4/27/10 Board Hearing
AB 2121
Deadline: 3/26/10 by 12 noon

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SWRCB EXECUTIVE

Tom Lippe
329 Bryant Street, Suite 3D
San Francisco, CA 94107

Re: Proposed Instream Flow Policy for Northern California Streams

Dear Mr. Lippe:

You have asked me to comment on the Final Draft of the *Policy For Maintaining Instream Flows In Northern California Coastal Streams* (the Policy) date February 17, 2010 and prepared by the staff of the Sate Water Resources Control Board.

I served as the Hydrologist for the Mendocino County Water Agency from 1989 through 1994. I have a Master degree in Physical Science with an emphasis on Hydrology. I have been a private consultant since 1995.

I concentrated my review on the question of whether the Regionally Protective Criteria always set diversion parameters that would err on the side of resource protection, that is always protect anadromous salmonids and their habitat. I found that the Regionally Protective Criteria rely on what I call the Scaling Method to transfer flow parameters such as the mean annual discharge, February median flow, the average seasonal flow and the 1.5-year instantaneous discharge from a reference stream gauge to an ungauged watershed upstream of a Point of Diversion (POD) or a Point of Interest (POI).

If the Regionally Protective Criteria do not *always* produce diversion parameters that err on the side of the resource then they can not be relied on to protect anadromous salmonids and their habitat. There is nothing in the Policy that would allow the SWRCB staff to predict when the Regionally Protective Criteria would err on the side of *not* protecting the resource. However, my analysis reveals a potential approach to improve the ability of the Scaling Method to make better estimates by choosing reference stream gauges based on the similarity of watershed characteristics instead of simply choosing the closest gauge. I do not have enough information to determine if my recommend procedure would actually be protective of the resource in all cases. Therefore, if the SWRCB pursues my recommendation it must be validated to always err on the side of resource protection.

I set the stage for my analysis by recalling the guiding principles of the Policy.

2.0 POLICY FRAMEWORK

2.1 Principles for Maintaining Instream Flows

Protection of fishery resources is in the public interest. The primary objective of this policy is to ensure that the administration of water rights occurs in a manner that maintains instream flows needed for the protection of fishery resources. This policy establishes the following five principles that will be applied in the administration of water rights:

1. Water diversions shall be seasonally limited to periods in which instream flows are naturally high to prevent adverse effects to fish and fish habitat;

2. Water shall be diverted only when streamflows are higher than the minimum instream flows needed for fish spawning, rearing, and passage;

3. The maximum rate at which water is diverted in a watershed shall not adversely affect the natural flow variability needed for maintaining adequate channel structure and habitat for fish;

4. The cumulative effects of water diversions on instream flows needed for the protection of fish and their habitat shall be considered and minimized; and

5. Construction or permitting of new onstream dams shall be restricted. When allowed, onstream dams shall be constructed and permitted in a manner that does not adversely affect fish and their habitat.

Season of Diversion

The season of diversion is not consistent throughout the Policy document. The main Policy document states that the season of diversion for new projects is December 15 to March 31.

> 2.2.1.1 Season of Diversion
>
> The season of diversion is the calendar period during which water may be diverted. New diversions are not allowed during the late spring, summer, and early fall because existing instream flows during this period generally limit anadromous salmonid rearing habitat quantity and quality in the policy area. The regionally protective criteria limit new water diversions in the policy area to a diversion season beginning on **December 15 and ending on March 31** of the succeeding year. Site-specific studies may indicate that the season of diversion can be extended into other times of the year. (Emphasis added)

But Appendix B starts the diversion season on October 1. This presumed typographical error must be changed.

> Section B.2.1.4 item 2 states:
>
> 2. Because the season of diversion specified in the Policy is **October 1 to March 31**, and irrigation of crops in the policy area typically does not begin before March 31, senior water rights authorizing direct diversion for irrigation before March 31 do not need to be considered part of the seasonal demand. (Emphasis added)

I strongly oppose the start of the diversion season on October 1 since diverting water during the beginning of the rainy season could delay the signal the first discharge peak gives to waiting salmonids that it is time to migrate.

Regionally Protective Criteria

The Instream Flow Policy requires that a season of diversion, a minimum bypass flow (MBF), the maximum cumulative diversion (MCD) and whether there is sufficient unappropriated water to be diverted must be determined for each diversion being considered. The Policy gives an applicant the choice of using either the regionally protective criteria to determine the above parameters or to perform site-specific studies to determine these values.

The section 2.2.1 of the Policy claims that the regionally protective criteria are conservative and will always err on the side of resource protection. This claim is not substantiated by the Policy's supporting documents.

2.2.1 Regionally protective criteria

The policy area is a diverse region. This policy allows the use of criteria that were developed to be protective of fishery resources throughout the policy area3 (regionally protective criteria or regional criteria). The intent of this approach is to provide the applicant an avenue for quicker processing of pending applications while protecting fishery resources. The regionally protective criteria should not be considered to have site-specific precision for every stream. ***The regional criteria are by necessity conservative and err on the side of resource protection***. To be regionally protective, the regional criteria limit water diversions so that adequate flows are available at sites with the greatest instream flow needs. At some sites, therefore, more than adequate flows will be provided by regionally protective criteria. Site specific studies may be used to identify more precisely the fishery resource instream flow needs of a particular location. (*Emphasis Added*)

The following procedures; (a) to determine if unappropriated water is available for diversion; (b) the procedure to determine the MBF; (c) the procedure to determine the MCD; and (d) the daily flow study all utilize the same methodology to estimate flows at an ungauged site (POD or POI) based on the discharge record of a nearby reference stream gauge. There is no discussion of the validity of the methodology used and no substantiation that it always produces an estimate that errs on the side of resource protection.

The five flows that are transferred from a reference gauge to an ungauged location are (a) the unimpaired seasonal average flow; (b) the unimpaired mean annual flow; (c) the 1.5-year instantaneous flood discharge; (d) daily average flows; and (e) the February median flow.

There is always some level of error associated with estimating a flow parameter at an ungauged site such as a POI or POD. Policy Section 2.2.1 above claims that the regional criteria, "...are by necessity conservative and err on the side of resource protection."

The methodology used to transfer the various flow parameters from a reference gauge to an ungauged POD adjusts the flow parameters at the reference gauge by the product of two ratios (1) the ratio of the drainage area of the ungauged site to the gauged site and (2) the ratio of the mean annual precipitation at the ungauged site to the mean annual precipitation at the gauge. The product of these two ratios is a simple linear scaling factor (Scaling Method)

The Scaling Method assumes that only drainage area and precipitation affect the runoff from a watershed. Watershed characteristics such as geology, soils, topography, vegetation, and land use are ignored by this methodology. Below I demonstrate that the Scaling Method does not always err on the side of resource protection. I also demonstrate that proximity of the reference stream gauge is not sufficient to guarantee results that protect the resource using the Scaling Method to estimate the flow at an ungauged location.

An analysis of unappropriated water to supply the project is necessary to determine if there is sufficient water to supply the proposed project after senior rights are accounted for (unappropriated water analysis). The average unimpaired flow volume between December 15 and March 31 (average seasonal unimpaired flow) is adjusted for senior demand to determine if there is any remaining water available for diversion. If the estimate of the average seasonal unimpaired flow is too high, more water will appear to be available than actually is the case. Therefore, to be protective of the resource, the methodology used to estimate the average seasonal unimpaired flow must systematically under-estimate the true value to err on the side of resource protection.

The technical documents supporting the Policy (*North Coast Instream Flow Policy: Scientific Basis and Development of Alternatives Protecting Anadromous Salmonids*) test whether the Policy procedures were protective of the resource by applying them at selected gauged validation sites. However, there is no evaluation of the proposed Scaling Method to estimate the required flow parameters at an ungauged location based on the nearest stream gauge. In the following section I demonstrate that the proposed Scaling Method does not always err on the side of resource protection. If these flow parameters are not conservatively estimated (err on the side of resource protection) then the estimate of available unappropriated water will likely be too high or the MBF will likely be too low. If ***either*** case occurs then the regionally protective criteria will ***not*** be protective of the target resource – salmonids.

I begin my demonstration that the methodology to estimate the various flow parameters at an ungauged site will not be protective of anadromous salmonids and their habitat at some sites by examining the procedure to determine the MBF.

