Draft Strategic Plan Appendix F: Non-Flow Measure Accounting

1 Introduction and Overview

This appendix is complementary to and builds on Section 3.1.4 in the Draft Strategic Plan describing the approach for Non-flow Measure Accounting. The following content spells out the accounting protocols that will compare pre- and post-implementation conditions in support of determining whether the Non-flow Measure commitments as detailed in the March 2022 MOU and Term Sheet have been met. Section 2 describes detailed accounting methods for tributary salmon spawning, in-channel rearing, and floodplain rearing habitats; Section 3 describes accounting methods for Bypass Floodplain projects, and Section 4 describes accounting approaches for Tidal Wetland Projects.

2 Accounting Protocols for Tributary Non-flow Measures

The following habitat accounting protocols pertain to tributary spawning, in-channel rearing, and tributary floodplain rearing habitat enhancement measures outlined in Table 25 of the Strategic Plan.

Habitat accounting for tributary spawning, in-channel rearing, and tributary floodplain rearing habitat enhancement measures accounts for the acreage of implemented habitat enhancement measures based on design criteria for specific projects. Design criteria include water depth and water velocity, as well as substrate for spawning measures, cover for tributary in-channel and tributary floodplain rearing measures (Table F-1), and inundation frequency and duration for tributary floodplain rearing measures.

Accounting is a site-specific assessment that will be conducted at the completion of each individual project construction and will serve as an incremental step for whether Parties have met their Non-flow Measure total acreage commitments described in the March 2022 MOU and Term Sheet and applicable amendments, and summarized in Table 25 of the Strategic Plan. Tributary/Delta Governance Entities (GEs), in coordination with the Science Committee, will build upon this methodological framework to develop detailed assessment protocols tailored to the specific habitat enhancement measures being implemented within their respective governance area. The accounting framework presented below is intended to be applied at the individual project level.

2.1 Design Flow Considerations for Tributary Accounting

Assessment of site-specific Non-flow Measure implementation requires spatially explicit quantification of those areas within a project boundary (i.e., “footprint”) that conform with specified design criteria at design flows. The term “design flows” refers to the range of flows over which a project is designed to create habitat. For the methodological steps identified below, the flows at which the “pre-project” and “as-built” conditions are evaluated must be the same to enable equitable comparisons, and the project design flows provide a meaningful basis for comparison.

Accounting for tributary spawning habitat, in-channel rearing habitat, and tributary floodplain rearing projects will be conducted over a range of design flows. The following section describes considerations regarding the identification of design flows for tributary projects, as well as how design flows relate to accounting for those projects.

The term “design flows” generally describes the range of flows over which habitat features constructed for a given project are intended to function (Copeland et al. 2001). For any given project, design flows can vary based on a number of factors including: (1) the Non-flow Measure (e.g., spawning, in-channel rearing, tributary floodplain rearing); (2) the desired habitat features (e.g., perennial side-channel, seasonal side-channel, alcove, etc.); and (3) the biological objectives (e.g., increasing growth and survival for initial fry rearing, maintaining and promoting diversity of rearing and emigration life histories). In addition to these factors, design flows reflect the fluvial geomorphological interactions between site-specific topography and hydrology (Copeland et al. 2001; Flosi et al. 2010).

Projects will be designed and constructed to meet water depth and velocity design criteria over a range of flows. Relevant permit requirements will ensure that design flows will be within the range of those typically observed and that habitat is available across a range of flows. Because of this, accounting will include development (or revision) of habitat-flow relationships over a range of flows reflective of those assumed in the Final Draft Scientific Basis Report Supplement (SWRCB 2023) for each tributary.

Development of these new or revised relationships will form the basis of a Consistency Assessment that will be designed to compare the availability of habitat (meeting design criteria) over the range of applicable flows realized through implementation with the assumptions made in the Final Draft Scientific Basis Report Supplement (SWCRB 2023).

2.1.1 Design Flows for Spawning Habitats

Despite the project- and feature-specific nature of design flows, certain generalities can be applied to the identification of design flows depending on the Non-flow Measure. For example, tributary spawning habitat for salmonids would not be expected to be effective if located at elevations associated with flows greater than the bankfull channel flow. Redd construction and, more importantly, embryo incubation require sufficient duration of inundation that is typically not realized outside of the bankfull channel. Thus, a general range of flows appropriate for designing and implementing tributary spawning habitat is the range of flows extending from baseflow to the bankfull channel flow. Within this general range, it is appropriate to examine hydrological records (i.e., monitored flows) or hydrological model output to identify a narrower range of flows that typically occur, or are intended to be utilized during the spawning period relevant to the specific project site.

2.1.2 Design Flows for Tributary Floodplain and In-Channel Rearing Habitats

The identification of design flows for tributary rearing is more complex because tributary rearing Non-flow Measures occur in two general forms: tributary floodplain rearing and in-channel rearing.

Design criteria for tributary floodplain rearing Non-flow Measures include targets for inundation duration, intra-annual frequency, and inter-annual frequency, and a flow event meeting these targets is described as a “Meaningful Floodplain Event” (“MFE”). Specifically, tributary floodplain projects will be designed with targets for inundation frequency and duration that are consistent with the intention of the MFE described in the 2023 Final Draft Scientific Basis Report Supplement (SWRCB 2023)[1], ensuring that tributary floodplain rearing projects will be available over a range of flows. See Section 2.2.3 for addition details.

The application of MFE targets necessarily restricts the range of potential design flows for tributary floodplain rearing projects because they are directly tied to the hydrologic regime. For this reason, tributary floodplain projects will incorporate design flows in consideration of targets for inundation frequency and duration that are consistent with the intention of the MFE described in the Final Draft Scientific Basis Report Supplement (SWRCB 2023). Other inundation designs consistent with the

[1] Design criteria for the Tuolumne River are pending development and will target consistency with the Tuolumne River Scientific Basis Report that is being prepared by the State Water Board.

intention of providing suitable rearing habitat may also be developed for specific tributaries and projects. For example, a tributary-specific approach may include consideration of the actual flows that occur during qualifying MFEs in the identification of design flows. Each Tributary/Delta GE will identify appropriate design flows for tributary floodplain rearing projects in coordination with the Science Committee. These intra- and inter-annual frequency and duration targets will be used to design and construct tributary floodplain rearing projects that meet water depth and velocity design criteria over a range of flows, consistent with the intent of the Final Draft Scientific Basis Report Supplement (SWRCB 2023).

For tributary in-channel rearing projects, the range of design flows depends on the project- and site-specific biological objectives. For example, it may be desirable to design some project features (e.g., seasonal side channels) to provide in-channel habitat at a higher flow or over a broader range of flows than those associated with perennially inundated in-channel habitat. Other features within the same overall project footprint could be designed to provide in-channel rearing habitat within the perennially inundated channel elevation, and it also is possible to design in-channel habitat features to function over a range of flows that spans the perennially inundated channel elevation. As such, it may be appropriate to identify a range of design flows for each in-channel rearing habitat feature based on feature-specific geospatial boundaries associated with distinct topographical delineation, or by the project-specific elevation associated with the flow that activates off-channel inundation.

