Commentary
Draft A.B. 2121 Instream Flow Policy: Framework Proposal for Defining Stream Management Objectives

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Introduction

With this paper I do not seek to define better formulas. Instead, I seek to define better management objectives.

If the management objectives are adopted, the analog to the draft policy regional criteria would be standard estimates of important flow thresholds incorporated into the management objectives. Those standard estimates could be validated or improved upon with site specific studies. Alternatively, the management objectives could become the foundation for a coordinated diversion management plan under a "watershed approach."

What follows is a framework proposal, not a final recommendation. With Trout Unlimited, I will further refine the ideas described here and discuss it with SWRCB, the fish agencies, and other parties.

Summary

We endorse the draft's general objective to focus diversions away from dry months and toward rainy season months, and to manage diversions in a way that protects spawning and winter rearing habitat and retains the variability of the hydrograph.

The framework proposal starts by defining two important flow thresholds for fish.

The first is the flow that fills the active channel, where most spawning takes place. (See MTTU 2000.) The second flow, which I call the winter baseline flow, is the flow that keeps riffles flowing, sustains juvenile rearing habitat, and prevents redds from de-watering.

The sweet spot for fish is between these two flow thresholds. Flows above the active channel get too fast. Flows below the winter baseline impair basic biological functions. The first management objective is to retain flows between those two depths.

The key is to divert water (but not too much) when flows are above the active channel, reduce (but not necessarily eliminate) diversions when flows are between the active channel and winter baseline flows, and avoid diversions below the winter baseline flow, we can protect spawning opportunity and success, sustain rearing habitat, and maintain high stream productivity to grow fish fast and large.

We can suggest calculations to estimate these two flows and refine the estimates over time. (For the active channel flow, I propose a more refined version of the 10% exceedance flow from MTTU 2000, with somewhat higher flows in watersheds below about 6 miles and somewhat lower flows in watersheds larger. For the winter baseline flow, we might consider the February Median as a starting point, or something similar.) The important thing for now is not the formula so much as the concept.

With site-specific studies, one could estimate the flows fairly precisely. With a watershed approach, one could estimate the threshold flows with site-specific studies and also design a diversion schedule by reference to those flows at particular points of interest.

The second step toward defining the instream flow protocol is to address rates of diversion and cumulative effects.

In an ideal world, diverters could vary their rate of diversion to match stream extractions to a percentage of ambient flows within a range defined to have "no impact." (Five percent of ambient daily flows above the active channel would have this effect.)

A variable diversion rate would offer the most finely tuned way to optimize diversions and stream flows. (I know of one water manager who is ready to test a variable diversion rate system and believes it is viable. Above a particular point of interest, a fill and spill reservoir also corresponds to a percentage of ambient flows, in proportion to drainage size.) For diversions that cannot precisely match a percentage of ambient flows, the management imperative is to mimic the stated objective by imposing standard terms and conditions such as a bypass flow and rate of diversion limitation.

The third step is to acknowledge that no management regime is perfect. Therefore, the protocol needs to define acceptable levels of deviation from the ideal (which could also be thresholds for imposing mitigation terms like a minimum bypass flow or thresholds for requiring site-level studies).

We are fairly confident, for example, that diversions occurring only above the active channel and limited to 5% of the ambient daily flow would have essentially no impact. The protocol could define that as Level One and consider projects in that range to fully satisfy the primary management objective.

Diversions that approximate Level Two impacts might be presumed acceptable with standard terms and conditions such as a minimum bypass flow. Level Three impacts might be acceptable but would require standard terms and conditions as well as site-specific studies.

I propose the following objectives for discussion.

Instream Flow Objective No.1. No Impact

No diversion at <= Q_{BLine} (for any Class II stream)
<= 5% reduction in $Q_D > Q_{Active}$

Instream Flow Objective No.2. Minimal Impact

No diversion at <= Q_{BLine}
<= 5% reduction in $Q_D <= Q_{Active}$
<= 10% reduction in $Q_D > Q_{Active}$

Instream Flow Objective No.3. Larger Impacts

No diversion at <= Q_{BLine}
<= 10% reduction in $Q_D <= Q_{Active}$
<= 20% reduction in $Q_D > Q_{Active}$

(Q_{BLine} = winter baseline flow)
(Q_{Active} = active channel flow)
(Q_D = ambient unregulated daily average streamflow)

How would it work in practice? Proposed projects would be conditioned with terms and conditions designed to approximate the management objective and evaluated with other existing diversions to assess the level of deviation from that objective.