Regionally Protective Minimum Bypass Flow

The MBF is determined by multiplying the estimated mean annual flow by a scalar factor that varies with drainage area (see table in Section 2.2.1.2). So, the magnitude and direction of error of the MBF is the same as for the estimate of the mean annual flow. The resource (salmonids) will be adversely impacted if the MBF is to low. Therefore, to err on the side of resource protection requires that the mean annual flow should tend to be over-estimated by the Scaling Method.

The section describing how to determine the regionally protective MBF is quoted below. My comments follow the quote.

> B.5.2.1 Estimate the mean annual unimpaired flow at the POIs
>
> Mean annual unimpaired flow is the average rate of flow past a location if no diversions (impairments) were taking place in the watershed above that point. Mean annual unimpaired flow shall be estimated by one of the following methods: (A) adjustment of streamflow records, (B) using a precipitation-based streamflow model, or (C) another method acceptable to the State Water Board.
>
> A. Adjustment of streamflow records method
>
> Steps required for this method are:
>
> 1. From the streamflow records collected in B.1.1, select a streamflow gage near the POI with at least ten water years of complete record of streamflow (streamflow time series). The water years do not have to be over a continuous time period if not available. Missing data that has been filled with estimates by the agency operating the gage based on standard methods is acceptable for use.
>
> 2. Calculate the mean annual flow rate at the gage by summing the recorded daily streamflow data for each day in the period of record and dividing it by the number of days in the period of record. Do not include data recorded for partial water years.
>
> 3. If the gage is located in a watershed that is impaired by water diversions, the mean annual flow rate at the gage shall be adjusted for the impairments to obtain an estimate of the unimpaired mean annual flow rate at the gage (Qgage). The details of how the upstream demands were estimated, and how they were used to unimpair the gage shall be detailed in the analysis report. Use of average annual demand is acceptable for the purposes of this analysis.
>
> 4. The mean annual unimpaired flow rate at each POI is calculated from Qgage by multiplying by the ratio of drainage areas and precipitation, according to the following equation:

$$Q_{POI} = Q_{gage} * (DA_{POI}/ DA_{gage}) * (P_{POI}/ P_{gage})$$

where:

Q_{POI} = mean annual unimpaired flow rate estimated at the POI, in cubic-feet per second;

Q_{gage} = unimpaired mean annual flow rate recorded at the gage, in cubic-feet per second;

DA_{POI} = drainage area at the POI, in square miles;

DA_{gage} = drainage area at gage, in square miles;

P_{POI} = average annual precipitation of the POI, in inches; and

P_{gage} = average annual precipitation of the gage, in inches.

B. Precipitation-Based Streamflow Model

Subject to State Water Board approval, the applicant may propose using standard hydrologic techniques or public domain computer models for estimating the mean annual unimpaired flow at the POI. This analysis shall be based on a ten-year simulation period, at a minimum. Model results shall be validated by comparison with recorded flows on or near the POD watershed. The recorded flows do not have to be unimpaired but the applicant shall take the impairment into consideration when calibrating the model. Model submittal requirements are described in Appendix A Section A.1.1.1.

Section B.5.2.1 B allows precipitation-based streamflow modeling, using a minimum of 10-years of precipitation data, to estimate the unimpaired mean annual flow. Transferring the results of a precipitation-based streamflow model that is calibrated to adequately replicate the unimpaired flow at a reference stream gauge to an ungauged watershed upstream of a POD can not be relied upon to give a reliable estimate of the unimpaired mean annual discharge if the model is not adjusted for any difference in watershed characteristics, such as soils, topography, geology, vegetation cover and land use, between the reference gauge watershed and the POD watershed. In addition, all assumptions and all input data should be readily available to the public and other government agencies in order for the public and other agencies to be able to evaluate the reliability of a precipitation-based streamflow model.

The Scaling Method to estimate the seasonal flow volume at the various POIs, described in step B.5.2.1 A-4 above, will not be conservative and is likely under-estimate the mean annual unimpaired flow at some sites. The following discussion demonstrates that the procedure described in B.5.2.1 A-4 will be inappropriate at some sites in the region covered by the Policy.

Assume that the flow at each of the POIs is ungauged. The procedure described in B.5.2.1 A-4 uses the following formula to estimate the mean annual unimpaired flow at an ungauged POI.

$$Q_{POI} = Q_{gage} * (DA_{POI}/ DA_{gage}) * (P_{POI}/ P_{gage}) \qquad \text{(Eq-1)}$$

Rearranging Eq-1:

$$Q_{POI} / (DA_{POI}) / (P_{POI}) = Q_{gage} / (DA_{gage}) / (P_{gage}) \qquad \text{(Eq-2)}$$

Looking at the right side of Eq-2:

$$Q_{gage} / (DA_{gage}) / (P_{gage})$$

This term says that the unimpaired mean annual flow recorded at the gauge is divided by the drainage area upstream of the gauge and the result is divided by the average annual precipitation that falls on the drainage area upstream of the gauge.

The unimpaired mean annual flow can be expressed as the daily average streamflow in cubic-feet per second (cfs). But 1.0 cfs flowing for one day yields 1.983 acre-feet. So, the unimpaired mean annual flow can also be expressed as a daily average volume of flow by multiplying the value for the mean annual flow in cfs by the above conversion factor. Dividing the unimpaired mean annual flow, in acre-feet, by the drainage area, in acres, results in the mean annual runoff being expressed in terms of feet of water released from the drainage area. Converting feet to inches in the ration yields the unimpaired mean annual runoff expressed as inches of water released from the drainage area. Symbolically this is written as follows:

Q_{gage} (acre-feet) / (DA_{gage} (acres) = Q_{gage} / (DA_{gage}) in feet (x 12 inches / foot) = Q_{gage} / (DA_{gage}) in Inches

The unimpaired mean annual flow is also called the unimpaired annual runoff which can be expressed as cfs, acre-feet or inches. Choosing to express the unimpaired mean annual flow in inches is the most meaningful choice when it is divided by the average annual precipitation. Setting the unimpaired runoff at the gauge equal to R_{gage}, expressed in inches, gives the following expression.

$$Q_{gage} / (DA_{gage}) = R_{gage} \text{ in Inches} \qquad \text{(Eq-3)}$$

$$Q_{gage} / (DA_{gage}) / (P_{gage}) = R_{gage} / P_{gage} \text{ in Inches/Inches} \qquad \text{(Eq-4)}$$

Since the unimpaired mean annual flow (runoff) is expressed in inches and the average annual precipitation is expressed in inches their ratio is dimensionless (inches/inches). Physically the ratio mean annual flow to mean annual precipitation, R_{gage} / P_{gage}, represents the average efficiency the watershed has in converting rainfall into runoff (runoff efficiency).

Substituting Eq-4 into both sides of Eq-2 yields:

$$R_{POI} / (P_{POI}) = R_{gage} / P_{gage} \qquad \text{(Eq-5)}$$

Note that Eq-5 is directly derived from Eq-1 by simply rearranging terms and expressing the unimpaired mean annual flow in inches. The terms in Eq-5 are dimensionless and represent the runoff efficiency of the watershed above the reference stream gauge and the POI. The equality in Eq-5 says that the runoff efficiency of *all watersheds* are *equal*. That is an amazing claim that the State Board staff has not verified.

I assert that Eq-5 does *not* hold for all pairs of watersheds in the Policy region. If the runoff efficiency at an ungauged site (POI) is substantially different from the runoff efficiency of the reference stream gauge, then using the Scaling Method to estimate the unimpaired mean annual flow at the ungauged site (POI or POD) will produce estimates with significant error. Errors that underestimate the unimpaired mean annual flow at the various POIs are likely to result in inadequate bypass flows and result in adverse impacts to salmonids and their habitat.

Rantz (1974) published USGS Map MF-613, *Mean Annual Runoff in the San Francisco Bay Region, California, 1931-1970.* Rantz used standard statistical methods to estimate the mean annual streamflow for the 1931-1970 at 76 stream gauges in the nine counties surrounding the San Francisco Bay. Table 1 lists a total of 28 of Rantz's stream gauges that occur in the southern portion of the Policy region. Runoff efficiency and loss were calculated from Rantz's data. Runoff efficiency is defined above. Loss is defined as mean annual precipitation minus mean annual runoff. Losses occur because of process such as evaporation, soil moisture recharge, groundwater recharge, subsurface flow out of the basin, and diversions.