2.2 Design Criteria for Tributary Spawning, In-channel Rearing, and Floodplain Rearing Habitats

2.2.1 Design criteria for tributary salmonid spawning Non-flow Measures

Given the widely accepted premise that water depth, water velocity, and substrate size strongly influence choice of spawning location by salmonids, those characteristics will be used to account for implementation of spawning habitat enhancement projects included in Non-flow Measure commitments identified in Table 25 of the Strategic Plan. Dominant substrate is defined by the particles that compose more than fifty percent of the surface area (Gard 1988, 2006, 2009). Substrates in Gard 2006 with a Habitat Suitability Index (HSI) Score ≥ 0.5 ranged between 2.5 cm and 10 cm (approximately 1-4 inches, fall run Chinook salmon in the Merced River and Clear Creek). This range was reduced to 2 cm (0.75 inches) to accommodate smaller sized spawning fish (i.e., including *O. mykiss*) using the equation developed in Riebe et al. 2014 and Merz et al. 2018 (Table F-1).

The specific accounting protocol for spawning habitat actions is described below in the Section 2.3, and it involves evaluating the acreage conforming to the approved design criteria at a range of flows compared to the pre-project condition.

Table F-1. Design criteria for the accounting of the relevant Non-flow Measure commitments on Sacramento Valley tributaries and floodplains (habitat construction, restoration, and enhancements, Table 26).

Non-flow Measure	Water Depth (ft)[1]	Water Velocity (fps)[1]	Other
Spawning	1.0 – 2.5	1.0 – 4.0	**Substrate[2]:** Dominant substrate size 2 cm-10 cm (0.75 in – 4.0 in)
In-stream Rearing	0.5 – 4.0	0.0 – 3.0	**Cover[3]:** Sufficient cover to provide suitable rearing habitat for juvenile salmonids, defined as a minimum of 20% coverage of cover features that have a Habitat Suitability Index (HSI)

Non-flow Measure	Water Depth (ft)[1]	Water Velocity (fps)[1]	Other
			score ≥ 0.5 supported by the scientific literature (listed in Table F-2) (further discussed below in Section 2.2.2).
Tributary Floodplain Rearing	0.5 – 4.0	0.0 – 3.0	**Cover[3]:** Sufficient cover to provide suitable rearing habitat for juvenile salmonids defined as a minimum of 20% coverage of cover features that have a Habitat Suitability Index (HSI) score ≥ 0.5 supported by the scientific literature (listed in Table F-2) (further discussed below in Section 2.2.2). **Floodplain Function:** Sufficient frequency, magnitude, and duration of inundation to provide benefits for rearing salmonids (further discussed below in Section 2.2.3)[4].

[1] Water depth and velocity criteria for each Non-flow Measure are consistent with SWRCB 2023 and identified by the Conservation Planning Foundation for Restoring Chinook Salmon and O. mykiss in the Stanislaus River (Anchor QEA, LLC 2019). Proposed variances from these specific values will be reviewed in the design criteria review process outlined above.

[2] Dominant substrate is defined by the particles which compose more than fifty percent of the surface area (Gard 1998, 2006, 2009). Substrates in Gard 2006 with HSI Score ≥ 0.5 ranged between 2.5 cm and 10 cm (fall run Chinook salmon in the Merced River and Clear Creek). This range was reduced to 2 cm (0.75 in) to accommodate smaller sized spawning fish (i.e., including *O. mykiss*) using the equation developed in Riebe et al. 2014 and Merz et al. 2018. Proposed variances from these specific values will be reviewed in the design criteria review process outlined above.

[3] Table F-2 synthesizes cover categories with a Habitat Suitability Index (HSI) Score ≥ 0.5. Cover will be evaluated at project completion in accordance with final phases and/or full implementation of the project design (e.g., vegetation at maturity).

[4] For instances where daily data or tributary-specific high-resolution models are available, a range of combined duration and frequency targets may adhere to the rationale of the Meaningful Floodplain Event (MFE, SWRCB 2023) and provide opportunities for adaptive management.

2.2.2 Design criteria for in-channel salmonid rearing Non-flow Measures

Cover has been identified as a key element of freshwater rearing sites within designated critical habitat for ESA-listed salmonids (NMFS 2005) and is therefore included as a design criterion along with quantitative design criteria water depth and water velocity for both in-stream and floodplain rearing habitat enhancement projects intended to meet Program Non-flow Measure commitments (Table 25, Strategic Plan). Cover will be evaluated at project completion in accordance with final phases and/or full implementation of the project design (e.g., vegetation at maturity) by the Tributary GE, as coordinated by the Science Committee. Table F-2 describes a range of cover types with a HSI Score ≥ 0.5. For in-stream and floodplain rearing acreage to conform to the narrative criterion for cover, a minimum of 20% of the habitat acreage (i.e., cover features will constitute 20% of the habitat area) that meets the water depth and water velocity ranges in Table F-1 will have combinations of features described in Table F-2 (Raleigh 1986). Juvenile salmonids are often found within 1m of a cover element (Moniz and Pasternack 2019, Hardy et al. 2006), which represents the burst distance for juvenile salmonids (Hardin et al. 2005). Methods for quantifying change in habitat acreage will be substantiated by peer-reviewed literature and best available science. Other designs consistent with the intent of providing suitable and adequate cover for juvenile rearing can be considered through the design criteria review process described above. Cover is further addressed in the Science Plan through Hypotheses H_{R3} and $H_{TribFP1}$.

The specific accounting protocol for rearing Non-flow Measures is described below in Section 2.3, and involves evaluating the acreage of habitat conforming to the approved design criteria at a range of flows compared to the pre-project condition.

Table F-2. Cover feature categories with HSI Score ≥ 0.5, reviewed in San Joaquin River Restoration Program's "Minimum Floodplain Habitat Report for spring and fall-run Chinook salmon" November 2012. Additional references with HSI values were included if they presented empirical results or were the outcome of a clearly articulated collaborative process. The intent of a HSI score ≥ 0.5 is to identify highly suitable cover features for inclusion in rearing habitat actions.

