Ecosystem Amendment Performance Measures Independent Scientific Review

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Performance Measure (PM) 4.12: Seasonal Inundation

Restoring land-water connections to increase hydrologic connectivity and seasonal floodplain inundation.

General Comments[1]

This is a good start at assessing two essential aspects of the condition of Delta ecosystems: the total amount of fluvial and tidal flood-prone areas, and the proportions of those areas that are actually inundated at least once every two years, but less than 50-90% of any year, as needed to support salmon and, to a lesser degree, other native fishes. This PM is evidently fish-centric.

Despite its name, the PM does not generally assess seasonal inundation, which is a large topic covering the seasonal hydro-periodicity of surface waters, including vernal pools and the seasonal wetlands behind levees and dikes. While vernal pools and other forms of depressional wetlands are important components of the greater Delta ecosystem, they are currently disregarded by this PM.

This PM also does not generally address land-water connectivity, since it ignores the terrestrial aspects of that connectivity.

For a variety of reasons relating to the restoration of resilient ecosystems in the context of climate change, the PM should be broadened in the future by adding metrics to assess land-water connectivity much more comprehensively. To be more specific, the PM should eventually address the terrestrial-estuarine Transition Zone as defined by the Baylands Ecosystem Habitat Goals Update (BEHGU) for Suisun and the Bay downstream of the Delta. The Transition Zone is essentially the riparian area of the Estuary, with special regard for the migration space needed to accommodate sea level rise and landward estuarine transgression. The Transition Zone can be delineated on maps for any future time period, using the mapping guidelines developed for the Bay Area including Suisun. The Transition Zone is completely consistent with the definition of riparian areas, as provided by the National Research Council, and as reflected by some existing state policies and programs (e.g., see supporting technical reports for the

[1] At the risk of being heretical, I'll just mention that the term, "co-equal goals," is nonsensical. The goals might be of equal importance, or not, but they can't be "co-equal."

new Dredge and Fill Procedures of State Water Board). The Transition Zone encompasses all land-water ecological and hydrological interactions. This PM can initially focus on floodplains and flood-prone areas, specifically to support some native fishes, but should eventually be broadened in scope to cover the array of land-water connections endemic to the Transition Zone of the Delta. The effort to map the Transition Zone should be extended upstream through the Delta.

The proposed trailing indicators of connectivity (hydrological and ecological) and seasonal inundation should be converted into leading indicators to assist in restoration planning. One step is to develop the capacity to forecast changes in connectivity and inundation due to climate change (sea level and peak riverine discharge), land use change (including restoration projects), and reservoir management. Another step is to correlate observed changes in connectivity and inundation to levels of selected ecosystems services. This approach will help assess the achievability of the targets, develop alternative trajectories of progress based on the assumptions of the predictive models, and assess actual progress reactive to the trajectories. This, in turn, will provide a basis for revising the targets.

An operational relationship between this monitoring and assessment effort and the Bay Area Wetlands Regional Monitoring Program (WRMP) should be explored to unite wetland and Transition Zone science for the Bay and Delta into single science enterprise for the San Francisco Estuary as a whole.

Charge Question #1

How clear and thorough are the performance measure's metric, baseline, and target? What, if any, additional information is needed?

Regarding Metrics

- For the purposes of providing food resources, migratory pathways, and rearing habitat for salmon and other fishes, the timing of the flood events would seem to be important. However, the timing of inundation is not a clearly stated aspect of the floodplain inundation metric. For example, the PM might state the relative importance of fall, winter, and spring flood events.
- Further clarification of the difference between fluvial and tidal floodplains (or fluvial riparian areas and estuarine-terrestrial transition zones preferably), and how to map them, would be helpful. Tidal areas above local Mean Higher High Water (MHHW) but below maximum observed tide (the maximum tide height observed during the last tidal epoch) meet the criteria defining seasonal inundation, because these areas are inundated less that 50-90% of the time, although their inundation may be monthly, and not seasonal. Delineation of these areas may require referencing high-resolution digital elevation models (DEMs) to local tidal gauge data, through a 2D modeling effort. Such an effort is mentioned, but the use of empirical data on stage height provided by existing and perhaps additional new gauges is not mentioned. Developing this capacity may also be necessary to assess the risk of tidal wetland restoration failure due to accelerated sea level rise.