Rantz (1974) used stream gauges whose watersheds were either undeveloped or had sufficient records to allow adjustment for any diversions. Several of the gauges in Table 1 are in areas with little development or extensive agriculture such as Big Sulphur Creek or Big Austin Creek.

Table 1 gives the drainage area and estimates the mean annual discharge and the mean annual precipitation for 1931-1970 (Rantz, 1974) for 28 stream gauges in the southern portion of the Instream flow Policy region. Validation sites used in Appendix F of the Policy technical document are in bold. In Table 1, loss is calculated as the mean annual precipitation minus mean annual runoff. Runoff efficiency equals mean annual runoff, in inches, divided by mean annual precipitation, in inches, see discussion above. A runoff efficiency of 1.0 (100%) indicates that mean annual runoff equals mean annual precipitation.

The data in Table 1 can be used to test the ability of Eq-1 (Scaling Method of Section B.5.2.1 A-4 of the Policy) to accurately predict the mean annual flow and MBF at an ungauged site. The test consists of selecting pairs of stream gauges from Table 1 and using one of the gauges to predict the mean annual flow at the other gauge and then switch roles. Seven pairs of gauges were selected for testing (see Table 2).

Using Santa Rosa Creek near Santa Rosa to predict the mean annual flow of Franz Creek results in 9.8% over-estimate. But reversing roles results in Franz Creek under-estimating the mean annual flow and the MBF in Santa Rosa Creek near Santa Rosa by -9.1%.

Austin Creek and Big Austin Creek near Cazadero are in a forested area with little development or agriculture. Using Austin Creek to estimate the mean annual flow in Big Austin Creek results in a -26.3% under-estimate. Reversing roles results in a 35.8% over-estimate.

The greater the difference in Runoff Efficiency between the pairs of gauges the larger the percentage prediction error of the Scaling Method. For example: Big Sulphur Creek and Maacama Creek share a watershed divide but using Maacama Creek to estimate the mean annual runoff in Big Sulphur Creek results in *underestimating* the mean annual flow and the MBF by -35.0%. The gauges in each pair, in Table 2, are adjacent or are close to each other, except for Maacama Creek and Dry Creek near Napa which are separated by about 18 miles. Even though Maacama Creek and Dry Creek near Napa are the pair separated by the greatest distance they have the lowest prediction error of the selected gauges because their runoff efficiencies are nearly the same. Clearly, watershed proximity does not guarantee an accurate prediction of mean annual flow using the Scaling Method outlined in B.5.2.1 A-4 (my Eq-1).

In the test conducted in Table 2, the mean annual flow was known so that the prediction error could be calculated. In practice, there would be no way to estimate the prediction error if an applicant used the proposed Scaling Method to estimate the unimpaired mean annual discharge of an ungauged watershed above a POI. Table 2 shows that, in some cases, the prescribed procedure *underestimates* the mean annual flow and the MBF by more than -30%. Remember that the MBF is calculated by multiplying the MBF by a scaling factor that varies with drainage area which means that the prediction error of the MBF is equal to the prediction error of the unimpaired mean annual flow. This level of under-estimation (-30%) of the mean annual flow and the MBF is very likely to result in a MBF that *fails* to protect the target resource.

Table 1. Rantz, 1974, gives the drainage area and estimates the mean annual discharge and mean annual precipitation for the 1931-1970 for 76 gauges in the San Francisco Bay region. The 28 gauges below are in the southern portion of the Instream flow Policy region. Validation sites used in Appendix F of the Policy technical document are in bold. Loss is precipitation minus mean annual runoff.

Rantz Map Number	USGS Stream Gauge	Drainage Area sq-mi	1931-1970 Precipitation Inches	1931-1970 Mean Annual Runoff thousands Ac-Ft	1931-1970 Mean Annual Runoff Inches	1931-1970 Runoff Efficiency Runoff/Rainfall Inches/Inches	1931-1970 Loss Inches	1931-1970 Percentage Loss	1931-1970 Mean Annual Flow cfs
1	Garcia River	98.5	56	229.4	43.7	78.0%	12.3	22.0%	316.7
2	SF Gualala	161.0	51	273.9	31.9	62.5%	19.1	37.5%	378.2
3	Russian River between Cloverdale and Healdsburg excluding gauged tributaries	148.6	40	121.6	15.3	38.4%	24.7	61.6%	167.9
4	Russian River between Healdsburg and Guerneville excluding gauged tributaries	361.0	35	346.9	18.0	51.5%	17.0	48.5%	479.0
5	Cumminisky Creek near Cloverdale	13.4	39	15.90	22.2	57.0%	16.8	43.0%	22.0
6	Big Sulphur Creek	82.3	48	132.23	30.1	62.8%	17.9	37.2%	182.6
7	Maacama Creek	43.4	58	54.80	23.7	40.8%	34.3	59.2%	75.7
8	**Franz Creek**	**15.7**	**40**	**15.85**	**18.9**	**47.3%**	**21.1**	**52.7%**	**21.9**
9	Dry Creek near Cloverdale	87.8	47	113.07	24.1	51.4%	22.9	48.6%	156.1
10	Warm Springs Creek at Skaggs Springs	32.7	50	53.16	30.5	61.0%	19.5	39.0%	73.4
11	Dry Creek between Cloverdale and Geyserville excluding Warm Sps	41.5	46	51.77	23.4	50.8%	22.6	49.2%	71.5
12	Mill Creek near Healdsburg	11.5	50	16.30	26.6	53.2%	23.4	46.8%	22.5
13	**Santa Rosa Creek near Santa Rosa**	**12.5**	**36**	**12.48**	**18.7**	**52.0%**	**17.3**	**48.0%**	**17.2**
14	Big Austin Creek near Cazadero	26.6	65	67.85	47.8	73.6%	17.2	26.4%	93.7
15	Austin Creek	36.5	59	62.25	32.0	54.2%	27.0	45.8%	85.9
16	**Salmon Creek**	**15.7**	**44**	**13.51**	**16.1**	**36.7%**	**27.9**	**63.3%**	**18.7**
17	Walker Creek	37.1	27	29.10	14.7	54.5%	12.3	45.5%	40.2
18	Nicasio Creek	36.6	33	28.70	14.7	44.6%	18.3	55.4%	39.6
19	**Pine Creek**	**7.8**	**36**	**6.80**	**16.3**	**45.2%**	**19.7**	**54.8%**	**9.4**
20	Arroyo Corte Madera del Presidio	4.7	35	4.11	16.4	46.9%	18.6	53.1%	5.7
21	Corte Madera Creek at Ross	18.1	41	17.88	18.5	45.2%	22.5	54.8%	24.7
22	Novato Creek at Novato	17.6	27	8.84	9.42	34.9%	17.6	65.1%	12.2
23	Petaluma River at Petaluma	30.9	25	11.77	7.14	28.6%	17.9	71.4%	16.3
24	Sonoma Creek at Agua Client	58.4	35	45.48	14.6	41.7%	20.4	58.3%	62.8
25	Napa River near St Helena	81.4	39	65.97	15.2	39.0%	23.8	61.0%	91.1
27	Dry Creek near Napa	17.4	37	13.38	14.4	39.0%	22.6	61.0%	18.5
28	Napa River between St Helena and Napa excluding gauged tributaries	67.1	31	30.90	8.6	27.9%	22.4	72.1%	42.7
29	Redwood Creek near Napa	9.8	36	7.28	13.9	38.7%	22.1	61.3%	10.1

Table 2. Selected pairs of stream gauges from Table 1 used to test the ability of Eq-1 to predict the mean annual flow (runoff) of the other gauge. For example Santa Rosa Creek near Santa Rosa is used to estimate the mean annual flow of Franz Creek and vice-a-versa. The greater the difference in Runoff Efficiency between the pairs of gauges the larger the percentage prediction error. The gauges in each pair are adjacent or are close to each other, except for Maacama Creek and Dry Creek near Napa which are separated by about 18 miles. Even though Maacama Creek and Dry Creek near Napa are the pair separated by the greatest distance they have the lowest prediction error of the selected gauges. Big Sulphur Creek and Maacama Creek share a watershed divide but using Maacama Creek to estimate the mean annual runoff in Big Sulphur Creek results in underestimating the mean annual flow and the MBF by -35.0%.