Cover feature type	HSI Reference	Description
Woody debris	Raleigh 1986, Sutton et al. 2006, Gard 2006	Fine woody vegetation + overhead cover, branches (2.5-30.5 cm diameter) and logs (> 30.5 cm diameter, Gard 2006)
Boulder	Sutton et al. 2006	Small-medium (12-48 inches) and large (>34 inches) boulder (Sutton et al. 2006)
Cobble	WDFW 2004[1]	Small (3-6 inches) and large (6-12 inches, WDFW 2004)
Grass/ Herbaceous	Sutton et al. 2006, WDFW 2004	Emergent rooted aquatic grass and sedges (Sutton 2006), and tall (>3 feet) dense grass (WDFW 2004)
Willow and other riparian vegetation	Moniz and Pasternack 2019, YCWA 2013, Sutton et al. 2006	Trees, bushes, willow riparian, willow scrub and other riparian vegetation, (Sutton et al. 2006) taller than 2 feet above the ground (YCWA 2013).
Undercut bank	Raleigh 1986, Sutton et al. 2006, WDFW 2004, Hampton 1988	Undercut at least 0.5 ft (Hampton 1988)
Aquatic vegetation	Sutton et al. 2006, WDFW 2004	Non-emergent rooted aquatic
Overhanging vegetation	Sutton et al. 2006, WDFW 2004	Near or touching water (WDFW 2004)
Root wad, logjam/submerged brush pile and large wood	Sutton et al. 2006, WDFW 2004, Hampton 1988	Logs and root wads greater than 9 inches in diameter (Hampton 1988)

[1] The reference for cobble as a cover element is based on Recommended Preference (WDFW 2004). The San Joaquin River Restoration Program's "Minimum Floodplain Habitat Report for spring and fall-run Chinook salmon" November 2012 does not conclude that cobble has an HSI value > 0.5, however, cobble is included as an acceptable cover feature because the WDFW 2004 Recommended Preference values were developed from empirical observations from multiple habitat suitability studies, and were intended to be applied to instream flow and habitat modeling.

2.2.3 Design criteria for tributary floodplain salmonid rearing Non-flow Measures

Intermittently or seasonally wetted areas that support floodplain processes are an important element of rearing habitat for salmonids. Therefore, in addition to the water depth, water velocity, and cover criteria for in-stream rearing habitat (Table F-1, Section 2.2.2), tributary floodplain habitats will be designed with targets for inundation frequency and duration that are consistent with the intention of the Meaningful Floodplain Event (MFE) described in the Final Draft Scientific Basis Report Supplement

(SWB in preparation). In addition, tributary floodplain inundation regimes may also be designed in a project-specific manner and in accordance with tributary-specific flow provisions.

Floodplain rearing projects are intended to provide sufficient frequency, magnitude, and duration of inundation as described in Table F-1 as well as the water depth, water velocity, and cover criteria. Accounting for floodplain rearing Non-flow Measure commitments will be based on modeled inundation frequency and duration, using modeling assumptions and hydrological time series consistent with those described in the Final Draft Scientific Basis Report Supplement (SWRCB 2023).

For instances where daily data or tributary-specific high-resolution models are available, a range of combined duration and frequency targets may adhere to the rationale of the MFE and provide opportunities for adaptive management. For example:

- Inter-annual frequency: Inundation 2 out of every 3 years on average and within a range of 50% to 80% of years.
- If modeled duration of inundation is between seven and 18 days, floodplain projects should target at least two distinct inundation events in the February through June rearing period. Grosholz and Gallo (2006) recommend repeated flood pulses at intervals of 2- to 3-weeks to best support native fish.
- If floodplain projects are designed for duration of inundation greater than 18 days, a single inundation occurrence during the February through June rearing period will satisfy the intention of the MFE criteria. The inundation habitat criteria in the Chinook Salmon Habitat Quantification Tool (HQT) for the CVPIA Science Integration Team assert that floodplain suitability is highest at 18-24 days (suitability weight of 1.0).
- Other inundation designs which target floodplain function consistent with the intention of providing suitable rearing habitat will also be considered by the design criteria review process described above. Tributary floodplain inundation regime may also be designed in a project-specific manner and in accordance with tributary-specific flow provisions.

The specific accounting protocol for tributary floodplain rearing Non-flow Measures is described below in Section 2.3, and involves evaluating the acreage conforming to the approved design criteria at a range of flows compared to the pre-project condition. The observed inundation area, frequency, and duration will be tracked and reported as part of the habitat suitability assessment described in Section 4.1.1 of the Science Plan.

2.3 Acreage Protocol for Tributary Spawning, In-channel Rearing, and Floodplain Rearing

Accounting assessments will be conducted at the time of project construction completion to evaluate whether the physical conditions at site-specific measures correspond with project specifications and design criteria.

The general methodology for evaluating the implementation of constructed tributary Non-flow Measures for Chinook salmon spawning and rearing habitat construction, restoration, and enhancements consists of the following steps at the time of project construction completion and will be the methodology for comparing the realized acreage with the commitments of the Term Sheet to determine when the commitments have been met.

In addition to quantifying the area of implemented habitat meeting design criteria for accounting, the methodology below also generates information (i.e., project-specific habitat-discharge relationships) that can be utilized for other, future Non-flow Measure assessments. These additional assessments will include a comparison of the additional acreage of suitable habitat resulting from Non-flow Measures with the acreage anticipated in the Final Draft Scientific Basis Report Supplement (SWRCB 2023). These assessments can enable a comparison of realized acreage with initial estimates of the Final Scientific Basis Report Supplement[2] (i.e., the Consistency Assessment described in Section 3.1.3 of the Strategic Plan) and will be provided to the State Water Board as part of basin-wide suitability assessments anticipated in the Triennial Synthesis Reports.

2.3.1 "Pre-Project" Characterization

1) Accurately characterize "pre-project" physical conditions[3] within specific project boundaries ("footprint"). Characterization of physical conditions[4] includes topography, substrate, and cover.
2) Create a digital elevation model (DEM) based on the pre-project topographical characterization and create substrate and cover rasters (see discussion of raster development below) for the project footprint.
3) Apply available two-dimensional ("2D") hydraulic models to calculate water depths and velocities within each computational pixel[5] within the project footprint at each modeled flow within the range of design flows.
4) Determine where design criteria (Table F-2) are met at each modeled flow within the range of design flows for each computational pixel within the project footprint using hydraulic (e.g., water depth and velocity) and relevant non-hydraulic (e.g., substrate for spawning) criteria as binary functions. In other words, if a computational pixel corresponds with the hydraulic and applicable non-hydraulic criteria, then the area represented by that pixel is considered to meet design criteria.
5) Sum the area of all computational pixels within the project footprint that meet design criteria to identify the explicit area (acres) that meet design criteria at each modeled flow within the range of design flows.

2.3.2 "As-Built" Characterization

6) Modify characterization of the physical conditions within the project footprint to reflect the constructed project features and develop a modified DEM as well as updated substrate and cover rasters (see discussion of raster development below).

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[2] The Tuolumne River Scientific Basis Report Supplement is being prepared by the State Water Board and as such, the nature of any similar assessments specific to the Tuolumne River is under development, are subject to negotiation amongst the parties, and will be included in the Scientific Basis Report Supplement for the Tuolumne River.

[3] For accounting purposes, areas that may exhibit some hydraulically suitable habitat under Pre-Project conditions but that are unsuitable or non-functional for other overriding reasons (e.g., known juvenile stranding or isolation features, predator hotspots, etc.) over the range of design flows are not included in the calculation of area meeting design criteria for the Pre-Project condition.

[4] Topographical characterization can be developed through traditional surveying techniques, multibeam echo sounding bathymetry, and/or LiDAR data acquisition. Substrate and cover characterization can be developed through field survey mapping, geo-referenced aerial imagery (e.g., fixed-wing aircraft, unmanned aerial vehicles, satellite), and/or LiDAR data acquisition.

