Draft 1/27/2009

AB 2121 Joint Recommendations
Q_{WB} and Q_S – Definitions and Methods

Note: see document titled "Context for Definitions and Methods" before reading this.

Definitions[1]

The Salmon and Steelhead Spawning and Migration Flow Threshold ("Salmon Spawning Flow" or Q_S) is a streamflow threshold important for protecting two steelhead and salmon life history functions in small North Coast California streams: (1) maintaining natural abundance and availability of spawning habitat; and (2) minimizing unnatural adult exposure, stress, vulnerability, and delay during spawning migration.

The Winter Baseline Flow Threshold (Q_{WB}) is a streamflow threshold important to managing several steelhead and salmon life history functions in small North Coast California streams: (1) maintaining good benthic macroinvertebrate habitat in riffles to foster high stream productivity, (2) preventing redd desiccation and maintaining hyphoreic subsurface flows, (3) sustaining high quality and abundant juvenile salmonid rearing habitat, and (4) facilitating smolt out-migration.[2]

Guidance for Estimating Q_{WB} and Q_S: Proposed Field and Analytical Methodologies[3]

The Riffle Crest Thalweg as a Reference

The riffle crest elevation is an important hydraulic control, and therefore an important physical feature affecting habitat quantity and availability. If all streamflow was abruptly cut-off, the stream's pools would become isolated "tea cups" of standing water. The water surface elevation of each "tea cup" would be controlled by the immediate downstream riffle crest's thalweg. This channel feature has already been commonly recognized by fish biologists and geomorphologists; maximum depth of a pool at zero streamflow is called the residual pool depth. Thus when stream surveys are being conducted, pool depth can be documented independent of the ambient streamflow (by subtracting streamflow depth at the downstream riffle crest from the maximum pool depth).

We propose adopting the riffle crest's thalweg as a reference point in the stream channel for developing our instream flow thresholds and diversion rates. The riffle crest thalweg (RCT) is easy to identify and consistent for measuring streamflow depth. It provides the nexus for recommending diversion rates that will protect salmonid life history needs. The shallowest location for fish passage, tracing the deepest route through a riffle, generally is at the riffle crest's thalweg. This location is easy to identify, take a depth measurement, and provide a streamflow estimate for any given water depth on the riffle crest's thalweg.

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[1] These definitions might function better with slightly more detail (an additional sentence or two) but for present purposes these definitions rely on the guidance below for much of their content.

[2] We are not sure "Winter Baseline Flow" is the best name for this threshold, since it implies "baseflow," which is not really what the threshold is about. We are considering other names such as "Winter Low Flow" or "QRiffle."

[3] This methodology is for small streams of 5 mi^2 and below. It could work for streams of up to 10 mi^2 but additional data is needed.

The Q – RCT Relationship

A primary task for utilizing the RCT is measuring and establishing a site-specific quantitative relationship between streamflow and RCT depth so that Q_S or Q_{WB} can be estimated at the POD. Identification of the riffle crest thalweg (RCT) requires minimal training and expertise, but professional guidance at the onset of fieldwork is recommended. Because the RCT depth can vary considerably for a given streamflow, more than 15 RCT depths should be measured per location. A map showing a typical study site is included as Figure __. Once collected at a given streamflow, the RCT depths are ranked so that the median RCT depth can be computed. Results from an RCT field survey for Sullivan Gulch, a 2.35 mi2 watershed in Humboldt County, is illustrated in Figure __. Outlying RCT depths (both shallow and deep) will have minimal effect on the median RCT depth with this large sample size. Once RCT depths at 5 to 7 streamflows have been surveyed, the median RCT depth can be plotted as a function of streamflow (the Q – RCT curve). Median RCT depths plotted against streamflow for Sullivan Gulch are illustrated in Figure __. Protocols for identifying Q_S and Q_{WB}, and for recommending specific diversion rates, will require this Q – RCT curve.

Insert map & profile of RCT locations on Davenport.

Insert Q – RCT Figure.