A retrofit fill and spill reservoir on a Class III stream above UPA with less than 5% of the drainage area impaired would be exempt from a bypass requirement. The same project on a Class II stream would be permitted, but require a minimum bypass term set at the winter baseline flow.

Similarly, a diversion below the upper point of anadromy could adopt a variable pumping rate if feasible, and set the rate at a level that would not harm fish. For those who don't have that option, standard terms for minimum bypass flow (set at the active channel level) and a rate of diversion limitation would apply so as to approximate the defined management objective. For those requiring a fixed rate of diversion, we propose a refinement of the MTTU 2000 calculation as an estimate for the term.

Protocols to assign the appropriate standard terms and cumulative effects analyses for other situations could be developed to approximate whatever thresholds of significance are adopted.

Discussion

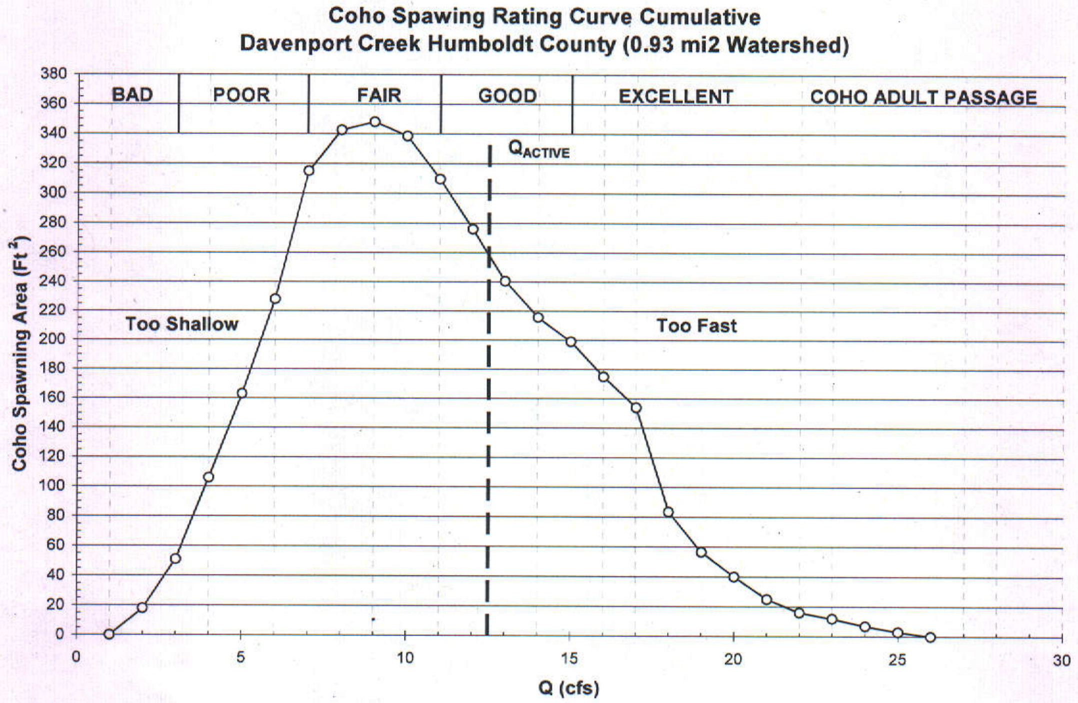
Coho Salmon Migration and Spawning in Davenport Creek

Davenport Creek (named locally, and not labeled on USGS topographic maps) is a tributary of Lindsay Creek, which in turn is a tributary to the Mad River in Humboldt County. Davenport Creek meanders through my property and I have been observing and measuring coho salmon migration and spawning since November 2001. The creek's drainage area at my stream gaging station is 0.93 mi^2 and Q_{ave} equals 3.3 cfs.

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 could be found. Coho spawning habitat at 10 channel sites was surveyed to established benchmarks to compute the surface area (ft^2) of each mapped habitat polygon and to document how habitat polygons shifted within each channel site as a function of changing streamflow.

Results of the habitat mapping fieldwork are presented first as in a classic PHABSIM format, where total habitat area from the 10 sites is plotted as a function of streamflow (Figure 1). Using the terminology of Appendix E, the lowest streamflow at which 'maximum spawning habitat availability" occurred is at 9 cfs, though narrowly bracketed by 8 cfs and 10 cfs streamflows that provide extremely similar total Coho spawning areas.