Stream Gauge Pairs used to Predict Each Others Mean Annual Runoff	Drainage Area sq-mi	Precipitation inches	Mean Annual Runoff cfs	Runoff Efficiency	Mean Annual Runoff Estimate from Other Gauge cfs	Mean Annual Runoff Prediction Error %	MBF from Gauge Data	MBF Prediction from Other Gauge	MBF Prediction Error
Franz Creek	15.7	40	21.9	47.3%	24.0	9.8%	52.8	57.9	9.8%
Santa Rosa Creek near Santa Rosa	12.5	36	17.2	51.9%	15.7	-9.1%	46.3	42.0	-9.1%
Big Sulphur Creek	82.3	48	182.6	62.8%	118.7	-35.0%	202.1	131.5	-35.0%
Maacama Creek	43.4	58	75.7	40.8%	116.3	53.8%	113.2	174.0	53.8%
Big Austin Creek near Cazadero	26.6	65	93.7	73.6%	69.0	-26.3%	176.4	129.9	-26.3%
Austin Creek	36.5	59	85.9	54.2%	116.7	35.8%	139.5	189.3	35.8%
Austin Creek	36.5	59	85.9	54.2%	58.1	-32.3%	139.5	94.3	-32.3%
Salmon Creek	**15.7**	**44**	18.7	**36.7%**	27.6	47.8%	45.0	66.5	47.8%
Walker Creek	37.1	27	40.2	54.5%	32.9	-18.2%	64.7	52.9	-18.2%
Nicasio Creek	36.6	33	39.6	44.6%	48.4	22.3%	64.2	78.5	22.3%
Petaluma River at Petaluma	30.9	25	16.3	28.6%	23.7	46.0%	28.5	41.6	46.0%
Sonoma Creek at Agua Client	58.4	35	62.8	41.7%	43.0	-31.5%	81.7	55.9	-31.5%
Maacama Creek	43.4	58	75.7	40.8%	72.2	-4.5%	113.2	108.0	-4.5%
Dry Creek near Napa	17.4	37	18.5	39.0%	19.4	4.8%	42.5	44.5	4.8%

In Table 1, the Runoff Efficiency ranges from about 28% to 78%. This large range in Runoff Efficiency is due to the fact that there is a wide range in the physical characteristics of the watersheds upstream of the stream gauges. For example, consider two small watersheds, of equal area, that have deep soils, significant groundwater storage, and receive identical rainfall. One of the watersheds is completely undeveloped and covered by a virgin forest in good condition. The second watershed was also once covered by the same type of virgin forest but half the watershed has been converted into an urban area. The substantial amount of impervious surfaces in the urbanized watershed will result in more rapid surface runoff and less infiltration into the soil. Since significantly less water infiltrates into the soil there will also be less groundwater recharge. Therefore, a greater percentage of the rainfall will appear as runoff after urbanization than did before urbanization. Thus, the Runoff Efficiency of the urbanized watershed will be significantly greater than the forested watershed. Mountainous watersheds with narrow valleys and with steep slopes tend to have thin soils and little groundwater storage and will tend to have a high Runoff Efficiency. A watershed that contains a high percentage of flat or gently rolling land will tend to have deep soils and significant groundwater storage resulting in a lower Runoff Efficiency. The Runoff Efficiency varies with the physical characteristics and land use of the watershed.

The above discussion shows that simply using the closest reference stream gauge will not result a protective MBF at some sites. Therefore, I recommend that the State Board undertake a study to relate the runoff efficiency of the watershed (Eq-4) above a large sample of gauging stations to watershed characteristics such as geology, soils, topography, vegetation type, and land use including the volume of diversion. The result of this type of study should allow selection of an appropriate reference stream gauge based upon the similarity watershed characteristics upstream of the reference gauge to the watershed characteristics upstream of a given POD or POI.

Water Availability Analysis

The procedure to determine if there is sufficient unappropriated water available for a project uses the Scaling Method to estimate the average seasonal flow at ungauged PODs that is analogous to the way that the mean annual flow is estimated. My comments follow the following quote from Appendix B of the Policy describing the process to determine the average seasonal flow.

> **B.2.1.3 Estimate the Average Seasonal Unimpaired Flow Volume at Each Senior POD Identified for Analysis Along the Flow Path**
>
> The average seasonal unimpaired flow volume at the identified POD shall be estimated by one of the following methods: (A) adjustment of streamflow records, (B) using a precipitation-based streamflow model, or (C) another method acceptable to the State Water Board.
>
> **A. Adjustment of streamflow records method**
>
> Steps for calculating the average seasonal unimpaired flow volume at the identified PODs from streamflow records include:
>
> 1. Select a streamflow gage near the POD with at least ten water years of complete record of daily streamflow data (streamflow time series).
>
> 2. Calculate the average seasonal flow volume at the gage. ***Assume this is the average unimpaired seasonal flow volume***. For each month in the diversion season, calculate the mean monthly flow volume at the gage. To get the mean monthly flow volume for a particular month, sum the daily flow data for that month to get a total volume, and repeat for that month for each year in the period of record. Next, sum the total monthly volumes for that month and divide by the number of years in the record to obtain the mean monthly volume for the particular month. Repeat these

calculations for each month in the diversion season and sum up each mean monthly total to get the average unimpaired seasonal flow volume for the diversion season at the gage. (*Emphasis Added*)

3. The average unimpaired seasonal flow volume at each identified senior POD along the flow path can be estimated by using the average unimpaired seasonal flow volume at the gage, the watershed area for the gage and at the identified senior POD, and the average annual precipitation at the gage and at the identified senior POD with the following equation:

$$Q_{POD} = Q_{gage} * (DA_{POD} / DA_{gage}) * (P_{POD} / P_{gage})$$

where:

Q_{POD} = average unimpaired seasonal flow volume estimated at the POD, in acre-feet;

Q_{gage} = average unimpaired seasonal flow volume recorded at the gage, in acre-feet;

DA_{POD} = drainage area at the POD, in square miles;

DA_{gage} = drainage area at gage, in square miles;

P_{POD} = average annual precipitation at the POD, in inches; and

P_{gage} = average annual precipitation at the gage, in inches.

B. Precipitation-Based Streamflow Model
Subject to State Water Board approval, the applicant may propose using standard hydrologic techniques or public domain computer models for estimating the average seasonal unimpaired flow volume. Precipitation input data shall be provided over a minimum of ten complete and continuous water years. Model results shall be validated by comparison with recorded flows on or near the POD watershed. The recorded flows do not have to be unimpaired but the applicant shall take the impairment into consideration when calibrating the model. The modeled output flows shall be summed in units of acre-feet to obtain an average seasonal unimpaired volume. Model submittal requirements are described in Appendix A Section A.1.1.1 of the policy.

Section B.2.1.3 B allows precipitation-based streamflow modeling, using a minimum of 10-years of precipitation data, to estimate the unimpaired average seasonal flow. Transferring the results of a precipitation-based streamflow model that is calibrated to adequately replicate the unimpaired flow at a reference stream gauge to an ungauged watershed upstream of a POD will likely not give a reliable estimate of the unimpaired average seasonal discharge if the model is not adjusted to for any difference in watershed characteristics, such as soils, topography, geology, vegetation cover and land use, between the reference gauge watershed and the POD watershed. In other word, a precipitation-based streamflow model that does not account for differences in Runoff Efficiency between the reference gauge and the ungauged watershed above a POD or POI will not produce reliable flow estimates. In addition, all assumptions and all input data should be readily available to the public in order for the public to be able to evaluate the reliability of a precipitation-based streamflow model.

The purpose of this part of the procedure is to determine the average volume of flow during the diversion season. In Section **B.2.1.3 A-3**, quoted above, the applicant is specifically directed to assume that the streamflow record of the reference gauge is unimpaired. If the average seasonal flow of the reference gauge is impaired than it will be lower than the true unimpaired value. Using the impaired average seasonal flow of the reference gauge will result in the procedure of **B.2.1.3 A-3** predicting a lower value of the average seasonal flow at the POD or POI. So, assuming the streamflow record at the nearby stream gauge is unimpaired is conservative and works to protect the resource.