The Winter Baseline Streamflow Threshold (Q_{WB})

The Winter Baseline Flow Threshold (Q_{WB}) is a streamflow threshold important to managing several steelhead and salmon life history functions in small North Coast California streams: (1) maintaining good benthic macroinvertebrate habitat in riffles to foster high stream productivity, (2) preventing redd desiccation and maintaining hyphoreic subsurface flows, (3) sustaining high quality and abundant juvenile salmonid rearing habitat, and (4) facilitating smolt out-migration.

Methodology Based on Habitat Mapping

Productive benthic macroinvertebrate (BMI) habitat is important to rearing healthy salmonid juveniles. An instream flow protocol must recognize this aspect of juvenile habitat to complement the more traditional concern for habitat abundance. Productivity is extremely difficult to measure. As a surrogate, we propose measuring riffles that provide good physical conditions for productive BMI habitat. For small North Coast California streams, highly productive BMI habitat can be habitat-mapped using the following physical criteria: (1) the median particle size of the rifflebed is inundated (establishing a minimum depth) and (2) the average column velocity is greater than 1.5 ft/sec. The median particle is estimated as the D50 from a standard 100 rock-count inventory. A productive BMI habitat – streamflow rating curve can be measured on the stream using habitat mapping. The resulting habitat rating curve would have Q (cfs) on the X-axis and productive BMI habitat (ft^2) on the Y-axis. With no maximum depth or velocity criteria, this BMI habitat rating curve will ramp-up to an asymptote as riffles are inundated bank-to-bank and velocities across the riffle exceed 1.5 ft/sec. All riffle habitats should be habitat-mapped in a channel length at least 30 bankfull widths long. Each riffle within this sample reach should be plotted separately and as one composite (the same as recommended for the spawning habitat rating curves). The recommended winter baseline streamflow (Q_{WB}) would be estimated at the asymptote of the BMI habitat rating curves.

Similar methodological approaches to quantifying juvenile salmonid rearing habitat and amphibian habitat would appear obvious tasks for developing Q_{WB}. However, streamflows sustaining good juvenile rearing habitat will range from low streamflows below Q_{WB} through high streamflows exceeding Q_S. We do not propose that juvenile rearing habitat or amphibian habitat be mapped, though it could be done. The policy presumes that the Q_{WB} and Q_S thresholds, in combination with the proposed protocols for determining diversion rates, will sustain good juvenile rearing habitat in small North Coast California streams. When flows are at Q_{WB} maintaining good BMI productivity, flows also prevent redd desiccation and maintain hyphoreic subsurface flows. Flows at the Q_{WB} threshold also support smolt outmigration.

Whenever considering baseflows, water temperature should be integral to an instream flow investigation and protocol. Given the time period in the policy for winter habitat (December 15 through March 31), however, we did not consider water temperature to be a factor of concern in small North Coast California streams.

Interim / Initial Methodology Based on Depth

To our knowledge, no BMI habitat rating curve has been constructed for a small North Coast California stream (we have one under construction for Davenport Creek). An interim methodology for estimating Q_{WB} for small North Coast California streams is to use the streamflow at the median RCT that inundates the dominant particle size of the riffles (quantified as the D84 in a 100 rock-count). If the riffle D84 is 120 mm (0.39 ft), the streamflow at 0.39 ft on the median RCT – Q curve would be the estimated Q_{WB}.

This method will be reviewed and could be adjusted based on the results of site specific studies using the habitat mapping methodology.

Interim / Initial Regional Estimate

In lieu of doing the rock counts, and until field studies with BMI habitat mapping are completed, Q_{FEB} may be used as a proxy for Q_{WB} in small North Coast California streams.

This method will be reviewed and could be adjusted based on the results of site specific studies using the habitat mapping methodology.

Example

Initial results for Davenport Creek give a Q_{WB} of 5.52 cfs based on the D84 method (0.3 ft), which is higher than Q_{AVE} (= 3.42 cfs) and similar to Q_{FEB} (= 4.82 cfs). Differences in stage height at the median RCT among these streamflows are small.