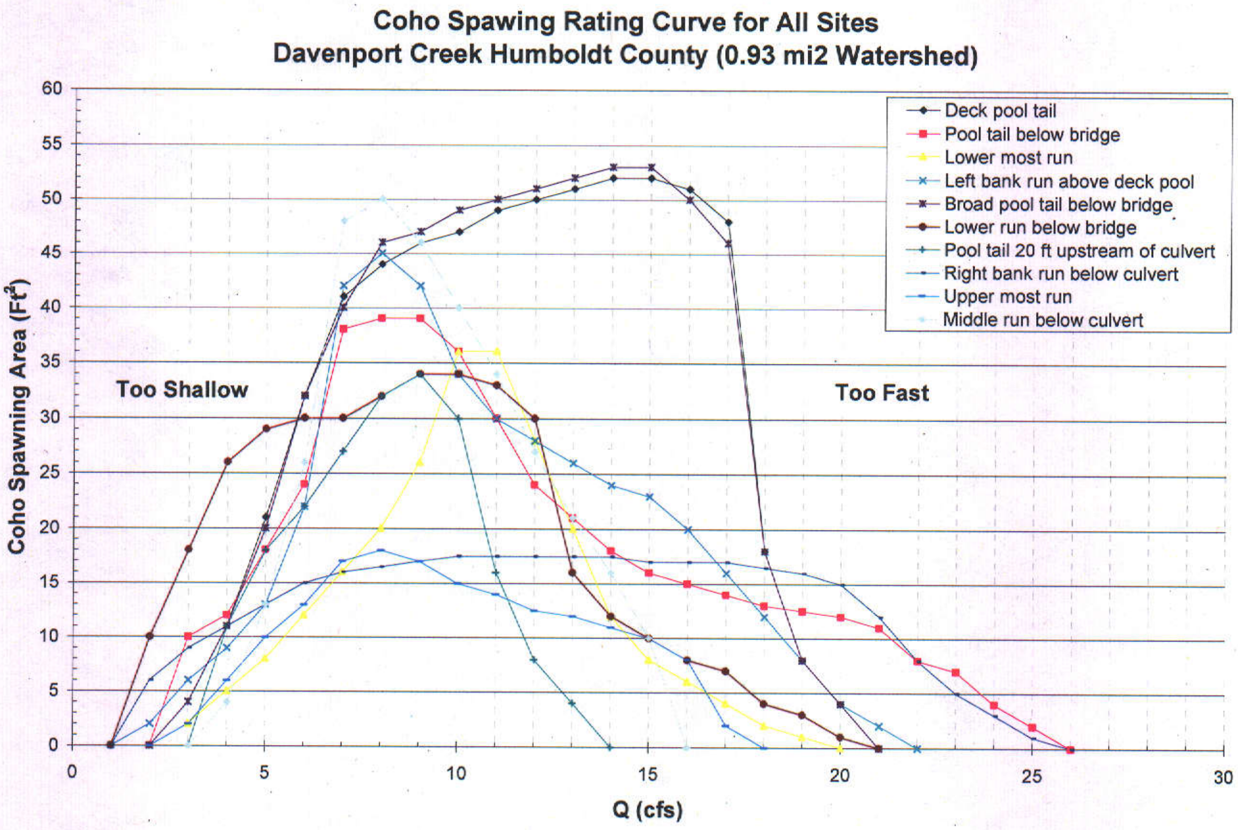
Figure 1. Coho spawning habitat rating curve for Davenport Creek, Humboldt County.


Coho Spawing Rating Curve Cumulative
Davenport Creek Humboldt County (0.93 mi2 Watershed)

Adult coho salmon almost seem too big for the active channel of Davenport Creek. This forces the adults to rely, critically, on peak stormflows, rather than winter baseflows, for successful migration and spawning within the active channel (refer to discussion in MTTU 2000 for elaboration of the active channel morphology and role sustaining anadromous salmonid habitat). The steep-sided, cone-shaped, spawning habitat rating (Figure 1) is a product of this misfit between small tributary and oceangoing fish. Streamflows must increase steeply (between 3 cfs and 8 cfs) to provide minimally sufficient depths (0.8 ft), thus the steep slope on the left side of this habitat rating curve. Then as streamflows approach 20 cfs on the right side, water velocities rapidly become too fast. While these rapidly increasing velocities are not too fast for adult migration, they do rapidly exceed preferred spawning velocities, especially close to the thalweg. The streamflow window for spawning in small streams, such as Davenport Creek, is narrow relative to larger streams. For a large stream, the right side of the habitat rating curve would not drop as rapidly.