- The proposed metrics do not robustly cover the land-water connectivity. By definition, fluvial riparian areas and the terrestrial-estuarine Transition Zones encompass floodplains of any recurrence interval (RI), *plus adjoining terrestrial areas that affect riparian or Transition Zone form and function.* Floodplain functions (e.g., floodwater storage, flood stage desynchronization, nutrient exchange, filtration of fine sediment, salmon and other fisheries support) comprise only a subset of the land-water connections. The state-of-the-science approach to mapping riparian areas and Transition Zones regards their lateral extent (i.e., width) to be function-dependent. Simply stated, the longitudinal extent and the width of a riparian area or Transition Zone can vary depending on topographic slope (perpendicular to stream flow direction), vegetation structure (height and dominant species composition especially), land use constraints (excluding land covers that do not provide riparian functions), and the riparian function of interest. For the Transition Zone, width also depends on the rate of sea level rise and the future time period for which the extent of the Transition Zone will be estimated. A more thorough approach to mapping the areas of likely land-water connectivity would be to start with a map of floodplains (perhaps as defined separately for tidal and fluvial systems – see bullet immediately above), but then layer-on areas of additional fluvial riparian and Transition Zone functions, such as support for riparian wildlife (e.g., yellow-billed cuckoo, red-legged frog, valley elderberry longhorn beetle, riparian brush rabbit, migratory neotropical passerines, etc.), social services (various forms of recreation, protection of cultural resources, etc.), and estuarine transgression, based on topography, vegetation, and historical and modern land use. Consider using the Riparian Zone Estimation Tool (RipZET), originally developed for the Central Valley Riparian Habitat Joint Venture, as a way to estimate functional fluvial riparian width, and consider using the Transition Zone mapping guidelines developed for the Bay and Suisun to estimate the areas of land-water interactions adjoining the intertidal environments.
- I assume that the continuity or connectedness of restored areas to each other and to other habitats matters, and could be built into one or more additional metrics. For example, an additional metric might address the connectivity between restored floodplain areas (e.g., intra-patch distance), and another might assess adjacency to existing habitat of the same or other kinds (e.g., inter-patch distance). Landscape ecology offers many metrics for assessing continuity and adjacency. FRAGSTATS is a statistical package for such spatial analyses.
- The proposed 5-yr timeframe for repeated assessments of condition, and the dependence on rather coarse remote sensing data, may prevent assessments of the effects of drought, extreme flood events, and gradual changes in inundation regime. It may be useful to establish Benchmark Sites (see Bay Area Wetlands Regional Monitoring Program Plan) to document finer scale changes in inundation depth and extent over shorter time scales.

Regarding Baseline

- The disregard of 15,000 acres of lands that fit the existing definition of seasonally inundated floodplain needs further clarification. These acres seem to have value as rearing habitat for salmon, which seems to be a priority floodplain function.
- Again, as suggested above, a more thorough approach would be to explicitly state the priority functions of tidal and fluvial riparian areas, and map the areas that provide one or more of these functions. Areas could then be categorized by the functions they are likely to support. This approach would probably include the existing 15,000 acres of seasonally inundated floodplain.

Regarding Targets

- The concept of assessing conditions relative to targets that represent desired conditions is compelling.
- The existing targets are based on analyses done for the Central Valley Flood Protection Plan (CVFPP) that involve numerous assumptions that therefore underlie the targets. The assumptions and uncertainties built into the CVFPP analyses should be summarized. This also relates to Charge Question #5. I am particularly curious as to how the targets proportioned between the Sacramento and San Joaquin Conservation Planning Areas reflect the relative value of these two parts of the system for: (a) salmon, and (b) the many other riparian functions.
- The targets are likely to be adjusted as a result of adaptive management, and should therefore be stated as “initial”, or “starting” values.

Charge Question #2

How clear is the basis for selection of the performance measure? How complete are the scientific rationale, the justification, and the supporting references for the selection?

The bulleted comments below are additional to, or amplify, other related commentary provided above, under Charge Question # 1.

- The rationale for the PM articulates on two basic ecological concepts: (a) interactions among populations of organisms and patches of their effective habitats determine the flow of energy and cycling of matter through ecosystems; and (b) disrupting these connections reduces the kinds and levels of the ecosystems’ functions. The cited literature helps apply these basic concepts specifically to the Delta. However, an important aspect of the historical nature of the Delta seems overlooked, namely the spatial and temporal variability of inundation. In very large part, the Delta was historically intertidal floodplain, with adjoining fluvial-tidal flood-prone lands. The intertidal areas were flooded at frequencies ranging from twice daily to once per tidal epoch (i.e., the area inundated by the highest tide of the epoch), and the flood-prone inland areas above the highest tide were flooded at various frequencies related to the stage-frequency curves of the many rivers and streams entering the Delta. The spatial and temporal complexity of “inundation” and its likely effect on ecosystem

services, such as biodiversity, is understated, and not captured by the metrics of this PM.

- I recommend clarifying that additional metrics will be added to the PM in the future to address land-water connectivity and inundation more comprehensively, guided by the concepts of fluvial riparian area and terrestrial-estuarine Transition Zone referenced above (see fourth paragraph of General Comments above).

Charge Question #3

How clear and complete is the scientific basis for setting the targets? How complete is the consideration of key scientific references, available data, and existing monitoring capabilities?

- There is no clearly stated relationship between the acreage targets and the desired levels of priority ecosystem services, namely support for salmon and other native fishes. Perhaps the relationship is documented in the CVFPP analyses. This relationship will be essential to guide restoration, assess progress, and adjust targets in the future. Please see the next bullet.
- The targets might be better stated as a range of acreages, rather than single numerical acreage values, where the ranges reflect the uncertainty in the relationship between acreage and level of function.
- The scientific process to revise the targets should be outlined. The monitoring should be planned to identify thresholds of change in connectivity and inundation that provide adequate levels of desired ecosystem functions, or that trigger intervention, or that trigger a revision of the targets. For example, the areas of inundation measured from cost-effective remote sensing data should be used to calibrate estimates of inundation derived by superimposing gauge data for riverine and tidal water levels on high-resolution DEMs. And, the actual changes in inundation area should be correlated to changes in levels of floodplain functions, such as salmon support. Together, these analyses will yield forecasts of changes in floodplain function based on expected changes in inundation, as affected by expected changes in river and tidal stage, due to changes in climate, land use, and reservoir management. The forecasts of areas of inundation can therefore be used to forecast levels of functional support, which, in turn, can be used to guide restoration actions and to adjust the targets. Simply stated, the trailing metrics become leading metrics.