However, the procedure to estimate the average seasonal flow volume at the various senior PODs, described in step B.2.1.3 A-3 above, will not be conservative and will over-estimate the seasonal flow volume at some sites. The following discussion demonstrates that the procedure described in B.2.1.3 A-3 will be inappropriate at some sites in the region covered by the Policy. The following discussion assumes that the gauged record is unimpaired.

The procedure described in B.2.1.3 A-3 to estimate the average seasonal flow volume at the senior PODs uses the same Scaling Method as was used to estimate the mean annual flow at the project POD which is described in B.5.2.1.A-4. My basic analysis presented in the *Regionally Protective Minimum Bypass* section above applies to estimating the average seasonal flow at a senior POD based on a flow record of a reference stream gauge. The following discussion applies my previous analysis to the Scaling Method used to estimate the unimpaired average seasonal flow.

Assume that the flow at each of the PODs is ungauged. The procedure described in B.2.1.3 A-3 uses the following formula to estimate the unimpaired average seasonal flow volume at an ungauged POD.

$$Q_{POD} = Q_{gage} * (DA_{POD}/ DA_{gage}) * (P_{POD}/ P_{gage}) \qquad \text{(Eq-6)}$$

Rearranging Eq-6:

$$Q_{POD} / (DA_{POD}) / (P_{POD}) = Q_{gage} / (DA_{gage}) / (P_{gage}) \qquad \text{(Eq-7)}$$

Looking at the right side of Eq-7:

$$Q_{gage} / (DA_{gage}) / (P_{gage})$$

This term says that the unimpaired average seasonal flow volume recorded at the gauge is divided by the drainage area upstream of the gauge and the result is divided by the average annual precipitation that falls on the drainage area upstream of the gauge.

The unimpaired average seasonal flow volume is expressed in acre-feet. Dividing the unimpaired average seasonal flow volume (acre-feet) by the drainage area, in acres, results in the unimpaired seasonal average flow volume being expressed in terms of feet of water released from the drainage area. Converting feet to inches in the ratio yields the unimpaired average seasonal flow volume expressed as inches of water released from the drainage area. Symbolically this is written as follows:

Q_{gage} (acre-feet) / (DA_{gage} (acres) = $Q_{gage} / (DA_{gage})$ in feet (x 12 inches / foot) = $Q_{gage} / (DA_{gage})$ in Inches

The unimpaired average seasonal flow volume is also called the unimpaired seasonal runoff. Choosing to express the unimpaired average seasonal flow volume in inches is a meaningful choice when it is divided by the average annual precipitation in inches. Setting the unimpaired seasonal runoff at the gauge equal to R'_{gage}, expressed in inches, gives the following expression.

$$Q_{gage} / (DA_{gage}) = R'_{gage} \text{ in Inches} \qquad \text{(Eq-8)}$$

$$Q_{gage} / (DA_{gage}) / (P_{gage}) = R'_{gage} / P_{gage} \text{ in Inches/Inches} \qquad \text{(Eq-9)}$$

Since the unimpaired average seasonal flow volume (runoff) is expressed in inches and the average annual precipitation is expressed in inches their ratio is dimensionless (inches/inches). The ratio of average seasonal flow volume to mean annual precipitation, R'_{gage} / P_{gage}, of Eq-9 is always going to be less than or equal to ratio of mean annual flow to average annual rainfall in Eq-4. Since the average annual rainfall is used instead of the average seasonal rainfall in Eq-9 it does *not* represents the average efficiency that the watershed has in converting rainfall into runoff (runoff efficiency) since the ratio in Eq-9 divides the *average seasonal* flow volume by the *mean annual* precipitation. Since the average seasonal flow volume is less than the mean annual flow volume the ratio of Eq-9 will always be less than or equal to the watershed efficiency ratio of Eq-4.

Substituting Eq-9 into both sides of Eq-7 yields:

$$R'_{POD} / (P_{POD}) = R'_{gage} / P_{gage} \qquad \text{(Eq-10)}$$

Even though the terms in Eq-10 are not the seasonal watershed efficiency ratios they can still be used in the same way to identify watersheds with similar runoff characteristics. That is, if Eq-10 is not a true statement of equality between two watersheds then significant error can be expected when using the record of one gauge to predict the unimpaired seasonal average flow of the other watershed. As discussed in the section on the MBF, there is presently no way to evaluate if the closest reference stream gauge will have similar watershed characteristics to the watershed above the PODs of interest.

Therefore, I recommend that the ratio of Eq-9 be calculated at all reference stream gauges used in the study I proposed above to relate the annual watershed efficiency ratio (Eq-4) to physical characteristics above the gauge. Such a study might show that the relationship between the watershed efficiency of Eq-4 and watershed characteristics was a sufficient guide for selecting a reference gauge to estimate both the mean annual flow and the average seasonal flow at the PODs and POIs for a project.

To err on the side of resource protection, the estimate of the unimpaired mean annual flow, used to calculate the MBF, should tend to over-estimate the true value of the unimpaired mean annual flow. To err on the side of resource protection, the estimate of the unimpaired average seasonal flow, used to determine is there is unappropriated water, should under-estimate the true value. Because the procedures to estimate the unimpaired mean annual flow and the unimpaired average seasonal flow are virtually mathematically identical it is highly likely that the estimation error for the unimpaired mean annual flow and for the unimpaired average seasonal flow, at a given POD or POI, will be in the same direction and have similar magnitude. That is, if the unimpaired mean annual flow is overestimated for a particular POD then, the estimate for the unimpaired average seasonal flow will also be overestimated by a similar amount. So, if the estimate for the MBF (calculated from the unimpaired mean annular flow) is over-estimated it will err on the side of resource protection but the estimate of the volume of unappropriated water (based on the unimpaired average seasonal flow) will also be over-estimated which will potentially lead to diverting more water than is actually available and so will not err on the side of resource protection. To always err on the side of resource protection requires an estimation procedure that can systematically over-estimate the unimpaired mean annual flow and simultaneously under-estimate the unimpaired average seasonal flow. The Policy procedures to estimate the unimpaired mean annual flow and the unimpaired seasonal average flow will result in erring against the resource for one of these two parameters and erring in favor of the resource on the other parameter.

Clearly, the Policy procedures to estimate the unimpaired mean annual flow and the unimpaired seasonal average flow need to be modified so ensure that the most accurate estimate of both parameters is obtained. This strongly argues in favor of creating a screening procedure to select an appropriate reference stream gauge based on watershed characteristics.

Alluvial Fans

Alluvial fans are found on many tributary streams of the Napa River, Russian River, Navarro River and other rivers in the Policy area. The stream reaches that cross alluvial fans provide passage for salmonids returning to the spawning and rearing habitat found in the headwater canyons. Spawning and rearing habitat may also occur in some reaches crossing alluvial fans.

The stream reaches crossing alluvial fans tend to be losing streams meaning that they lose water in the downstream direction. In contrast, a stream reach in a headwater canyon tend to be gaining stream in that streamflow increases in the downstream direction. These stream reaches crossing alluvial fans tend to lose water not only in the summer and early fall but even between storms during the rainy season because, on an alluvial fan, there are no extensive groundwater sources above the top of the streambank to supply stream flow. And alluvial fans tend to be composed of fairly porous material so infiltrating water tends to percolate downward quickly. I have seen stream reaches that cross alluvial fans dry up between winter storms trapping fish in residual pools. A stream reach on an alluvial fan that becomes a losing reach between winter storms can limit the time available for in-migration and out-migration of salmonids.

Agricultural pumping on alluvial fans during the growing season can lower the groundwater surface below the bed of the stream. Consequently, the stream reach crossing the pumped alluvial fan dries up in summer and fall. In such cases, substantial rain must fall before continuous flow through the reach crossing the alluvial fan can resume.

The methodology used to estimate the unimpaired average seasonal flow assumes that streamflow always increases in the downstream direction. But the flow in a stream reach crossing an alluvial fan can decrease in the downstream direction between winter storms. So, applying the procedure in Section B.2.1.3 A-3 to estimate the unimpaired seasonal average flow volume is likely to over-estimate the true flow seasonal flow volume artificially making it appear there is more water available for appropriation than is actually the case. Applying the methodology in Section B.2.1.3 A-3 to a stream reach that crosses an alluvial fan is likely to result in an estimate of the unimpaired seasonal flow volume that does fails to protect the resource.