[5] Several factors contribute to the size of DEM and 2D model output mesh size, including the quality/density of LiDAR or other topographic data, computational ability, and desired accuracy of output. For high resolution results, a 3 ft. by 3 ft. DEM and 2D hydraulic model output mesh size is generally appropriate for the suite of habitat evaluations for the Program.

7) Apply available hydraulic models to calculate water depths and velocities within each computational pixel within the project footprint at each modeled flow within the range of design flows.
8) Determine where design criteria (Table F-1) are met at each modeled flow within the range of design flows for each computational pixel within the project footprint using hydraulic (e.g., water depth and velocity) and relevant non-hydraulic (e.g., substrate for spawning) criteria as binary functions (Figure 1, Figure 2).
9) Sum the area of all computational pixels meeting design criteria within the project footprint to identify the explicit area (acres) that meet design criteria at each modeled flow within the range of design flows.

2.3.3 "Pre-Project" vs. "As-Built" Differencing

10) At each modeled flow within the range of design flows, identify spatially explicit areas that meet design criteria in the as-built condition that did not meet design criteria in the pre-project condition (i.e., "gains"), as well as the spatially explicit areas that do not meet the design criteria under the as-built condition but met design criteria under the pre-project condition (i.e., "losses", Figure 3).

2.3.4 Total Acreage of Unique Habitat Created Over the Range of Design Flows

Providing increases in habitat areas at different flows provides notable fisheries benefits (e.g., more diverse rearing conditions across a range of flows, potential for improved juvenile life history diversity). Therefore, a quantitative metric was developed to account for the total areal extent of habitat gains and losses within the project footprint at each flow over the range of design flows. This metric is derived from the spatially explicit incremental gains and losses over the range of design flows, which shows the incremental amount of additional habitat gains and losses as flows increase from the lowest design flow up to the next higher modeled flow, without double-counting any areas.

To calculate the total amount of spatially explicit (i.e., unique) habitat gains and losses created at each modeled flow over the range of design flows relevant to the Non-flow Measure (i.e., spawning, in-channel rearing, tributary floodplain rearing) being evaluated, the following steps will be undertaken.

11) Using the flow-specific difference rasters ("as-built" minus "pre-project") generated in Step 10, identify the areas of habitat gains and losses at the lowest design flow.
12) At the next higher modeled flow, calculate the amount of habitat gains and losses additional to (i.e., not contained within the spatial extent) the areas identified in the previous step.
13) Repeat Step 12, increasing to the next higher modeled flow with each iteration, for all remaining modeled flows within the range of design flows.
14) Aggregate all areas of flow-specific habitat gains and losses identified in the previous steps to identify the overall areas of gains and losses over the range of design flows.

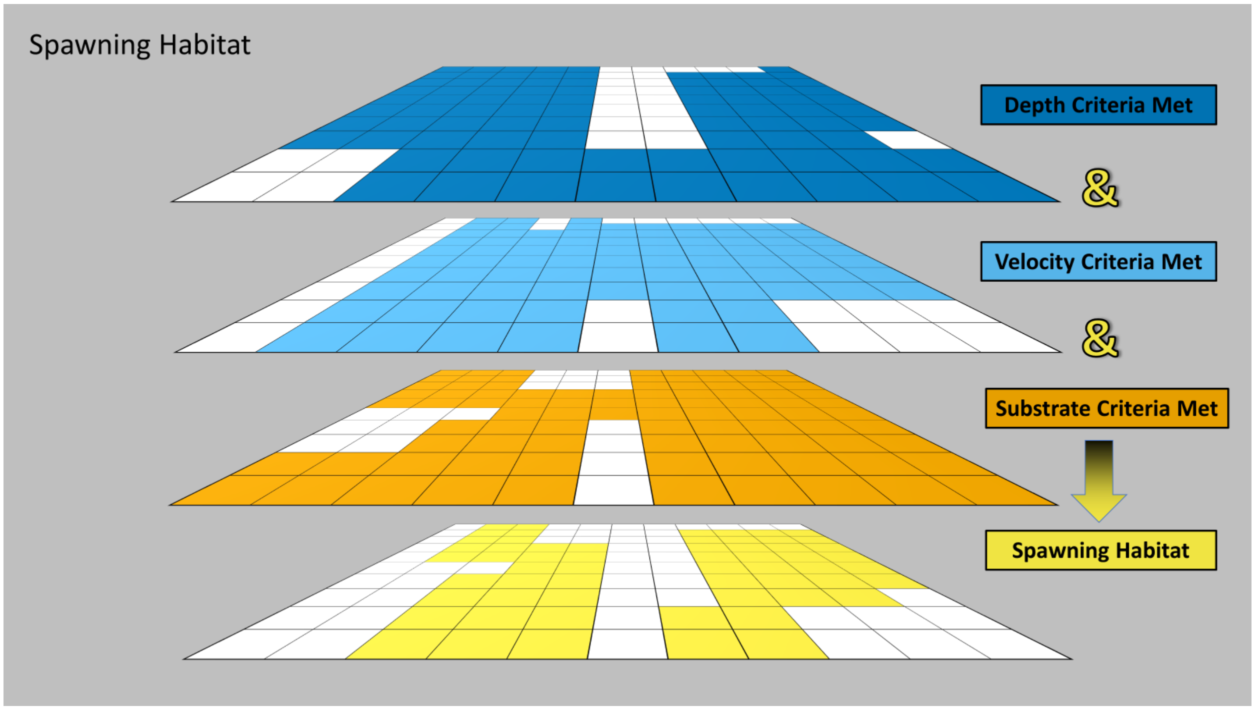


Figure 1. Conceptual representation of the determination of spawning acreage where design criteria (Table F-1) are met at a modeled flow in the range of design flows for each computational pixel within the project footprint using hydraulic (water depth and velocity) and relevant non-hydraulic (substrate for spawning) criteria as binary functions. In other words, if a computational pixel corresponds with the hydraulic and applicable non-hydraulic criteria, then the area represented by that pixel is considered to meet design criteria. The same process is used for both "pre-project" and "as-built" conditions.