Charge Question #4

How achievable are the targets relative to the stated time scales?

- The section titled “Expectations” contains the following phrase: “… increased frequency of seasonal inundation …” The meaning of this phrase should be clarified. Does it mean increasing the number of seasons that inundation occurs each year, or the proportion of years in a multi-year period that inundation occurs for a given season, or the number of inundations within a given season each year, or some combination of these meanings? And, how is “season” defined?

Here I assume it means the number of inundations during the wet season, defined as the period from October of one year through May of the next year.

- Neither metric of this PM addresses the objective to increase the frequency of seasonal inundation as defined immediately above.
- It is not clear to what extent existing levees or other water control structures can be removed to increase the extent of inundation, without also increasing the unacceptable risk of flooding agricultural lands or the built environment. Existing and future landscape scenario planning should be used to assess the risks and opportunities of alternative actions to increase acres of seasonal inundation.
- It should be noted that climate change, especially sea level rise and increased peak stage of riverine runoff, will increase the frequency and extent of seasonal inundation, without requiring any purposeful modification of existing Delta landscapes. There should be an analysis of the degree to which the inundation targets will be met passively due to climate change, within the 2050 and 2100 timeframes. This will require superimposing expected tidal and riverine stage heights on DEMs for the Delta and adjoining inland areas (see second bullet under Charge Question #1 above).
- This PM is tightly coupled with PM 4.16 in a number of ways, most of which I address in my review of that PM. However, with regard to this PM 4.12, it's important to note that increased depth of inundation, which is concomitant with increased extent of inundation, is disregarded, and therefore the risk of drowning existing tidal floodplain and decreasing its extent is also disregarded.
- It should be noted that simply increasing the acres of flood-prone lands and increasing the acres of seasonal inundation will not by themselves increase levels of desired functions. The functional increases will depend on the development of habitats. This is further addressed in my review of PM 4.16.
- The timelines should be further defined with increments of time that correspond to more realistic milestones in progress toward the targets. The current milestones represent linear progress toward the targets. More realistic milestones will reflect changes in key factors, including available lands, funding, expected rates of sea level rise, and expected rates of increases in peak riverine discharges (relative to land elevations). Perhaps 2-3 alternative trajectories could be developed, based on different assumptions for these facts, and used to set alternative interim 5-10 year targets.

Charge Question #5

How well were scientific uncertainties (both outside and within management control) incorporated in the development of the targets and in the assessment of progress towards the targets?

I will address this question by referencing some of my earlier comments.

- The relationship between the proposed metrics and riparian or floodplain functions other than perhaps salmon support is unclear (see Question #1 Regarding Metrics; third bullet). This incurs the risk of meeting some targets

while not adequately supporting many other functions of the riparian area or Transition Zone.

- The assumptions of the CVFPP analyses underlying the targets translate into unstated risks that the targets will not support the desired levels of the targeted functions. The targets might be better stated as a range of acreages, rather than single numerical acreage values, where the ranges reflect the uncertainty in the relationship between acreage and level of function (see Question #3; first and second bullets).
- The meaning of “increased frequency of seasonal flooding” needs to be clarified (see Question #4; first bullet).
- The degree to which either climate change (sea level rise and increased peak discharge) or the removal of water control structures (levees, tide gates, etc.) will help achieve the targets is uncertain (see Question #4; third and fourth bullets).

The following comments about risks and uncertainties are provided in addition to the comments repeated above.

- Any use of numerical models to extrapolate or forecast future conditions will involve uncertainties that should be quantified as ranges of forecasted conditions. Likewise, any use of maps should acknowledge the spatial error or uncertainty of any depicted boundaries.
- Any use of monitoring data to assess conditions over time or through space should report the statistical variance of the data. It should be noted, for example, that any assessments of progress or success will involve some level of uncertainty, or likelihood of being incorrect. This re-enforces that suggestion that the targets be characterized as initial, inexact, and subject to revision based on the results of status and trends monitoring, new scientific understanding, changing public expectations, etc.

Charge Question #6

Are the identified data sources complete and appropriate to support robust assessment of the performance measure?

Regarding Connectivity:

- I believe the correct reference to EcoAtlas is actually its Project Tracker Tool, which is one of many tools in the EcoAtlas toolset. Project Tracker is currently used by some Regional Water Boards, including the Bay Area Water Board, to acquire maps of boundaries of projects as a condition of 401 Certifications and Waste Discharge Requirements. The Bay Area Water Board has begun encouraging the Central Valley Water Board to use Project Tracker. The Delta Plan could assist with this encouragement.
- The standardized project information sheet pf Project Tracker may require modification to meet the needs of the Delta Plan. For example, additional functionality may be needed to map different habitat types within a project. Furthermore, there needs to be consistency, or a crosswalk, between the habitat

classification system used in Project Tracker (i.e., the California Aquatic Resource Inventory) and the system used for the targets.