The above comments about the nature of stream reaches crossing alluvial fans can also be applied to stream reaches that are heavily aggraded.

Maximum Cumulative Diversion Rate

The Policy section defining the Regional Criteria for the Maximum Cumulative Diversion (MCD) is quoted below.

> 2.2.1.3 Maximum cumulative diversion
>
> The **bankfull flow** is the flow at which channel maintenance is the most effective. The 1.5-year return peak flow is a hydrologic metric that can be used to estimate bankfull flow and effective channel maintenance flows. The **1.5-year instantaneous peak flow** is the annual maximum instantaneous peak streamflow that is equaled or exceeded, on average over the long term, once every one and a half years. The frequency at which this peak flow is expected to occur is referred to as the **recurrence interval**. Limiting the maximum rate at which water is withdrawn by all water diverters in a watershed so that peak streamflows are reduced by no more than a small fraction of the 1.5-year instantaneous peak flow will result in a relatively small change to channel geometry, and will ensure that natural flow variability and the various biological functions that are dependent on that variability are protected.
>
> To ensure maintenance of natural flow variability and protection of the biological functions dependent on it, ***the maximum cumulative diversion rate is set at the largest value of the sum of the rates of diversion of all diversions upstream of a specific location in the watershed***. . (Emphasis Added)
>
> The maximum cumulative diversion rate criterion is equal to: five percent of the 1.5-year instantaneous peak flow.

> For projects located above anadromy, the maximum cumulative diversion rate criterion shall be evaluated at POIs at and/or below anadromy in order to identify the allowable rate of diversion at project PODs. The maximum cumulative diversion rate puts limitations on the cumulative rate of water withdrawal in a watershed, not necessarily the rate of withdrawal at a point of diversion. The rate of diversion for a project is not necessarily equal to the maximum cumulative diversion rate in a watershed. This is because the project's rate of diversion is based on an evaluation of whether the project, together with existing diversions, causes an exceedance of the maximum cumulative diversion rate criterion at points of interest at and/or below the upper limit of anadromy. Guidelines for calculating the maximum cumulative diversion rate criterion and for determining whether a limit on the rate of diversion is needed are provided in Appendix A, Section A.1.8 and Appendix B Section B.5.2.3.

In the second paragraph of Section 2.2.1.3 quoted above, the phrase, "…the maximum cumulative diversion rate is set at the largest value of the sum of the rates of diversion of all diversions upstream of a specific location in the watershed" is in conflict with paragraph three of Section 2.2.1.3 which states that, "The maximum cumulative diversion rate criterion is equal to: five percent of the 1.5-year instantaneous peak flow."

> B.5.2.3 Regional Criteria for the Maximum Cumulative Diversion
>
> The maximum cumulative diversion is equal to 5 percent of the 1.5-year instantaneous peak flow, in cubic feet per second. The 1.5-year instantaneous peak flow is the maximum instantaneous peak streamflow that occurs or is exceeded, on average over the long term, once every one and a half years. The frequency at which this peak flow is expected to occur is referred to as the recurrence interval. The 1.5-year instantaneous peak flow shall be calculated at each POI located at and below anadromy either by peak flow frequency analysis of instantaneous peak flow records or by other methods acceptable to the State Water Board.
>
> The peak flow frequency analysis methods described below are the annual flood methodology described in Bulletin 17B "Guidelines for Determining Flood Flow Frequency" (IACWD, 1982) and the peaks over threshold methodology (also referred to as the partial duration method) described in Hydrology for Engineers (Linsley, et al, 1982). Although two peak flow frequency analysis methods are described, the peaks over threshold method is the preferred method, and applicants are encouraged to use it where possible.
>
> The peak flow frequency analysis results provide the 1.5-year instantaneous peak flow at the gage. For this analysis, assume that the calculated 1.5-year instantaneous peak flow data are representative of unimpaired conditions. The 1.5-year instantaneous peak flow at each POI shall be estimated from the 1.5-year instantaneous peak flow at the gage using the proration methods described in method A of section B.5.2.1.
>
> A. Peaks over threshold method
>
> The peaks over threshold method (also referred to as the partial duration method) is more accurate for recurrence intervals less than five years (Linsley et al, 1982). Steps required are as follows:
>
> 1. Select a flow threshold so that approximately three peaks over the threshold will be recorded per year on average.
> 2. Select all distinct well-separated flood peaks exceeding the selected flow threshold.
> 3. Rank the peaks from largest to smallest.

4. Estimate the recurrence interval, T, for each peak flow by the Weibull formula: T=(N+1)/m

where:

T= recurrence interval in years;

N= the record length in years; and

m= the rank of the peak, the largest peak having m=1.

5. Plot the magnitude of the peak flow versus the recurrence interval on loglog scale and estimate the 1.5-year instantaneous peak flow from a curve fit of the data.

B. Bulletin 17B Flood Flow Frequency methodology

Bulletin 17B provides guidelines for determining flood flow frequency using annual peak flow data in a log-Pearson Type III distribution. Reservoirs in the policy area tend to be associated with small dams that operate without large sudden changes in flow releases. Bulletin 17B notes that "The procedures [contained in this Bulletin] do not cover watersheds where flood flows are appreciably altered by [large] reservoir [flow] regulation..." (p. 2).

The first sentence of Section B.5.2.3 states that, "The maximum cumulative diversion is equal to 5 percent of the 1.5-year instantaneous peak flow, in cubic feet per second." So, in the second paragraph of Section 2.2.1.3 quoted above, the phrase, "...the maximum cumulative diversion rate is set at the largest value of the sum of the rates of diversion of all diversions upstream of a specific location in the watershed" is in conflict with Section B.5.2.3. My review assumes that the maximum cumulative diversion rate is equal to 5% of the 1.5-year instantaneous peak flow.

The Policy document appears to have an inconsistent use of the term *instantaneous* with regard to flow. In hydrology, the term instantaneous flow means the flow over a very short period of time such as 15 minutes or less. The USGS typically collects streamflow data with digital instruments that average the flow over a 15 minute period. Instantaneous flood peaks tends to occur for less than 15 minutes. The instantaneous maximum flow during a flood peak may occur over only a few minutes of time. In flood hydrology, the 1.5 year instantaneous peak flow is calculated from an analysis of the series of the maximum instantaneous flow from each year of record.

The sample calculation of 1.5 year channel maintenance flows posted on the SWRCB AB-2121 website (*Attachment 2 sample calculation of 1.5 year channel maintenance flows*) demonstrate a calculation based on daily *average* discharges instead of *instantaneous* discharges. The data used in the sample calculation of 1.5 year flow (Attachment 2) were clearly obtained from the daily average data used in *Attachment 1 Sample Water Availability Calculation.*

Using daily *average* values to calculate the 1.5-year flood will always result in estimates that are significantly lower than if the 1.5-year discharge was calculated with *instantaneous* data. Using the maximum annual daily average streamflow to calculate the 1.5-year discharge will provide a more conservative (lower) value of the MCD. Therefore, I recommend that the Policy be changed to define the MCD as 5% of the 1.5-year discharge calculated using *daily average* data instead of maximum annual instantaneous flow. However, the resulting discharge will significantly be less than the 1.5-year discharge defined by using the annual maximum instantaneous peak discharge that has been related to the bankfull discharge.

It is standard hydrologic practice to calculate the 1.5-year flood flow using the maximum *instantaneous* discharge (maximum annual flood) for each year of record. Alternatively, the partial duration series can be used to calculate the 1.5-year instantaneous flow. The partial duration series is composed of ***independent*** *instantaneous* flows above a threshold. The USGS used to post the partial duration series for gauges with flood records on their NWIS web site. However, the USGS now only reports the maximum annual instantaneous flow for each water year of record.

Section B.5.2.3-A, quoted above, recommends the use of the *Peaks Over a Threshold* (Partial Duration Series) to calculate the 1.5 year instantaneous flow. Part B.5.2.3-A.1 says to select a threshold so that an average of three peaks a year will be selected. However, it is not mentioned in Part B.5.2.3-A.1 that the peaks should be from *distinctly* different flood events, that is, the peaks over the threshold should be independent. The use of "peaks" from the same flood event will bias the result.