The Salmon and Steelhead Spawning and Migration Flow Threshold (Q_S)

The Salmon and Steelhead Spawning and Migration Flow Threshold ("Salmon Spawning Flow" or Q_S) is a streamflow threshold important for protecting two steelhead and salmon life history functions in small North Coast California streams: (1) maintaining natural abundance and availability of spawning habitat; and (2) minimizing unnatural adult exposure, stress, vulnerability, and delay during spawning migration.

Returning to the two objectives for establishing Q_S, the first is accomplished by positioning Q_S on the right side of the spawning habitat rating curve as described below. The second will be to recommend a diversion rate, whenever unregulated streamflows exceed Q_S, that combined with a Q_S that covers the back of migrating fish, will minimize unnatural adult exposure, stress, vulnerability, and delay during spawning migration.

Methodology Based on Habitat Mapping

Essential fieldwork for estimating Q_S is to quantify the relationship between streamflow and spawning habitat abundance. In small North Coast California streams, habitat mapping is well-suited for quantifying spawning habitat. Physical criteria characterizing physical attributes of good spawning habitat include depth, velocity, substrate, and cover. These criteria have been developed for other instream flow methodologies, such as PHABSIM, and have been inserted into mapping spawning habitat for steelhead, Chinook salmon, and coho salmon. Portions of the streambed that satisfy these criteria are mapped onto a basemap of the stream channel, with each mapped patch of habitat called a habitat polygon. The channel is repeatedly mapped over a pre-determined range of streamflows. Polygon areas are tallied for each streamflow and then plotted as a function of the measured streamflow. This spawning habitat rating curve, with the X-axis = Q (cfs) and the Y-axis = spawning habitat (ft^2), is the basis for estimating Q_S. (See ___.)

Depths of flow at the RCT are used to estimate flows needed for fish passage and migration as well as spawning habitat. Minimum fish depths for passage and migration are assigned to the three primary anadromous species in North Coast California at a level that does not expose a migrating fish. A median riffle crest thalweg (RCT) depth of 0.7 ft deep is considered a conservative minimum depth for inundating an adult steelhead swimming 0.10 ft off the channelbed. A median RCT depth of 0.8 ft deep is considered a conservative minimum depth for inundating an adult coho salmon swimming 0.10 ft off the channelbed. A median riffle crest thalweg depth of 1.0 ft deep is considered a conservative minimum depth for inundating an adult Chinook salmon swimming 0.10 ft off the channelbed.

Habitat Mapping Method Demonstrated by Example

Note: We will translate the following example into the language of guidance, followed by an example to illustrate and explain the method.

In this example, Bill Trush mapped coho salmon spawning habitat in an approximate 700 ft reach of Davenport Creek (named locally), a tributary of Lindsay Creek within the Mad River watershed of Humboldt County. The creek's drainage area at the stream gauging station is 1.07 mi^2. Q_{AVE} equals 3.42 cfs. Davenport Creek meanders through this reach, and Trush has been observing and measuring coho salmon migration and spawning in Davenport Creek since November 2001. Taking advantage of extensive field observations, as well as using preferred depth, substrate, and velocity criteria, coho spawning habitat was mapped (using a modified head rod to check water velocities) over the full range of streamflows wherever habitat was found.[4] Coho spawning habitat at 10 channel sites was surveyed to established benchmarks to compute the surface area (ft^2) of each delineated spawning habitat polygon and to document how habitat polygons shifted within each channel site as a function of changing streamflow.

Next, present the habitat mapping results by plotting spawning habitat rating curves for each spawning habitat site separately. The 10 individual curves in Figure __ illustrate the hydraulic diversity among the spawning sites that is masked by the composite rating curve (Figure __). No single rating curve adequately approximates this collective diversity.

Figure __. Coho spawning habitat rating curves for Davenport Creek, Humboldt County, for individual channel locations.[5]

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[4] Insert preferred depth, substrate, and velocity criteria with citations.

[5] Insert latest version of the figure. (The data is unchanged.)