- The concepts of “connected” and “disconnected” must be quantified. The following question should be answered definitively: how far apart do two patches of habitat need to be, to be disconnected? Ideally, the distance is ecological. For example, the minimum or average dispersal distance for key species might be used. Or average inter-patch and intra-patch distances might be calculated from the maps of historical habitats developed by SFEI. In any case, it should be noted that patches might be connected for some functions, and not for others.

Regarding Inundation:

- The primary data sources (i.e., present and future remote sensing data) and the alternative source (2D modeling) should be used together as outlined above, in the third bullet under Charge Question #3. The intent should be to develop the capacity to forecast the depth and extent inundation based on expected changes in climate (sea level rise and riverine discharge), land use, and reservoir management, with the goal of converting training metrics into leading metrics, and identifying thresholds in condition or progress that trigger and guide management actions.
- As stated above (see fifth bullet under Charge Question #5), the resolution, minimum mapping units, and spatial errors of any habitat maps will contribute to the uncertainty of the assessments of progress. The proposed remote sensing data are rather coarse (30 m resolution) to support 5-yr assessments of the effects of sea level rise and increase peak discharge on inundation extent, especially during the early stages of relatively gradual climate change. As stated above (see fifth bullet under Charge Question #1), it may be useful to establish Benchmark Sites (see Bay Area Wetlands Regional Monitoring Program Plan) to document finer scale changes in inundation depth and extent over shorter time scales. This can be especially helpful in assessing ecological responses to gradual changes in inundation regimes, drought, and extreme flood events.

Charge Question #7

How well are adaptive management and alternative actions considered in performance assessments and reporting?

- It is not clear what will be reported to the Delta Plan Interagency Implementation Committee and other interests every year, if the assessment occur on 5-yr intervals. Perhaps the annual reports between assessment years can focus on costs and status of analytical plans, including contractors and partnerships.
- Progress in planning, and any assessment results, should be reported at the biennial State of the Estuary Conference and Bay-Delta Science Conference.

Performance Measure (PM) 4.15: Subsidence Reversal for Tidal Reconnection

Subsidence reversal[2] activities are located at shallow subtidal elevations to prevent net loss of future opportunities to restore tidal wetlands in the Delta and Suisun Marsh.

General Comments

- The identification of subsided lands suitable for tidal marsh restoration is an essential part of a regional approach to both preserve and prioritize restoration opportunities. The method of identification applied thus far is rudimentary, however. Its primary shortcoming is the disregard of suspended sediment supply relative to its demand, in the context of climate change. As a consequence, the amount of feasible subsidence reversal in the Delta is unknown. A more rigorous approach based on original analyses of sediment supply and demand, using existing data, has been developed and applied recently to the San Francisco Estuary, including Suisun, downstream of the Delta. This more rigorous approach attempts to account for changes in both supply and demand due to restoration, the availability of dredged sediment and other anthropogenic sediment sources, and the effects of climate change on local yields of terrigenous sediment, natural processes of sediment delivered to subsided areas, and autochthonous organic sediment production in relation to aqueous salinity. The same approach should be applied to the Delta. For more information about this more rigorous approach, which has already been applied to Suisun, contact Scott Dusterhoff at SFEI.
- An operational relationship between this monitoring and assessment effort and the Bay Area Wetlands Regional Monitoring Program (WRMP) should be explored in search of ways to share costs and otherwise unite the Bay and Delta into a single science enterprise for the protection and restoration of the wetlands and related resources of the San Francisco Estuary as a whole. The WRMP has proposed a science framework with indicators and metrics to assess the effects of climate change, initial tidal elevation, and land motion on net elevation change due to autochthonous sediment production and allochthonous sediment deposition, across a broad range of time and space scales.

Charge Question #1

How clear and thorough are the performance measure's metric, baseline, and target? What, if any, additional information is needed?

Regarding Metrics

- The Metric that focuses on acres of subsidence reversal activity is essential and can be evaluated using Project Tracker, which will enable managers to track activities from their permit stage through construction completion. However, the

[2] Subsidence reversal is a process that halts soil oxidation and accumulates new soil material in order to increase land elevations. Examples of subsidence reversal activities are rice cultivation, managed wetlands, and tidal marsh restoration.

project information form of Project Tracker will need to be modified to capture information about project-specific methods of subsidence reversal, otherwise there will be no way to assess their relative efficacy.