Dunne and Leopold (*Water in Environmental Planning*, 1978) remind us that the recurrence interval of the partial duration series (peaks over a threshold) is not the same as the recurrence interval for the annual flood series.

> But there is a distinction between the meaning of the recurrence interval of floods obtained from the two series. For the annual-maximum series the recurrence interval is the average interval within which a flood of a given size will occur as an *annual maximum*. The recurrence interval obtained from the partial-duration series (peaks over a threshold) is the average frequency of occurrence between floods of a given size irrespective of their relation to the year. It is the average time between flows equal to or greater than a give discharge. The usual method of obtaining return periods for the partial duration series (peaks over a threshold) is to obtain them for the maximum annual series and then convert the frequencies by use of Table 10-13.

> Table 10-13. Relation between recurrence intervals of the annual-maximum series and the partial-duration series (peaks over a threshold). (From Langbien, 1960)

Recurrence Interval (Yr)	
Annual Maximum Series	Partial Duration Series
1.16	0.5
1.50	0.9
1.58	1.0
2.00	1.5
2.54	2.0
5.52	5.0
10.50	10.0
20.50	20.0
50.50	50.0
100.50	100.0

According to Dunne and Leopold, the annual maximum flood recurrence interval of 1.5-years corresponds to a partial-duration series (peaks over a threshold) recurrence interval of 0.9 years. The use of the partial-duration series (peaks over a threshold) procedure can produce good estimates of the 1.5-year discharge, but only if (a) independent peaks are used and (b) the recurrence interval is appropriately corrected by the use of Table 10-13 from Dunne and Leopold (1978).

The above discussion focused on estimating the 1.5-year instantaneous discharge at the reference gauge. The Policy directs the applicant to use the Scaling Method to determine the 1.5-year discharge at the ungauged POD or POI.

The ability of the Scaling Method to conservatively estimate the 1.5-year discharge at an ungauged location was tested by using Maacama Creek near Kellogg Big as the "ungauged" location and using Sulphur Creek near Cloverdale as the reference stream gauge. The watershed area and precipitation for these two sites was obtained from Table 1. The 1.5-year instantaneous flood discharge was calculated using the annual maximum flood series at both stream gauges and the Log Pearson Type III flood frequency distribution. The Log Pearson Type III procedure applied using a spreadsheet developed by Dr Fred Watson of California State University, Monterey Bay.

The 1.5-year discharge for Maacama Creek near Kellogg was calculated to be 3,440 cfs. The observed 1.5-year discharge for Big Sulphur Creek near Cloverdale was calculated to be 8,202 cfs. The Scaling Method was then applied using Big Sulphur Creek near Cloverdale as the reference stream gauge and Maacama Creek near Kellogg as the ungauged site (POD). The Scaling Method produced an estimate of 5,226 cfs for the 1.5-year discharge at Maacama Creek near Kellogg, overestimating the 1.5-year discharge by +1,786 cfs or +51.9%. The resulting MCD was overestimated by 89 cfs or 51.9%. The watersheds of these two gauges share a common watershed divide.

Table 3. Results of the experiment to predict the 1.5-year discharge at the Maacama Creek near Kellogg stream gauge based on the Big Sulphur Creek near Cloverdale stream gauge using the Scaling Method. The Scaling Method overestimated the 1.5-year discharge at Maacama Creek near Kellogg by 1,786 cfs or 51.9%. The resulting MCD was overestimated by 89 cfs or 51.9%. The watersheds of these two gauges share a common watershed divide.

Stream Gauge	Years of Record	1.5-Year Discharge cfs	MCD cfs
Big Sulphur Creek	16	8,202	
Predicted Maacama Creek	20	5,226	261
Observed Maacama Creek		3,440	172
Error		1,786	89
%-Error		51.9%	51.9%

Since the Scaling Method overestimates the 1.5-year discharge for Maacama Creek near Kellogg by 89 cfs or 51.9% there is a strong possibility that the channel forming discharges (bankfull) in Maacama Creek could be adversely impacted by the Instream Flow Policy. If this was an actual diversion instead of a test of the Scaling Method, the reduced high flows would likely result in a long-term change in channel characteristics at the Maacama Creek near Kellogg stream gauge. A long-term change in the channel characteristics, at and downstream of the POD, would result in a deterioration of salmonid habitat and therefore overestimating the MCD does not protect the resource.

Daily Flow Study

The daily flow study, described in Section B.5.3, relies on the Scaling Method to estimate daily flow at the ungauged POI based on the daily discharge at a reference gauge with at least 10-years of record.

B.5.3.1 Estimate time series of unimpaired daily flow at POIs located at and/or below anadromy

The unimpaired daily flow is the average daily rate of flow past a point in a stream if no diversions (impairments) were taking place in the watershed above that point. The time series of unimpaired daily flow is a continuous record of unimpaired daily flows. The time series shall include at least ten complete water years. Data must be complete for the water years used but the water years do not have to be consecutive if the data is not available.

The time series of unimpaired daily flow past a POI shall be calculated using methods similar to those used to estimate the mean annual unimpaired flow in B.5.2.1. The methods used to estimate the time series required for the daily flow study of the Cumulative Diversion Analysis differ slightly and are as follows: (Emphasis Added).

The entire *Daily Flow Study* rests on the estimated daily flows at the POI calculated by the Scaling Method. The *Daily Flow Study* uses both simulated daily flows estimated by the Scaling Method and it uses the mean annual flow, estimated by the Scaling Method, to calculate the MBF. As demonstrated above the Scaling Method can not guarantee that its flow estimates err on the side of resource protection. Table 4 shows the result of applying the Scaling Method to the daily flows, during the diversion season, at Maacama Creek near Kellogg to estimate the daily flows at Big Sulphur Creek near Cloverdale. The Scaling Method underestimated the daily flow on 93.3% of the days during the diversion season over an eleven year period of joint record. The daily flow estimates for Big Sulphur Creek near Cloverdale, from the Scaling Method, would *not* err on the side of resource protection.

Table 5 shows the results of using the Scaling Method to predict the daily streamflow, during the entire water year, at Big Sulphur Creek near Cloverdale based on the daily flow at Maacama Creek near Kellogg. A total of 11 years were available when the streamflow was recorded at both stations. The Scaling Method underestimated the daily flow at the Big Sulphur near Cloverdale gauge on 3,910 days of the 4,018 days of record (97.3%). The Scaling Method overestimated the daily flow at the Big Sulphur near Cloverdale gauge on only 108 days of the 4,018 days of record (2.7%). %). The simulated mean annual flow underestimated the observed mean annual flow by -59.5 cfs or -30.5%. The calculated MBF was underestimated by -65.9 cfs or -30.5%. The mean annual flow estimates for Big Sulphur Creek near Cloverdale, from the Scaling Method, would *not* err on the side of resource protection. The resulting MBF would also not err on the side of resource protection.

The Scaling Method would underestimate the 1.5-year instantaneous flow at Big Sulphur Creek near Cloverdale stream gauge based on the 1.5-year flow at Maacama Creek near Kellogg thus; the MCD would err on the side of resource protection.

The streamflow record of both Maacama Creek near Kellogg Creek and Big Sulphur Creek near Cloverdale are impaired. But the level of impairment due to diversion from 1962 to 1972 is significantly less than the present day impairment. Use of Maacama Creek near Kellogg and Big Sulphur Creek near Cloverdale are reasonable choices to demonstrate that adjacent watersheds do not necessarily give flow estimates that err on the side of resource protection when using the Scaling Method as proposed in the Instream Flow.

Table 4. The Scaling Method was used to predict the daily streamflow at Big Sulphur Creek near Cloverdale based on the daily flow at Maacama Creek near Kellogg, during the December 15 to March 31 diversion season. A total of 11 years were available when the streamflow was recorded at both stations. The Scaling Method underestimated the daily flow at the Big Sulphur near Cloverdale gauge on 1,101 days of the 1,180 days of record (93.3%). The Scaling Method overestimated the daily flow at the Big Sulphur near Cloverdale gauge on only 79 days of the 1,180 days of record (6.7%).