Figure 1 is not too informative as to how spawning habitat availability relates to streamflow, and its interpretation can be misleading. Figure 2 decomposes Figure 1 into the 10 original spawning sites. The cluttered appearance of Figure 2 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 clutter of individual habitat rating curves, therefore, offers risk management to coho salmon trusting their redds to an unpredictable future.

Figure 2. Coho spawning habitat rating curves for Davenport Creek, Humboldt County, for individual channel locations.



Spawning habitat availability, not shown on the habitat rating curve in Figure 1 or individual curves in Figure 2, requires consideration in space and time. The habitat a migrating coho adult will see first, on entering my segment of Davenport Creek shortly following a peak flow event, are those spawning habitats on the right side of Figure 2. If a female delays spawning for 0.5 days to 1.5 days, she will select a spawning site among habitats available at approximately 7 cfs to 10 cfs portrayed in Figure 2. There is nothing optimal about the 'optimum' streamflow (commonly ascribed to the peak habitat area in Figure 1 or in Appendix E) in a natural stream. Our goal in recommending a winter instream flow protocol for small Northcoast streams is to not diminish spawning opportunity and success for that female coho entering my segment of Davenport

Creek, as well as to sustain ample rearing habitat of her juvenile progeny and maintain high stream productivity to grow them fast and large.

We would welcome the opportunity to present a much more in-depth reporting/discussion of the Davenport Creek observations and findings. Of particular interest might be the methods employed, that could be used in monitoring. While doing my investigation, I used only equipment that could be purchased from a local hardware store (plus a stopwatch) to emphasize simplicity of purpose.

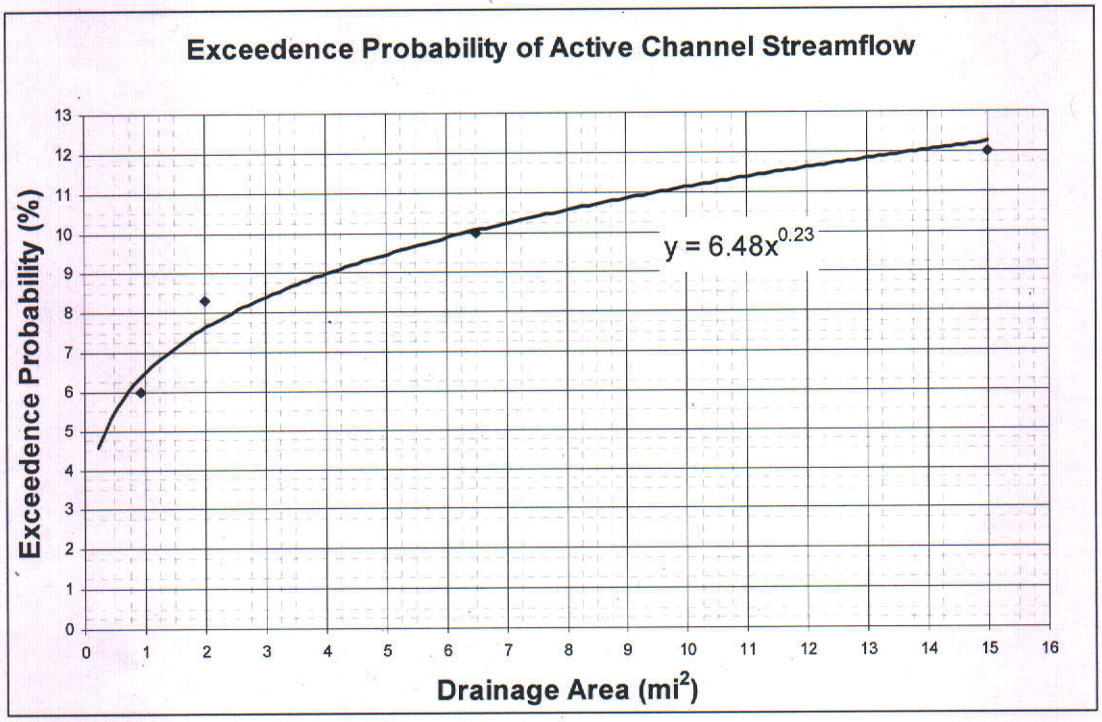
We applied the SWRCB report recommendations to Davenport Creek with the following results:

Upper MBF3 = 32.1 cfs 'risk averse'
Lower MBF4 = 18.8 cfs 'below which there is substantial risk of impacting population sustainability'
Q_{TP} = 31.7 cfs (using 0.7 ft passage depth) 'minimum fish passage streamflow' (Appendix E, p. E-2)

All three parameters seem to substantially over-estimate streamflows necessary for protectiveness. Since 2001, I have been documenting how well adult coho coped with the ambient streamflow during upstream migration (and downstream ... particularly roving male adults). Excellent conditions for upstream passage (with essentially no pause or splashing) occurred above 15 cfs.

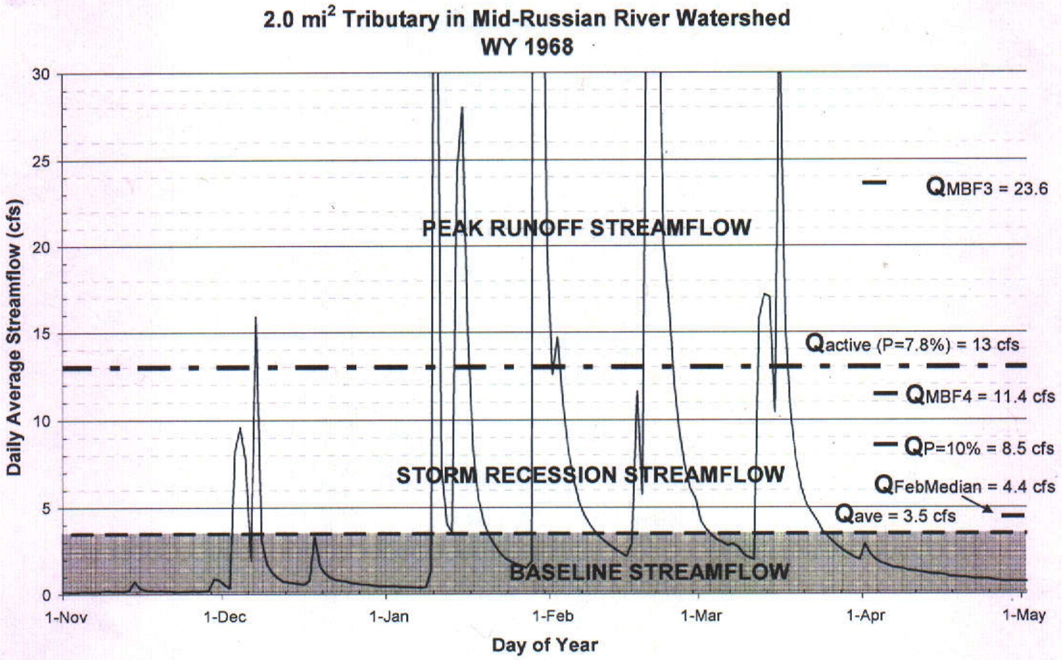
The streamflow that fills the active channel is an important geomorphic and ecological benchmark for anadromous salmonids. In the MTTU (2000) report, the exceedence probability for the active channel streamflow was assumed constant at p = 10% over all drainage areas, but with the suspicion and some field evidence that the active channel streamflow in streams less than 5 mi2 likely had smaller values of p (i.e., higher streamflows). Figure 3 is our latest estimate of the relationship between drainage area and the exceedence probability of the active channel streamflow. To protect spawning opportunity in small streams, streamflows equal to and less than the active channel stage must be explicitly considered in recommending any instream flow protocol.

Figure 3. Exceedence probabilities for the active channel streamflow as a function stream drainage area.



The annual hydrograph for a 2 mi^2 tributary watershed in the mid-Russian River Basin (Figure 4) was subdivided into three broad categories of streamflow and anadromous salmonid life history needs: (1) baseline streamflow that essentially keeps riffles flowing, sustains juvenile rearing habitat, and prevents redds from de-watering, (2) storm recession streamflow when most spawning occurs, and (3) peak runoff streamflow when the adults are actively migrating into headwater watersheds and some adults are beginning spawning activities. The same diversion rate for baseline, recession, and peak streamflows would have differing impacts to stream productivity and salmonid life history needs.

Figure 4. WY1968 hydrograph for a 2.0 mi^2 tributary in the Mid-Russian River Watershed categorized by streamflow runoff with accompanying streamflow exceedences and thresholds.