- The Metric that focuses on accretion lacks methodological detail. Substantially more information is needed to operationalize this Metric. Coordination with the WRMP, which has more fully developed related Indicators and Metrics, may be very beneficial. To be more specific, this Metric will need to be further developed to address the following factors.
    - Different methods of subsidence reversal will be best suited for different tidal elevations, ranging from shallow subtidal to supra-tidal. Therefore, the best way to measure net accretion will vary with elevation also. The best methods to provide comparable measures of accretion across the range of elevation and methods of subsidence reversal should be identified.
    - Vertical land motion, due to tectonic forces and seismic events, can have major effects on elevations of tide lands and their rates of accretion (or erosion). The best methods to assess local and regional vertical land motion should be identified.
    - Sedimentary processes will naturally vary through space and over time due to many factors, including but not limited to variations in allochthonous sediment supplies (i.e., concentration of available suspended inorganic sediment and amounts of organic debris) and their delivery rates, autochthonous sediment production (i.e., in-situ primary production by vascular vegetation), and climatic variability (i.e., drought and deluge). Activities to reverse subsidence, such elevating subsided lands by importing and placing organic and inorganic materials, are seldom uniform, and result in variable amounts and rates of elevation change within and among sites. A sampling plan will be needed to account for these sources of variability, or they will be inadequately understood to be effectively managed.

Regarding Baseline

- The baseline for the Metric focused on tracking activities is incorrect. There is at least one existing restoration project within the Delta-Suisun region that incorporates substantial subsidence reversal. The Montezuma Wetlands Project is a major tidal marsh restoration effort involving subsidence reversal near Collinsville, at the eastern mouth of Montezuma Slough. Since receiving its permits in 2001, this project has received over 8 million cubic yards of sediment, has raised the first 600-acre phase of the formerly subsided site to target tidal wetland topography. This for-profit project has pioneered science-based tidal marsh restoration designs and landscape engineering within the region, with ongoing advice and review by an independent Technical Review Team, and has provided many lessons that are transferrable to other projects in the future. Return of the tides to this first section of the site is scheduled for November 2020.

- The baseline discussion might also note that Sherman Island and other islands along the old Sacramento River channel between Rio Vista and Collinsville were used to store hydraulic mining debris dredged from the Sacramento River in a major effort of the late nineteenth century to improve navigation and reduce flood risks. The current tidal marshes of Sherman Island are the result of very early dredged sediment placement and subsequent levee failures.

Regarding Targets

- The targets should be termed “initial’ or “starting” until the recommended analyses of sediment demand and supply are competed (see first bullet under General Comments above).
- Future refinement of the targets should take a full regional approach involving all subsided former tide lands upstream (landward) of the Golden Gate. It is likely that subsidence reversal activities within the Delta, Suisun, and North Bay will affect each other through tidal circulation of suspended sediment among these subregions, interception of Delta through-put and local watershed yields of sediment that otherwise would contribute the regional sediment load, and the prioritization of dredged sediment reuse among project sites. Without considering these interactions that emerge at the regional scale, the targets within any sub-region are not likely to be adequately realistic.

Charge Question #2

How clear is the basis for selection of the performance measure? How complete are the scientific rationale, the justification, and the supporting references for the selection?

- The Basis for this Measure is clear but incomplete. The need to address climate change, especially sea level rise, by creating or preserving tidal marsh restoration opportunities is well recognized. However, because of limiting sediment supplies, the likely heights and rates of sea level rise, and the concomitant increased likelihood of island levee failure, managed retreat and land use conversion are very likely inevitable aspects of climate change adaptation for the Delta and Suisun. The Measure might focus on subsidence reversal as an early phase of adaptation, but it should acknowledge that the best opportunities of restoration during the latter half of this century and beyond will be provided by land use change at the inland margins of the Estuary that allow for its transgression across the land, where sediment supply is not as limiting.

Charge Question #3

How clear and complete is the scientific basis for setting the targets? How complete is the consideration of key scientific references, available data, and existing monitoring capabilities?

- I have addressed this addressed the above (see first bullet under General Comments; and fifth and sixth major bullets under Charge Question #1). Furthermore, the targets might incorporate opportunities for tidal marsh restoration resulting from managed retreat and land use conversion at the landed margins of the Delta and Suisun (see my comments under Charge Question #2

immediately above). The San Francisco Bay Shoreline Adaptation Atlas produced for the Bay Area and Suisun is an example approach to incorporate tidal marsh restoration into broader adaptation scenarios that also consider land use change to accommodate estuarine transgression.

Charge Question #4

How achievable are the targets relative to the stated time scales?

- The achievability of the targets is unknown, because they have not been validated or rectified based on a rigorous assessment of sediment supply, relative to demand, in the context of climate change. Based on such analyses recently completed for the Bay Area and Suisun, which indicate a very large and possible growing sediment deficit going forward, I expect the targets will need to be revised significantly downward. I also expect that the downward adjustments in the targets cannot be fully mitigated by increasing migration space through upland land use change, although this should be analyzed.

Charge Question #5

How well were scientific uncertainties (both outside and within management control) incorporated in the development of the targets and in the assessment of progress towards the targets?

- There are many kinds of uncertainties, and many of them are large. It may not be reasonable or necessary to address them all in this Measure. The uncertainties associated with future sea level rise heights and rates are adequately addressed. The relationship to carbon budgets might better acknowledge the uncertainties in net flux rates to the atmosphere for carbon as well as other Green House Gasses, notably methane. However, there are some other major sources of uncertainty that should be more fully acknowledged. These include, but are not limited to the following:
    - Changing sediment demand due to climate change (i.e., sea level rise) that increases accommodation space for existing elevations;
    - Changing regional and sub-regional sediment supplies due to changes in watershed yields;
    - Spatial variation in natural processes of sediment delivery to project sites;
    - Prioritized allocation of dredged sediment among sites, and changes in dredging amounts and prioritization for reuse over time;
    - The undecided or unknown role of land use change at the inland margins of the Estuary in future tidal marsh restoration planning;
    - Changes in funding due to changes in public and political will to invest in tidal marsh restoration relative to other aspects of climate change adaptation, or other social programs.

