my review:
Overall I found that the document meets all of the criteria listed above. The underlying method of benthic macroinvertebrate bioassessment is sound and incorporates modern ecological principles relevant to aquatic ecosystems, especially as they relate to intermittent waters. The reference approach is well-formulated and likely to be robust to variability across site conditions and changes due to land use and climate change. The index score threshold is justified based on considerations specific to southern California as well as biomonitoring efforts in other states. The implementation of these objectives follows a reasonable schedule, the methods are clearly articulated, and they are compatible with Beneficial Uses as articulated in the document. I commend the authors for developing a thoughtful approach grounded in current science. This could become a model for other regions and states to adopt practices for biomonitoring intermittent waters. One challenge for the methodology -- a challenge that is common to most biomonitoring studies -- will be how to account for natural seasonal and interannual variability in benthic invertebrate community structure. I elaborate on this point in the review below.

Integration of intermittent and ephemeral waterways into our assessment of water quality has been achieving much deserved attention in recent years. This is logical given that intermittent and ephemeral stream reaches form the dominant ecosystem type in most aridland regions including southern California. Basic research into our understanding of these ecosystems has surged in recent years, with much attention from the National Science Foundation and the Environmental Protection Agency. Our counterparts in Europe are actively developing and implementing biomonitoring programs that incorporate intermittent and ephemeral streams. Even the US Department of Defense has actively embraced this effort by funding research projects throughout the western US, including Camp Pendleton, Naval Air Weapons Station China Lake, and Fort Hunter-Liggett in California. Thus our understanding of the basic ecology underlying intermittent and ephemeral waterways is sufficiently mature to allow the development of sophisticated and accurate biomonitoring programs for these ecosystems.

Some of the contributing authors to this report have been active in publishing their methods and concepts in peer-reviewed scientific journals such as *Freshwater Biology, Freshwater Science,* and *Ecological Indicators*, thus ensuring a solid scientific basis for applications.

3.1 The use of bioassessment methods rather than specific chemical monitoring is well justified.

3.3 Use of a reference site approach is also well supported by other studies which have come to the same conclusion. The large number of reference sites available (currently 750 statewide) makes this objective viable.

3.3.4 Resiliency. Since rivers and streams in aridland systems are particularly dynamic and prone to natural disturbances such as flood and drought, this is a key point that strengthens the approach. The discussion of resilience concepts based largely on Oliver et al. (2015) is relevant here and adds to the approach justification.

4.4.2 The point about unmapped anthropogenic activities (illegal grazing, cultivation) impacting the pool of reference sites is a good one, but not easily remedied.

4.4.3 Use of a 10% threshold for impairment seems to be well justified - at least this is a commonly used cutoff in other biomonitoring applications.

4.4.4 Naturally occurring factors. This is one of the main challenges of any biomonitoring program -- how to deal with naturally occurring variability within and among sites. In general I feel that the authors have done an excellent job identifying possible factors, and the reference site approach with all of its refinements (identifying natural gradients via GIS, iterative resampling to identify nonconforming sites, etc.) represents the state of the art. Some clarification on how the methodology could account for known seasonal and inter-annual variances in community composition could be discussed. For example, it is well known that there is a degree of among year turnover or detectability in invertebrate communities (McElravy

et al. 1989 *J. North American Benthological Society*, Resh et al. 2005 *Freshwater Science*), which will lead to some differences in community structure and possibly condition. Similarly, California and other Mediterranean climate streams exhibit a seasonal oscillation in community composition with EPT (Ephemeroptera, Plecoptera, Trichoptera) more dominant during winter and wet years and OCH (Odonata, Coleoptera, Hemiptera) increasing in summer or dry periods (Bonada & Resh 2013 *Hydrobiologia*, Tonkin et al. 2017 *Ecology*). The latter point may be addressed somewhat by standardization of sampling timing (as is discussed in section 4.5 and in Ode 2016b), but the occurrence of wet or dry year types may affect the results as well.

Hydromodification. As the authors state this is a factor that surely has impacts on stream community composition and thus quality scores, but is in need of further research and development. One place where this surely has an effect is with flow augmentation due to treated wastewater returns, which can at times result in increases in biological scores.

4.5 (and also language in Chapter 3 of the amendment): Seasonal streams are defined here as "freshwater streams that are expected to be inundated with flowing water for at least four weeks between the months of February and October, except during periods of atypical or extreme drought. Seasonal streams have sufficient flows to conduct bioassessment sampling for stream aquatic benthic macroinvertebrates in most years. Seasonal streams do not include those streams that only exhibit ephemeral flow, which is flow that occurs only during or immediately following (e.g. 24-48 hours) rainfall events." The 4 week delay in sampling from onset of surface flows would likely allow sufficient time for development and growth (and thus detectability) of intermittent stream specialist taxa such as stoneflies and blackflies (see Bogan & Carlson 2018 *Illiesia*). The sampling timeline guidances in Table 4 seem like a reasonable framework to achieve the correct timing.

One related factor is the role that hydroperiod, the duration of surface water occurrence, might play in determining community composition. I don't see any mention of instrumentation, but deployment of wet/dry sensors could be a useful way to determine the duration of surface water occurrence.

4.7.1 The RWB approach is a definite advantage when sampling intermittent streams due to their variability in flow conditions and microhabitats.

5 Program implementation. Much of this section pertains to the specifics of permitting and adherence to state and federal policies. As an ecologist I have less to comment on for this section, however I do note areas where ecological considerations come into play.

5.3 As noted above, flow augmentation due to discharge (to get rid of pollutants or otherwise) can fundamentally change stream character by shifting the hydrograph from ephemeral to intermittent, or from intermittent to perennial. I suspect this can be accommodated by careful selection of reference sites, and I see that the topic is discussed on p.78 as well.

5.3.3 An important point is made here - that deviation from the natural flow regime can have negative effects including facilitating nonnative species and changes to benthic invertebrate communities.
5.6 I am not an expert on policy related to CWA permitting, but I did find this section somewhat vague on specifics relating to what actions would be taken given specific biological findings. Perhaps the details of implementation will be articulated secondarily, and this material is just intended for general guidance, and determining who is responsible for what aspects of permitting?

Appendix 1 and 2. I consider these as background material and so do not review them here. The Mazor et al. paper is a good one and forms a solid foundation for the methods outlined in the other documents.

Chapter 3 amendments. These are reasonable and discussed in the context of intermittent stream definitions, above.

Chapter 4 amendments. Implementation. I found the specifics of this section, both legal and logistical, to be outside my area of knowledge in places. That said, I saw no indication that the proposed methods, timelines, and policies are at odds with the fundamental biomonitoring principles set forth in the other documents.