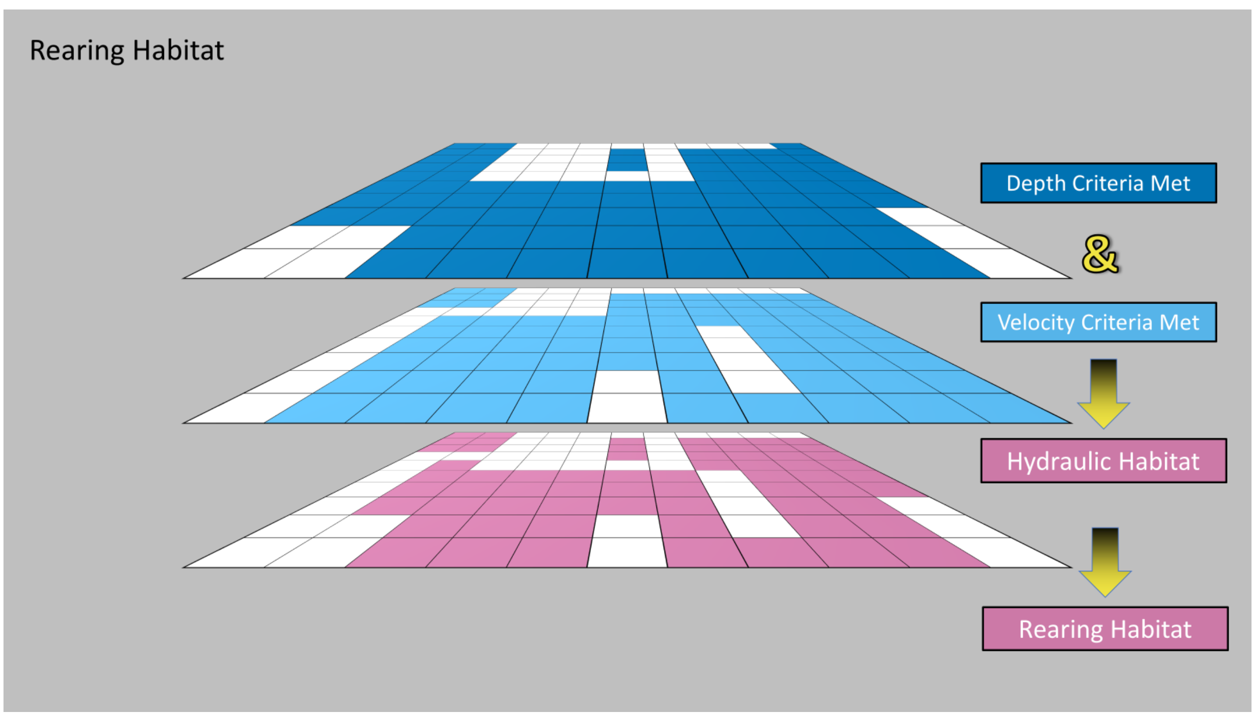


Figure 2. Conceptual representation of the determination of rearing acreage where design criteria (Table F-1) are met at a modeled flow in the range of design flows for each computational pixel within the project footprint using

hydraulic (water depth and velocity) criteria. Treated as binary functions, if a computational pixel corresponds with the hydraulic criteria, then the area represented by that pixel is considered to meet design criteria. The same process is used for both "pre-project" and "as-built" conditions.