Charge Question #6

Are the identified data sources complete and appropriate to support robust assessment of the performance measure?

- The existing list of data sources and other scientific resources is a good start. I suggest adding the following:
    - Project Tracker of EcoAtlas to track subsidence reversal as a type of restoration project (see first bullet under Charge Question #1);
    - The analyses of sediment supply and demand for tidal marsh mash restoration recently completed for the Bay and Suisun as a model approach to revise the targets for Suisun and the Delta (this report provides a review of existing conceptual and numerical models of tidal marsh accretion;
    - The Wetlands RMP Plan (imminently available from the WRMP website) that provides a science framework and metrics for assessing tidal marsh response to climate change across broad scales of space and time;
    - The San Francisco Bay Shoreline Adaptation Atlas as context for subsidence reversal and other adaptation actions;
    - Monitoring reports for the Montezuma Wetlands Project pertaining to sediment management as a source of realistic information on the costs and timeline of large-scale subsidence reversal.

Charge Question #7

How well are adaptive management and alternative actions considered in performance assessments and reporting?

- A primary outcome of serious adaptive management will be revision of the targets. It is unlikely that they will not require revision, given the uncertain but inevitable effects of climate change and other driving factors on the supply of available sediment relative to its demand. The existing targets therefore should be termed “initial” or “starting” targets.
- It is not clear what will be reported to the DPIIC and other interests every year, if the assessments occur on 5-yr intervals, and given the slow process of project permitting and completion. If the recent analyses of sediment supply and demand for the Bay and Suisun are extended into the Delta, the annual reports could initially cover updates of those analyses, and subsequent results of efforts to prioritize subsidence reversal opportunities based on the analytical results. I expect that the DPIIC will eventually need to help manage and ongoing process of ecological conservation that cover many climate adaptation scenarios, not limited to subsidence reversal.
- Progress in planning, and any assessment results, should be reported at the biennial State of the Estuary Conference and Bay-Delta Science Conference.

Performance Measure (PM) 4.16: Acres of Natural Communities Restored

Restoring large areas of natural communities to provide for habitat connectivity and crucial ecological processes, along with supporting viable populations of native species.

General Comments

- The stated Expectations should generally acknowledge that there are many species of special-status plants and fish and wildlife of conservation concern in the Delta and adjacent riverine, fluvial riparian, and terrestrial-estuarine Transition Zone habitats. While the restoration and protection of salmon and other native fishes of the Delta may be most important at this time, these other species of special legal status (including species covered by the Migratory Waterfowl Treaty Act) cannot be lumped together as "other wildlife" without ignoring their specific habitat requirements during the planning and design of restoration projects.
- An operational relationship between this monitoring and assessment effort and the Bay Area Wetlands Regional Monitoring Program (WRMP) should be explored to find ways to share costs and otherwise unite the Bay and Delta into a single science enterprise for the protection and restoration of the wetlands and related resources of the San Francisco Estuary as a whole. There is a wealth of ideas and information about data collection, management, interpretation, and reporting developed for Bay Area WRMP that is applicable to the Delta, and the Delta effort has much to share with the WRMP. The fact that the emerging science plans to support wetland and riparian restoration and protection in the Delta and the Bay share the Suisun sub-region makes coordination of the plans inevitable, if not imperative at this time.

Charge Question #1

How clear and thorough are the performance measure's metric, baseline, and target? What, if any, additional information is needed?

- The single metric is termed "acres of natural communities restored." This is a laudable objective and metric. However, mapping "communities" is technically very challenging for a variety of reasons. A main difficulty is the ongoing changes in the composition and relative abundance of assemblages of species used to define communities. This will be an increasingly difficulty due to ongoing changes in the distribution of preferred habitat conditions, as affected by climate change. For example, shifts in flood regimes and salinity regimes will drive major changes in the distribution an abundance of intertidal and riparian plants and animals, causing new assemblages or "communities." A better approach going forward is to map habitat types, using an available, standard habitat classification system based on physical factors, such as hydrology and geomorphology. The Delta Aquatic Resource Inventory (DARI) is being produced jointly by DWR and SFEI, with input from NWI of USFWS and NHD from USGS. DARI will be joined to the Bay Area Aquatic Resource Inventory (BARI) to produce one seamless base

map of wetland and aquatic habitat types for the San Francisco Estuary, as a regional version of the California Aquatic Resource Inventory (CARI) endorsed by the CA Water Quality Monitoring Council. DARI can be updated online by local stewards using the CARI editing tool, and is entirely compatible with the Project Tracker Tool of EcoAtlas, which the Delta Plan endorses (see Performance Measure 4.12). When used together, DARI and Project Tracker can enable resource managers to assess the separate contributions of restoration projects and natural (i.e., non-project) changes in the distribution and abundance of habitat types.