Sustaining a continuous baseline streamflow is important for stream productivity (keeping riffles inundated for high benthic macroinvertebrate production), maintaining juvenile salmonid rearing habitat, and preventing redd dewatering. Following each peak runoff event, streamflows gradually recede before the next event (Figure 4). With closer spacing of storms, the recession from one storm is interrupted by the next storm at a higher baseflow. In Figure 4, the 'bottoming-out' of individual peak storm events occurs at approximately 2 cfs. However in other water years with more closely spaced storms, the 'bottoming-out' between individual storm events occurs at 3 cfs to 4 cfs. The baseline winter streamflow (Q_{BLine}) where the stage drops over many winters was, coincidently, about Q_{ave} (shown here in grey). The February median (Q_{FebMed}) is only slightly greater and is the calculation we would evaluate first as a suitable way to estimate threshold streamflow for Q_{Bline}.

A methodology for recommending instream flows in small streams must have biological objectives. Three potential instream flow objectives, with hypothesized spawning habitat impacts based on limited field study, that might be considered by SWRCB are:

Instream Flow Objective No.1. No Impact

No diversion at <= Q_{BLine} (for any Class II stream)
<= 5% reduction in Q_D > Q_{Active}

Instream Flow Objective No.2. Minimal Impact

No diversion at <= Q_{BLine}
<= 5% reduction in Q_D <= Q_{Active}

$<=$ 10% reduction in $Q_D > Q_{Active}$

Instream Flow Objective No.3. Larger Impacts

No diversion at $<= Q_{BLine}$
$<=$ 10% reduction in $Q_D <= Q_{Active}$
$<=$ 20% reduction in $Q_D > Q_{Active}$

(Q_{BLine} = winter baseline flow)
(Q_{Active} = active channel flow)
(Q_D = ambient unregulated daily average streamflow)

Note that there is a gray zone between Instream Flow Objective No.2 and Objective No. 3. Within the recession streamflows in Figure 4, an ambient streamflow reduction somewhere between 5% and 10% would likely produce a measurable reduction in spawning habitat opportunity, but may not compromise protectiveness (an hypothesis based on the Davenport data and the MTTU 2000 report). A diversion rate approaching 10% of the ambient unregulated streamflow likely would begin to compromise protectiveness but it still might not cause significant habitat reductions until reaching or exceeding a 20% diversion rate (particularly in the larger 'small' streams, i.e., greater than 5 mi^2). Similarly, the gray zone between Instream Flow Objective No.2 and Objective No.3 within the peak streamflows in Figure 4 also warrants a similar caution.

Also note that although all three protocols employ streamflow thresholds, as does SWRCB's proposed use of MBF3 or MBF4, there are no fixed diversion rates. The diversion rate is a function of the ambient unregulated streamflow (i.e., if the daily average streamflow is 10 cfs, a variable diversion specification of 5% allows up to a 0.5 cfs daily diversion). A variable diversion rate avoids the potential for excessive diversion created by fixed diversion rates at low streamflows (e.g., Q_{FebMed} of NMFS/CDFG Guidelines in small streams). Although a variable diversion rate requires more hardware and maintenance, it offers more opportunity for diverting at lower streamflows.

Fixed diversion rates, however, can be formulated. For example, the diversion table in MTTU (2000, Figure 27) for the middle Russian could be applied to streamflows exceeding the active channel streamflow. For the WY1968 in Figure 4, the daily diversion rate would equal up to 2.6 cfs whenever streamflows exceeded the active channel streamflow of 13 cfs. This would require an intake at a stage height equivalent to 13 cfs, and would not reach the full fixed rate of 2.6 cfs until the streamflow reached 13 cfs + 2.6 cfs = 15.6 cfs.

An important feature of the three variable diversion scenarios/goals (Instream Flow Objectives No.1 through No.3) is that each goal is quantifiable and offers many innovative solutions to satisfying each one. In contrast, MBF3 already has the goal 'built into it" (i.e., a product of many instream flow studies regressed) that offers little opportunity for innovation solutions other than seeking a variance.

Another important feature of the three variable diversion goals/scenarios is that they can be used to establish biological goals for headwater fill-and-spill reservoirs. If 5% of the watershed above the Point of Anadromy (POA), say at 0.5 mi2, is behind headwater reservoirs, the daily variable diversion rate at the POA would be a maximum of 5%.