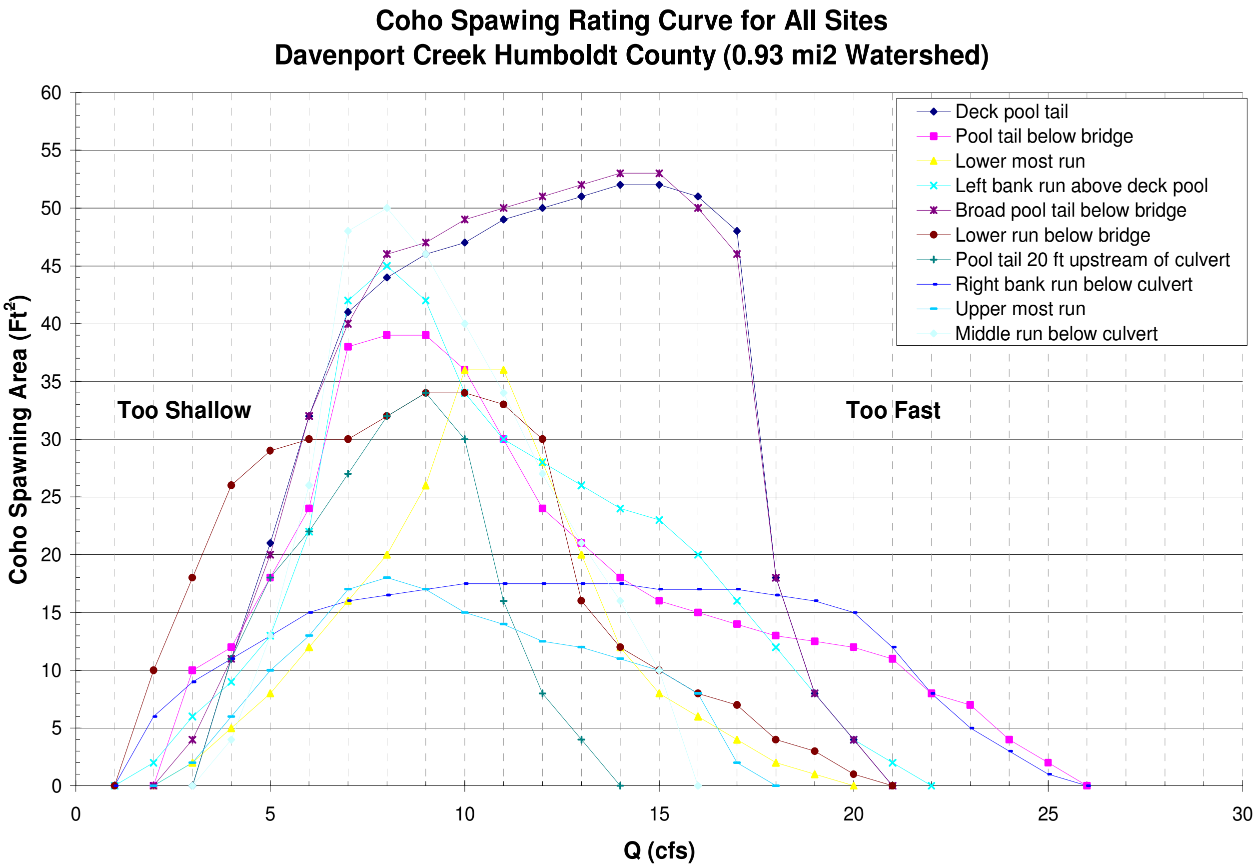

Figure __ highlights the complexity of how channel morphology, streamflow, and fish behavior interact. The two biggest curves are for broad pool tails, where channel width is approximately 20% greater than the mean width. In contrast, the site with a pronounced platform at 17 cfs (spanning 7 cfs to 19 cfs) is a long, wide run with a lateral bar along its right bank. The three sites with steep, cone-shaped habitat rating curves peaking between 7 cfs and 9 cfs are short pool tails. Ongoing field monitoring is revealing that redds constructed in these short pool tails tend to scour more easily and often during peak winter flows than redds constructed in the runs. Each spawning site offers a unique redd environment that may or may not promote success (fry emergence) depending on the magnitude, duration, frequency, and timing peak streamflows during egg incubation and alevin development. The variety of individual habitat rating curves, therefore, offers risk management to coho salmon trusting their redds to an unpredictable future.