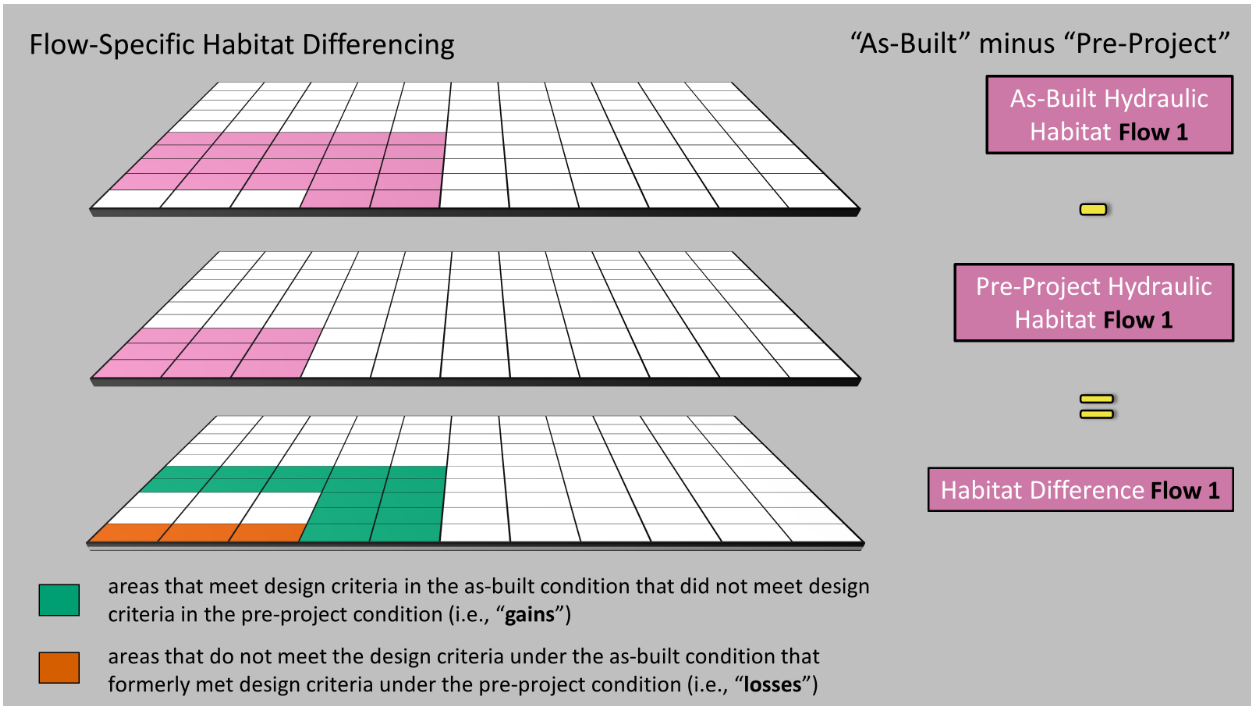


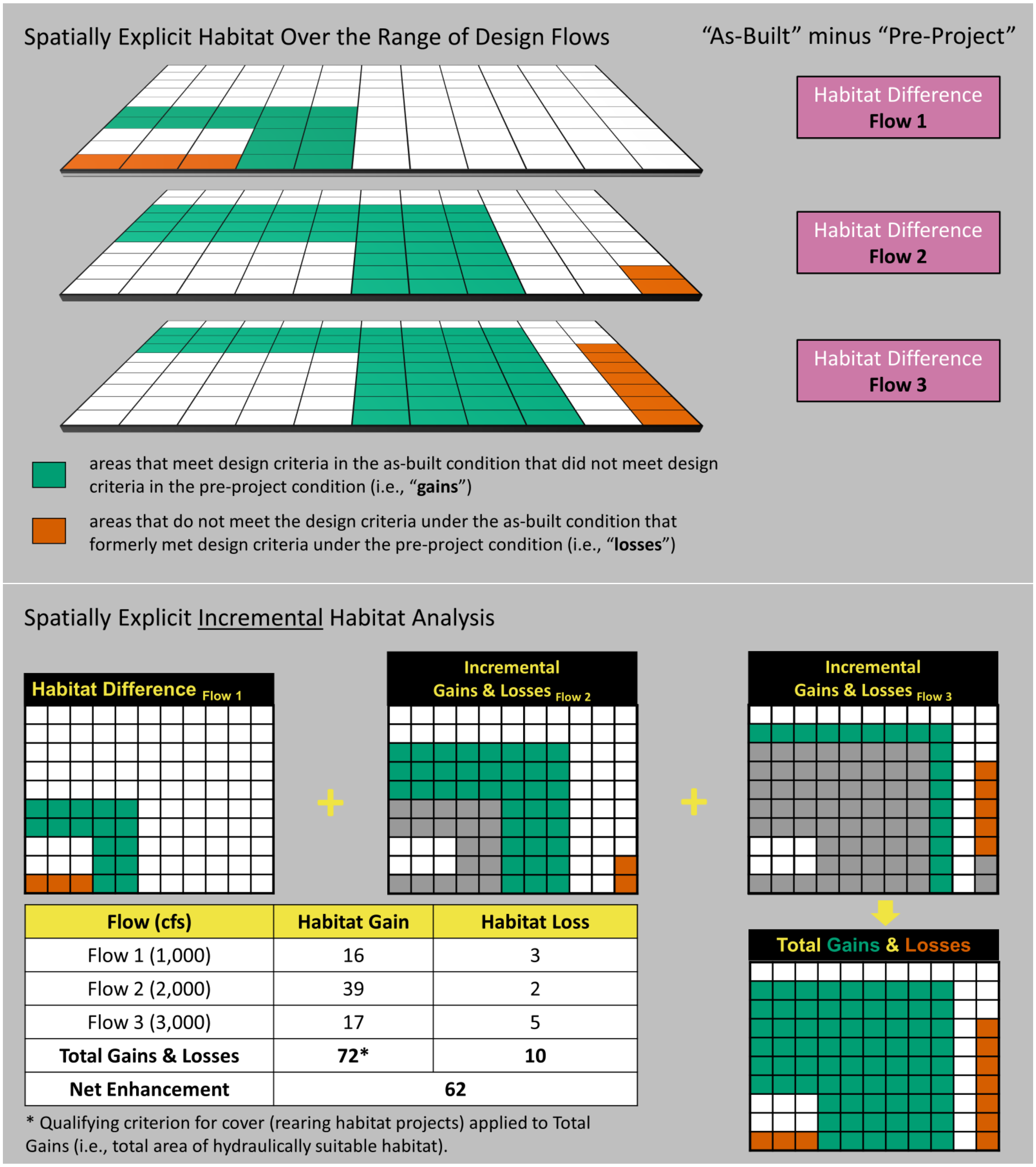
Figure 3. Example showing the differencing of the "as-built" and "pre-project" DEMs at a single flow in the range of design flows to identify the flow-specific areas of habitat gains (i.e., spatially explicit areas that meet design criteria in the as-built condition that did not meet design criteria in the pre-project condition; green cells) and habitat losses (i.e., spatially explicit areas that do not meet the design criteria under the as-built condition that formerly met design criteria under the pre-project condition; red cells).

2.3.5 Application of Cover to Rearing Non-Flow Measure Accounting

For each tributary in-channel and tributary floodplain rearing Non-flow Measure, cover is a qualifying criterion such that if ≥20% of the area meeting hydraulic criteria also includes cover features (HSI≥0.5, Table F-2), then the area meeting hydraulic criteria represents the acreage meeting design criteria. If the ≥20% qualifying cover criterion is not met, then no newly constructed acreage for a specific Non-flow Measure is counted. This qualifying criterion is applied to the total acreage of habitat gains calculated in Step 14 (detailed cover raster development is described below).

15) Calculate the difference between the total area of habitat gains and the total area of habitat losses to identify the total net area of the Non-flow Measure for accounting.

Figure 4 provides an example of Steps 11 through 15 to illustrate the concept of identifying and aggregating spatially explicit habitat gains and losses associated with different flows over the range of design flows. As illustrated in Figure 4, this approach considers the entire areal extent of unique habitat gains and losses created across the range of design flows without double counting any areas.



Flow (cfs)	Habitat Gain	Habitat Loss
Flow 1 (1,000)	16	3
Flow 2 (2,000)	39	2
Flow 3 (3,000)	17	5
Total Gains & Losses	**72***	**10**
Net Enhancement	**62**	

* Qualifying criterion for cover (rearing habitat projects) applied to Total Gains (i.e., total area of hydraulically suitable habitat).

Figure 4. Example showing the identification and aggregation of flow-specific habitat gains (green cells) and losses (red cells) resulting from implementation of a project. The top portion of the figure demonstrates the flow-specific spatially explicit habitat difference rasters. The bottom portion of the figure demonstrates the incremental habitat gains and losses by flow across the range of design flows. In this example, if the Non-flow Measure being evaluated is rearing habitat, the application of the qualifying criterion for cover would be applied to the overall area of habitat gains corresponding with the overall area meeting the hydraulic design criteria (i.e., water depth and velocity). The final step in accounting is to calculate the difference between the overall area of habitat gains and the overall area of habitat losses to identify the total net area of the Non-flow Measure.

2.3.6 Cover Raster Development

For accounting assessment application, cover feature types must have a HSI value of 0.5 or greater, described in Table F-2. Cover features within the project footprint are mapped and a shapefile is generated in GIS containing the mapping data. Cover is typically mapped as point, line, or polygon features as appropriate to the cover feature type. Juvenile salmonids are often found within approximately three feet of a cover element (Moniz and Pasternack 2019; Hardy et al. 2006), which represents the burst distance for juvenile salmonids (Hardin et al. 2005). Consequently, each suitable non-cobble cover feature element in the shapefile will be buffered out by three feet (Moniz and Pasternack 2019). For building the cover raster, each raster pixel with a centroid that falls within the buffered cover shapefile is assigned that cover type (Figure 5).

Cover will be evaluated at project completion in accordance with final phases and/or full implementation of the project design (e.g., vegetation at maturity). For projects that incorporate riparian vegetation planting or planned recruitment into the project design, the expected resultant area of riparian vegetation in the mature condition should be a species-specific estimate of mature canopy size using, for example: (1) literature-based data or models for riparian vegetation recruitment, growth, size-at-maturation, or survival (e.g., HEC-RAS-RVSM (Riparian Vegetation Simulation Module; Zhang et al. 2019)); or (2) analyses of recruitment, growth, and size based on local observations of riparian vegetation. This estimated area of mature vegetation, including the buffer applied to the perimeter of the mature vegetation area estimate, will be incorporated into the quantification of cover (i.e., development of the cover raster) for assessing whether the cover qualifying criterion is met for accounting purposes on a project-specific basis. It is recognized that the actual realized area of riparian vegetation over time would be analyzed during suitability assessments.