- VegCAMP is an important tool for mapping vegetation. Expert application of the VegCAMP protocols yields a detailed map of vegetation alliances and assemblages. But, it does not yield a map of effective animal habitats, or general habitat types. I strongly recommend aligning this Measure with DARI (see bullet immediately above) rather than VegCAMP, Cal Veg, or any other vegetation mapping methodology (also see second bullet under Charge Question #3 below).
- However, there should be a set of metrics based specifically on vegetation. To be more specific, there should be metrics for tracking the primary and secondary successions of plant cover (e.g., total percent cover, percent cover of major dominants, and average cover height) consistent with the metrics proposed for the Bay Area Wetlands RMP (WRMP). Such metrics are essential for assessing ambient and project-based habitat development, in the context of sea level rise, salt water intrusion, extreme climate conditions (e.g., drought and deluge), and other aspects of climate change.
- The Baseline should be the distribution and abundance of habitat types as determined by DARI. The first version of DARI is due to be published in 2020. Using DARI to determine baseline conditions, and to set habitat acreage targets, will align habitat mapping in the Delta with that of Suisun and the Bay, thus setting the stage for accurate future assessments of changes in habitat distribution and abundance due to projects (as assessed using Project Tracker of EcoAtlas) and non-project drivers, such as sea level rise and estuarine transgression, throughout the Estuary. This approach using Project Tracker and DARI will also enable Delta data to be included in state-wide assessments of wetlands and aquatic habitat change, such that changes in the Delta can be compared to changes elsewhere along the California coast.
- Targets should also be based on DARI, as discussed further below (see second bullet under Charge Question #3).

Charge Question #2

How clear is the basis for selection of the performance measure? How complete are the scientific rationale, the justification, and the supporting references for the selection?

- The stated linkages to the Delta Reform Act, Co-equal Goals, and existing fish and wildlife conservation plans are essential. However, the reported rationale for this Measure omits the increasingly urgent need to fully consider how climate change will influence the targets and all efforts to achieve them. The timelines to

achieve the targets span expected major future changes in tidal flooding regime (i.e., local sea level rise), freshwater supply (i.e., timing and heights of peak riverine discharges), and salinity regime (i.e., salt water intrusion) that should be considered in project citing and design.

Charge Question #3

How clear and complete is the scientific basis for setting the targets? How complete is the consideration of key scientific references, available data, and existing monitoring capabilities?

- Setting quantitative, map-based targets based on a synthesis of existing wildlife conservation and recovery plans is compelling. I have not made any effort to determine if the list of plans referenced in the Measure as Appendix Q4 is exhaustive. I suspect it's complete enough to justify the targets.
- The current version of the baseline and targets are organized according to the VegCAMP classification system, as applied to historical natural community types outlined in the Sacramento-San Joaquin Delta Historical Ecology Investigations led by SFEI. Looking forward, I recommend restating the baseline and targets for wetlands and aquatic resources in terms of the Delta Aquatic Resource Inventory (DARI), based on the following considerations.
    - The approach based on VegCAMP facilitated an assessment of historical changes in the distribution and abundance of these communities, for a period during which the changes were due almost entirely to planned land use change, rather than large-scale, unplanned environmental change. In the future, climate change will drive shifts in vegetation species assemblages and alliances that will greatly complicate comparison between future, current, and historical conditions.
    - The use of vegetation mapping as a proxy for habitat mapping was necessitated by a lack of a standardized habitat classification system for the Delta or for the state, plus the lack of modern habitat maps based on a standardized classification system, and the lack of verified linkages between habitat types and wildlife support functions. However, as mentioned above, DARI will be completed in 2020. The DARI classification system exists now.
    - DARI can be combined with a riparian mapping and classification based RipZET (see my review of Performance Measure 4.12) to produce a comprehensive map of habitat types that cover all the wildlife support functions associated with any VegCAMP assemblage or alliance. Furthermore, a crosswalk between DARI habitat types and the California Wildlife Habitat Relationships data base (CWHR) of CDFW has been automated in the Landscape Profile Tool of EcoAtlas. This enables rapid online summaries of habitat amounts and their endemic flora and fauna of special concern for any user-defined area of the Delta or elsewhere in the State.
    - The adoption of DARI as the basis for establishing baseline conditions and future targets does not nullify the existing rationale reported for this Measure. The rationale for adopting DARI is available on the DARI