Q_S could be defined as the highest streamflow that sustains any spawning habitat. Referring to Figure __, Q_S would be 26 cfs. Our methodology protects “good” habitat, rather than accounting for the last square foot of spawnable channelbed, by assigning an adjusted estimate for Q_S based on spawnable area. In Figure __, the last habitat occurs at 26 cfs, but a minimum area of 15 ft^2 for a single habitat site would put Q_S at 20 cfs. This methodology excludes more marginal habitat at the highest flows, for example, the “tails” at the far right side of the habitat graph. Another approach for trimming the tails at the far right side of Figure __ could be to use a percentage of spawnable area.

The recommended methodology is to set Q_S at a level to account for all good habitat defined as individual sites with at least 15 ft^2 for coho and 10 ft^2 for steelhead. (I.e., increasing flow does not produce additional spawning locations with areas of those sizes.) Therefore, Q_S in this example is 20 cfs.

Interim / Initial Method for Estimating Q_S Based on Fish Passage Depth

Our protocol for prescribing instream flow thresholds and diversion rates depends on quantifying Q_S. However very few spawning habitat rating curves exist for North Coast California streams especially in small streams with drainage areas less than 5 mi^2. We propose using streamflows that produce the minimum fish depths at the median RCT as a surrogate for Q_S. Combined with ecologically sensitive diversion rates, this protocol should be protective for watersheds up to 5 mi^2 and likely larger. This maximum drainage area may seem small. But with almost all water rights applications on small streams, even a policy applicable to a maximum watershed size of 5 mi^2 will have highly important ramifications anadromous salmonid populations through river basins.

Stage height for Q_S at the RCT is estimated by selecting the "fish depth" appropriate to the diversion. If only steelhead spawn in the vicinity of the POD, then Q_S is assigned a RCT depth of 0.7 ft. If steelhead and coho salmon spawn in the vicinity of the POD, then Q_S is assigned a RCT depth of 0.8 ft. If all three species are present, Q_S is assigned a depth of 1.0 ft.

This approach requires an assessment of the Upper Point of Anadromy (UPA) for each anadromous salmonid species. Where the project is above the UPA but still requires calculation off QS (this will happen only where there are large cumulative effects), the methodology directs the studies to the nearest downstream reach of anadromous fish habitat. Where the applicant uses a depth of 0.7 or 0.8 because only steelhead, or steelhead and coho, are present in the vicinity of the POD, but other species are present farther downstream within the same basin, then the applicant shall take steps to ensure that assigning QS a depth based only on the most upstream habitat also serves to protect spawning and migration flows for fish farther downstream. (This should be possible using desktop depletion analysis, because in most cases the area of greatest cumulative effect will be nearest the diversion.)[6]

The streamflow magnitude for Q_S is estimated by associating the selected RCT depth with streamflow in the Q – RCT curve constructed from the RCT field surveys.

This method will be reviewed and could be adjusted based on the results of site specific studies using the habitat mapping methodology.

Example

For example, Chinook salmon spawn above the stream gage on Sullivan Gulch. Using the Chinook salmon fish depth of 1.0 ft for the RCT at Q_S, the estimated streamflow magnitude for Q_S would be

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[6] The guidance will define "in the vicinity of the POD." There will also be guidance on estimating the UPA (either here or elsewhere in the policy), and estimating effects on other species farther downstream.

35 cfs at the stream gage in Sullivan Gulch (Figure __). The habitat mapping method resulted in a Q_S of approximately 32 cfs.

Insert Sullivan Gulch Q – RCT curve with line showing Q_S.

Interim / Initial Regional Estimate

TBD.