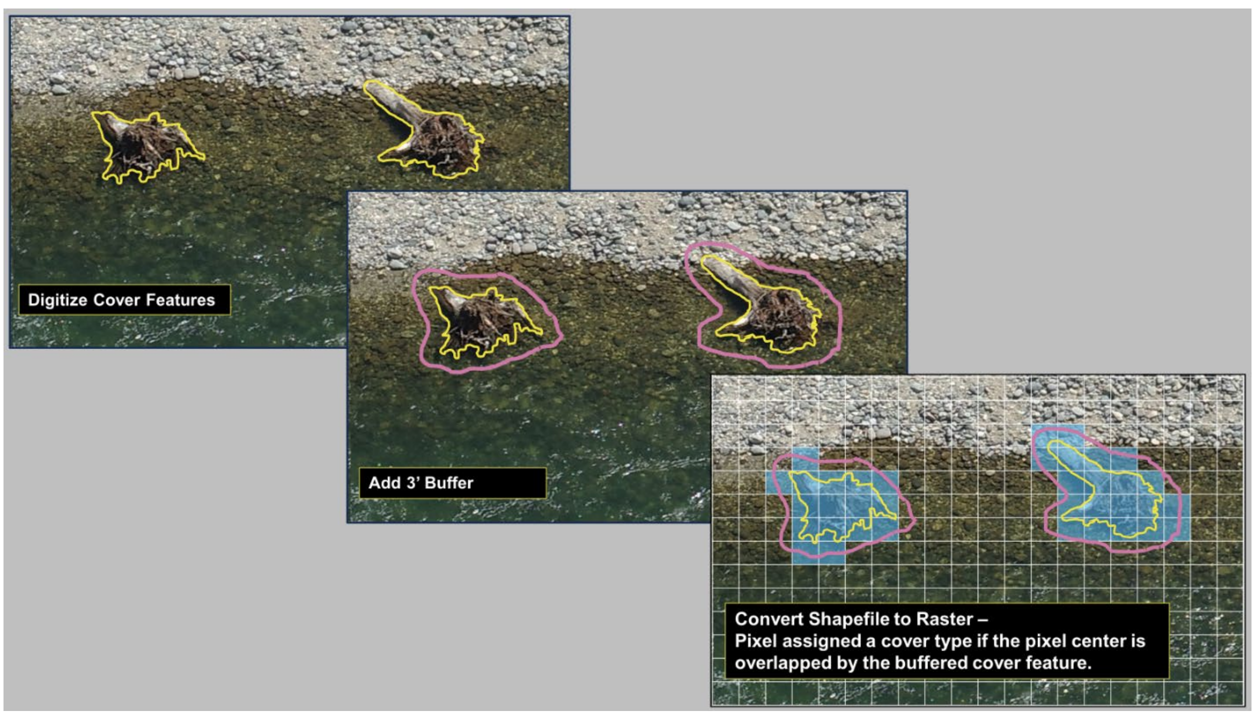


Figure 5. Example of digitizing cover features, applying a buffer to cover features (example of rootwads shown), and converting a cover shapefile to a cover raster. Note: the buffer also would be applied to estimated areas of vegetation at maturity.

2.3.7 Substrate Raster Development

Substrate within the project footprint is mapped, typically as polygon features where each polygon contains an area of substrate with a unique percent composition of grain size classes. For accounting assessment application, appropriate substrate for spawning Non-flow Measures is characterized as having a dominant (>50%) grain size in the range of 0.75 in – 4.0 in as described in Table F-1. Substrate polygons with dominant grain size classes in this range are identified and a shapefile is generated containing substrate polygons that meet design criteria. For building the spawning substrate raster, each raster pixel with a centroid that falls within the spawning substrate shapefile is identified as meeting the substrate criteria for spawning.

2.4 Accounting for Multiple Habitat Objectives within a Single Project Footprint

For instances where a single Non-flow Measure contains more than one habitat objective (i.e., tributary spawning, in-channel rearing, tributary floodplain rearing) within the overall project footprint, accounting must be able to quantify each Non-flow Measure separately. In the case of a project that provides both spawning habitat and rearing habitat within the same spatial boundary, it is appropriate to quantify the habitat meeting each Non-flow Measure separately for the accounting assessment, even if there is spatial overlap between the two Non-flow Measures. This is because of the temporal distinction (i.e., the spawning period does not overlap with the rearing period), and the design criteria differ for the Non-flow Measures. In the case of a project that includes both in-channel rearing habitat and tributary floodplain rearing habitat within the same footprint, they will be distinguished by a feature-specific geospatial boundary associated with distinct topographical delineation, or by the project-specific elevation associated with the flow that activates off-channel inundation, such that there is no spatial overlap between these habitats for the accounting assessment.

2.5 Calculation of Tributary Total Non-flow Measure Contribution

After all specific projects have been evaluated according to the relevant accounting approach (accounting approaches differ for early implementation projects; see Section 3.1.5), then sum the amounts of newly constructed acreage meeting design criteria across all implemented projects within a Tributary/Delta GE area. Compare this amount with the amount of additional acreages specified in Table 25 of the Strategic Plan to identify whether the commitments have been achieved.

3 Accounting Protocols for Bypass Floodplain Rearing Non-flow Measures

3.1 Design Flow Considerations for Bypass Floodplain Rearing Projects

Bypass floodplains can be inundated under baseline conditions. Therefore, bypass floodplain rearing habitat actions are intended to increase connectivity, and the frequency and duration of inundation within the project footprint. As such, acreages will be measured by those areas which demonstrate an incremental change in modeled inundation frequency and duration as a result of project implementation at design flows. As noted in the tributary accounting protocols, the term “design flows” refers to the range of flows over which a project is designed to create habitat. The flows at which the “pre-project” and “as-built” conditions are evaluated must be the same to enable equitable comparisons.

3.2 Design Criteria for Bypass Floodplain Rearing Projects

As described in Final Draft Scientific Basis Report Supplement (SWRCB 2023), the bypasses contain a unique set of challenges compared to floodplain restoration projects on the tributaries and the bypasses are also occupied seasonally by a broader range of native fish species. Specific quantitative design criteria for bypass projects are not provided here due to the variety of fish species and life stages that are present in the bypasses. Consideration should be given to generally accepted habitat components for salmonid rearing habitat (as described for tributary floodplains) for actions promoting salmonid rearing, but also to connectivity, fish passage (e.g., adult salmonids and *ascipenserids*), and spawning (e.g., splittail). Project planning should give consideration to whether and to what extent a project will address the aquatic ecosystem stressors that are described for the bypasses in the Final Draft Scientific Basis Report Supplement (SWRCB 2023). Design consideration for bypass habitat enhancements (e.g., fish passage as listed in Table 26 of the Strategic Plan) is provided in the Science Plan. These include NMFS guidelines for fish passage facilities (NMFS 2023) as well as metrics for evaluating zooplankton production in shallow water areas for duration and water temperature conditions during suitability and utilization and biological effectiveness assessments (e.g., as described in Corline et al. 2017).

To evaluate whether Non-flow Measures are implemented according to project specifications and design, the implementation metrics will be measured once project construction is completed, and the post-construction measured values of the implementation metrics will be compared to approved project design criteria. The project design criteria will reflect the best available science on the habitat requirements of the species and life stage the project is intended to benefit and will follow the design criteria review process. For enhancement projects, accounting will be based on the incremental change from baseline (physical conditions and regulatory requirements as of December 2018), with specific protocols for assessing this change proposed alongside the proposed design criteria. Accounting will be based on modeled inundation with respect to physical aspects of the projects (e.g., water velocity). Observed inundation levels and aspects of habitat suitability (including appropriate ranges of water quality parameters such as temperature) will be tracked and reported as part of the habitat suitability assessment described in Section 4.1.1 of the Science Plan.