websites, and compliments the existing rationale. I note that the Bay Area and Central Valley Habitat Joint Ventures have adopted their respective regional versions of CARI (i.e., DARI and BAARI) to track progress toward their strategic conservation goals.
    - Adoption of DARI and Project Tracker provides access to the larger suite of EcoAtlas tools with abundant opportunities to share the costs of consistent, comprehensive, coordinated assessments of wetland and riparian conditions throughout the San Francisco Estuary, and beyond.
- Although vegetation should not be the basis of mapping habitat types going forward, it warrants its own set of metrics for tracking primary and secondary succession, as affected by projects and climate change (see third bullet under Charge Question #1 above).
- The method of allocating acreage targets between the Delta and Suisun, and among the various "communities" is logical and defensible. However, two inevitable, extenuating circumstances should be acknowledged.
    - Climate change, especially sea level rise and increased peak stage of riverine runoff, will increase the extent of tidal and seasonal wetlands, without requiring any purposeful modification of existing Delta landscapes. There should be an analysis of the degree to which the inundation targets will be met passively due to climate change, within the 2050 and 2100 timeframes. This will require superimposing expected tidal and riverine stage heights on DEMs for the Delta and adjoining inland areas (also see second bullet under Charge Question #1 for Performance Measure 4.12).
    - Accelerating sea level rise may cause existing and restored tidal marsh areas to drown, meaning their conversion from wetlands to tidal flat or shallow subtidal environments, slowing or preventing the achievement of tidal marsh targets.
    - it should be acknowledged that project opportunities can be driven by changes in land ownership or other local and regional economic or other factors that cannot be predicted, and that unpredicted circumstances may cause shifts in the allocation of acreage targets among subregions and among habitat types.
- A monitoring program is required beyond what is proposed by the and related Measures to generate the kinds of information needed to guide project citing and design, including purposeful intervention in habitat devolvement, to address the challenges of climate change. As states above (see second bullet under General Comment), an operational relationship between this monitoring and assessment effort and the Bay Area Wetlands Regional Monitoring Program (WRMP) should be explored to find ways to share costs and otherwise unite the Bay and Delta into a single science enterprise for the protection and restoration of the wetlands and related resources of the San Francisco Estuary as a whole.

Charge Question #4

How achievable are the targets relative to the stated time scales?

- It should be noted that achieving the targets for functional acres of selected habitat types will require their evolution or development. Recent and ongoing efforts to produce Habitat Development Curves (HDCs) for wetlands and other aquatic resources (Kentula et al. 1992, Zedler and Callaway 1999, Lowe et al 2014) indicate that tidal marshes can take many decades to naturally achieve reference conditions (i.e., target levels of selected ecosystem services). For this Measure, the rationale for the targets should distinguish between project completion (i.e., when construction is completed), and project success (when the project begins meeting its particular performance standards). I note that project performance standards, as defined by project permits, are starting to shift from desired endpoint conditions, which cannot usually be achieved during any one permit cycle, to adequate progress, as indicated by the project conditions on appropriate HDCs. This is one approach to deal with the uncertainty of project conditions in the long-term, as habitats develop, in the context of climate change. HDCs exist for tidal marsh and depressional wetlands, and a vernal pool HDC is currently in production. The existing riverine HDC only pertains to wadeable streams of the Southern California Bight.
- The timelines should be further defined with increments of time that correspond to more realistic milestones in progress toward the targets. The current milestones represent linear progress. More realistic milestones will reflect changes in key factors, including available lands, funding, expected rates of sea level rise, and expected rates of increases in peak riverine discharges (relative to land elevations). Perhaps 2-3 alternative trajectories could be developed, based on different assumptions for these facts, and used to set alternative interim 5-10 year targets.

Charge Question #5

How well were scientific uncertainties (both outside and within management control) incorporated in the development of the targets and in the assessment of progress towards the targets?

- I have suggested significant changes in the basis and approach for assessing baseline conditions, setting targets, and tracking progress that are intended to better address the various major kinds of uncertainty relating to climate change. These categories are:
    - Intractable shifts in the distribution and abundance of habitat types as defined by plant species composition (habitat types should be defined by hydro-geomorphic factors, as in DARI);
    - Habitat development within projects (project performance should be defined based on project position along Habitat Development Curves);
    - Vegetation metrics are needed to assess the effects of various aspects of climate change on the plant and wildlife support functions of habitats within and outside projects;

- Efforts to monitor and assess wetland, riparian and aquatic habitats in the Delta should be tightly coordinated with the Bay Area WRMP to share costs and thereby reduce the risk of inadequate funding.

Charge Question #6

Are the identified data sources complete and appropriate to support robust assessment of the performance measure?

- I suggest that the Delta Plan should utilize the EcoAtlas tools, including but not limited to Project Tracker, the landscape Profile Tool, CRAM, HDCs, and DARI. With regard to this Measure 4.16, adoption of DARI, due to be published in 2020, is especially important for reasons given above (see comments regarding Charge Questions #1 and #3 above)

Charge Question #7

How well are adaptive management and alternative actions considered in performance assessments and reporting?

- A primary outcome of serious adaptive management will be revision of the targets. It is unlikely that they will not require revision, given the uncertain but inevitable effects of climate change and land availability on the future status of existing habitats and projects. The existing targets therefore should be termed “initial” or “starting” targets.
- It is not clear what will be reported to the Delta Plan Interagency Implementation Committee and other interests every year, if the assessment occurs on 5-yr intervals, and given the slow process of project permitting. If the WRMP is extended into the Delta, especially if Delta Benchmark Sites are established (see the fifth bullet under Charge Question #5 of my review of Performance Measure 4.12), the annual reports could cover status and trends of habitat response to various key factors of climate change.
- Progress in planning, and any assessment results, should be reported at the biennial State of the Estuary Conference and Bay-Delta Science Conference.