3.3 Acreage Protocols for Bypass Floodplain Projects

3.3.1 "Pre-Project" Characterization

The existing frequency and duration of inundation over a range of water year types for a specific project footprint will be the baseline for the accounting assessment. For example, a two-dimensional hydrologic model has been developed for the Yolo Bypass for the years 1997 to 2012 (USBR & DWR, 2019). A similar baseline model has been developed for the Sutter Bypass and Butte Sink as part of the Floodplains Reimagined Program (https://floodplainsreimagined.org/resources/reports-data/).

3.3.2 "As-Built" Characterization

The project-specific modeled change in inundation frequency and duration provided by the bypass floodplain Non-flow Measure.

The project area which demonstrates a modeled increase in frequency and duration of inundation from 'pre-project' and meets the inundation frequency and duration 'floodplain function' (Table F-1) described for tributary floodplains (further described in Section 2.2.3) will total the acreage provided by bypass floodplain Non-flow Measures. As stated above, specific quantitative design criteria for bypass projects are not provided here due to the variety of fish species and life stages that are present in the bypasses. When design consideration for bypass floodplain Non-Flow Measures includes fish passage, connectivity is also expected to be incorporated into design. The ‘as-built’ models of fish passage enhancements will demonstrate that established species and life-stage specific guidelines have been integrated, such as NMFS 2023 and adult fish passage criteria previously developed for projects in Yolo Bypass (DWR & USBR, 2019).

4 Accounting Protocols for Tidal Wetland Non-flow Measures

4.1 Designed Inundation Considerations

The tidal wetland Non-Flow Measure acreage will be quantified as new wetted acres. Tidal wetland Non-flow Measure habitat construction, restoration, and enhancements may include transitional sites that have different habitat types, such as associated floodplains adjacent to the tidal wetland project (Memorandum of Understanding, Appendix 2). For accounting purposes, tidal wetland Non-Flow Measure acreages will include these associated transitional sites’ acreage. The acreage protocol for those associated habitats will adhere to the most applicable Non-flow Measure procedure (see Sections 2.3 and 3.3).

4.2 Design Criteria for Tidal Wetland habitat actions

Design criteria for tidal wetland Non-Flow Measures will be site-specific and will include inundation levels of constructed channels and marsh plains in response to the daily tidal regime, among other metrics specific to the individual project goals and objectives. The reason that design criteria for these Non-flow Measures will be project specific is that the intended benefits of tidal wetland projects will vary with location and target native fish species.

For example, tidal wetland structure (including structural attributes described in Sherman et al., 2017) is a driver of the capacity of tidal rearing habitats to support juvenile salmon and opportunity for juvenile salmon to access that capacity. Simenstad and Cordell (2000) list four suggestions for incorporating landscape structure in tidal marsh restoration for supporting Pacific salmon populations:

1. “Use natural landscape templates that are specific to the estuary and local region to guide restoration;
2. Emphasize corridors and other linkages among marshes and other tidal landscape elements that facilitate physiological, foraging, and refuge requirements of different fish species and life history stages;
3. Incorporate landscape elements and a mosaic that maintain a natural diversity of primary producers and detritus sources; and,
4. Promote landscape structure that accommodates fish responses to climatic variability and natural disturbance regimes.”

Furthermore, Simenstad and Cordell (2000) propose additional landscape metrics, such as heterogeneity of topography, vegetation patch structure, channel system order, the number of channels, average sinuous length of channels, length of channel edge, drainage density, and the occurrence, distribution, and size of pans on the marsh plain. It has also been shown that bifurcation ratios can indicate opportunities for foraging interactions between prey being transported off the marsh and fish in larger channels (Coats et al. 1995; Simenstad et al. 2000). These are examples of design elements that may be considered to provide habitat opportunities for juvenile salmon; other design elements may be considered for goals of food production and export to pelagic areas or spawning or rearing habitat for other native fishes, such as Longfin Smelt.

Hydrologic connectivity to migration corridors and pelagic habitats should also be considered. Established marshes and migration corridors act as source populations for vegetation, detritus, nekton, and invertebrates for the restoration site, and will also influence marsh evolution, habitat function, and access to the restoration site. Particularly for salmonids, which are a migratory species, the proximity of a restoration site to established marshes and migration corridors may affect juvenile salmon access to the wetland and the strength of cues that might attract them to the restored wetland (i.e., opportunity). Additionally, their available paths to the ocean by way of migration corridors will affect their survival, life history, and migration timing. Connectivity between marshes also provides refuge for juvenile salmon (Simenstad et al. 2000; Hering et al. 2010; Hanson et al. 2012). Considering both connectivity and structural complexity when evaluating restoration projects requires a landscape approach. However, urbanized estuaries can be constrained by the industries they support. For this reason, site selection provides important context, such as the influence of contaminants, invasions by non-native species, and alterations to flow (Sherman et al., 2017).

Quantified design criteria for tidal wetland Non-Flow Measures are not provided here due to the wide variety of target species, life-stages, and types of habitat goals. Values (as provided for tributary habitat actions in Table F-1) would need to be generalized to a point that they would not provide meaningful targets. Therefore, to evaluate whether Non-flow Measures are implemented according to project specifications and design, the implementation metrics will be measured once project construction is completed, and the post-construction measured values of the implementation metrics will be compared to approved project design criteria. The project design criteria will reflect the best available science on the habitat requirements of the species the project is intended to benefit and will follow the design criteria review process. The area of the project conforming to the approved design criteria will count towards the Tidal Wetland Non-flow Measures in Table 25 of the Strategic Plan. Similar to tributary and bypass floodplain Non-flow Measures, accounting for tidal wetlands will be based on modeled inundation with respect to physical aspects of the projects (e.g., water depth). Observed inundation levels and aspects of habitat suitability (including appropriate ranges of water quality parameters such as temperature, salinity, and turbidity) will be tracked and reported as part of the habitat suitability assessment described in Section 4.1.1 of the Science Plan.

As described above, project specific design criteria for tidal wetlands are subject to the design criteria review process outlined in the Strategic Plan.

4.3 Acreage Protocols for Tidal Wetland Non-flow Measures

4.3.1 "Pre-Project" Characterization

The existing habitat will be quantified by a DEM representing the pre-project topography. Wetted area will be defined by inundation levels relative to mean high-high water. If the site is not wetted or not tidal, a 'pre-project' characterization is not necessary, and all 'as-built' acreage will be additive.

4.3.2 "As-Built" Characterization

The post construction inundation levels will be determined by a site-specific tidal datum reflective of accurate tidal elevations at the project scale.

Acreages will be the result of the 'pre-project' DEM wetted area differenced from the 'as-built' DEM wetted area, with inundation levels relative to mean high-high water (Wheaton et al., 2009, Hensel et al., 2023). There is an expectation that access will be provided for estuarine species, and that the depth and width of the opening will be designed for full tidal exchange and the species and life stage expected to benefit. 'Full tidal exchange' is defined as a similar difference between high tides and low tides inside the opening of the site and outside the site. As noted in Section 4.2, design criteria for tidal wetland Non-flow Measures are not provided here due to the wide variety of target species, life-stages, and types of habitat goals. Therefore, project specific design criteria for tidal wetlands are subject to the design criteria review process outlined above.

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