Water Year	Maacama Seasonal Flow Ac-Ft	Estimated Big Sulphur Seasonal Flow Ac-Ft	Observed Big Sulphur Seasonal Flow Ac-Ft	Error Ac-Ft	%-Error
1962	41,905	65,764	84,472	-18,708	-22.1%
1963	37,967	59,583	93,247	-33,663	-36.1%
1964	12,652	19,855	30,350	-10,495	-34.6%
1965	69,062	108,383	147,946	-39,562	-26.7%
1966	41,877	65,720	97,466	-31,746	-32.6%
1967	49,048	76,973	93,647	-16,674	-17.8%
1968	36,345	57,038	79,334	-22,296	-28.1%
1969	85,937	134,867	188,121	-53,255	-28.3%
1970	93,179	146,232	205,810	-59,578	-28.9%
1971	30,990	48,635	72,040	-23,405	-32.5%
1972	14,185	22,261	26,195	-3,934	-15.0%
Average	46,650	73,210	101,693	-28,483	-27.5%

Table 5. The Scaling Method was used to predict the annual streamflow at Big Sulphur Creek near Cloverdale based on the daily flow at Maacama Creek near Kellogg, during the water year. A total of 11 years were available when the streamflow was recorded at both stations. The Scaling Method underestimated the daily flow at the Big Sulphur near Cloverdale gauge on 3,910 days of the 4,018 days of record (97.3%). The Scaling Method overestimated the daily flow at the Big Sulphur near Cloverdale gauge on only 108 days of the 4,018 days of record (2.7%). The simulated mean annual flow underestimated the observed mean annual flow by -59.5 cfs or -30.5%. The calculated MBF was underestimated by -65.9 cfs or -30.5%.

Water Year	Maacama Annual Flow Ac-Ft	Estimated Big Sulphur Annual Flow Ac-Ft	Observed Big Sulphur Annual Flow Ac-Ft	Annual Flow Error Ac-Ft	Annual Flow %-Error
1962	47,867	75,121	110,407	-35,285	-32.0%
1963	74,676	117,194	175,445	-58,251	-33.2%
1964	23,521	36,913	55,210	-18,297	-33.1%
1965	85,065	133,498	194,141	-60,643	-31.2%
1966	50,441	79,161	118,484	-39,324	-33.2%
1967	91,091	142,955	188,598	-45,643	-24.2%
1968	41,757	65,531	97,640	-32,108	-32.9%
1969	96,006	150,668	215,130	-64,462	-30.0%
1970	98,139	154,015	222,343	-68,328	-30.7%
1971	60,193	94,464	136,231	-41,766	-30.7%
1972	18,178	28,528	38,504	-9,976	-25.9%
Average Ac-Ft	62,449	98,004	141,103	-43,099	-30.6%
Average cfs	86.2	135.3	194.8	-59.5	-30.5%
MBF cfs	129.0	149.8	215.7	-65.9	-30.5%

Example Diversion

An example diversion was used to test the ability of the Scaling Method estimates of mean annual flow and 1.5-year instantaneous discharge to produce a MBF and MCD values that err on the side of resource protection. The Maacama Creek near Kellogg (Maacama Creek) stream gauge was designated as the reference stream gauge. The site of the example diversion was chosen to be the Big Sulphur Creek near Cloverdale stream gauge (Big Sulphur Creek). The daily streamflow recorded at the two gauges overlaps from 1962-1972. I assumed that the recorded streamflow at both gauges was unimpaired since the level of impairment due to diversion from 1962 to 1972 is significantly less than the present day impairment. I assumed that no senior diversions were present. I assumed that the single point of diversion (POD) was located at the Big Sulphur Creek near Cloverdale stream gauge. And I assumed that the maximum allowable diversion would occur on each day of the record. I also assumed that the example diversion is within the range of anadromy.

The test was done in three parts. Part 1 of the test consisted of using the Scaling Method to estimate the unimpaired daily stream flow record at Maacama Creek from the Big Sulphur Creek unimpaired daily flow record (predicted unimpaired flow). The Scaling Method was also used to predict the MBF (predicted MBF) and the MCD (predicted MCD).

The actual recorded unimpaired stream flow at the Big Sulphur Creek near Cloverdale was then subjected to the diversion based on the predicted MBF and the predicted MCD. The diversion was calculated according to the following rules:

If the recorded flow at the Big Sulphur Creek gauge was:

- Less than the predicted MBF then no diversion was made.
- Greater than the predicted MBF but less than the predicted MCD then;
  the predicted diversion = flow – predicted MBF
- Greater than the predicted MCD then; predicted diversion = flow – predicted MCD
- The predicted impaired flow below the diversion = flow – predicted diversion

Part 2 of the test consisted of using the "actual" unimpaired daily streamflow at the Big Sulphur Creek near Cloverdale stream gauge to calculate the MBF ("actual" MBF) and the MCD ("actual" MCD).

The "actual" recorded unimpaired stream flow at the Big Sulphur Creek near Cloverdale was then subjected to the diversion based on the predicted MBF and the predicted MCD. The diversion was calculated according to the following rules:

If the recorded flow at the Big Sulphur Creek gauge was:

- Less than the "actual" MBF then; no diversion was made.
- Greater than the "actual" MBF but less than the "actual" MCD then; diversion = flow – "actual" MBF
- Greater than the "actual" MCD then; diversion = flow – "actual" MCD
- The "actual" impaired flow below the diversion = flow – "actual" diversion

Part 3 of the test consisted of comparing the predicted diversion, based on flow parameters estimated by the Scaling Method, to the actual diversion, based on estimating the flow parameters directly from the Big Sulphur Creek gauge data. Table 6 shows the values of the MBF and MCD used in the test. Table 7 shows a summary of the comparison of the predicted diversion and the "actual" diversion.

The predicted diversion at the Big Sulphur Creek near Cloverdale stream gauge was calculated using the flow record from the Maacama Creek near Kellogg stream gauge. The predicted diversion at Big Sulphur Creek was compared to the "actual" diversion based on the streamflow record at Big Sulphur Creek. The text gives the details of how the diversions were calculated. The MBF and MCD used are shown in Table 6. The predicted diversion resulted in a lower impaired streamflow below the simulated diversion at the Big Sulphur Creek stream gauge on an average of 36.7 days per year, or 34.2% of the diversion season. On almost half of those days (17.9 of 36.7) the estimated impaired flow was less than the "actual" MBF by its maximum rate of -65.9 cfs, the difference between the predicted MBF and the "actual" MBF (see Table 6). An average of -3,555 acre-feet was lost per year on the days that the estimated impaired flow below the diversion (gauge) was less than the "actual" impaired flow below the diversion. The predicted diversion diverts less water over the 11 years of record than the "actual" diversion but it still adversely impacts the flow below the diversion (Big Sulphur Creek gauge). The predicted diversion fails to err on the side of resource protection an average of 34.2% of each diversion season.

Table 6. The values for the predicted MBF and predicted MCD for Predicted Diversion were calculated by using the Scaling Method to estimate the daily flow at the Big Sulphur Creek gauge based on the flow at the Maacama Creek gauge. The "Actual" diversion was calculated directly from the Big Sulphur Creek stream gauge data.

	Predicted Diversion	Actual Diversion	Difference	%-Difference
MBF cfs	149.8	215.7	-65.9	-30.5%
MCD cfs	269.9	410.1	-140.2	-34.2%

Table 7. The predicted diversion at the Big Sulphur Creek near Cloverdale stream gauge was calculated using the flow record from the Maacama Creek near Kellogg stream gauge. The predicted diversion at Big Sulphur Creek was compared to the "actual" diversion based on the streamflow record at Big Sulphur Creek. The text gives the details of how the diversions were calculated. The MBF and MCD used are shown in Table 6. The predicted diversion resulted in a lower impaired streamflow below the simulated diversion at the Big Sulphur Creek stream gauge on an average of 36.7 days per year, or 34.2% of the diversion season. On almost half of those days (17.9 of 36.7) the estimated impaired flow was less than the "actual" MBF by its maximum rate of -65.9 cfs, the difference between the predicted MBF and the "actual" MBF (see Table 6). An average of -3,555 acre-feet was lost per year on the days that the estimated impaired flow below the diversion (gauge) was less than the "actual" impaired flow below the diversion. The predicted diversion diverts less water over the 11 years of record than the "actual" diversion but it still adversely impacts the flow below the diversion (Big Sulphur Creek gauge). The predicted diversion fails to err on the side of resource protection an average of 34.2% of each diversion season.

Water Year	Gauged Big Sulphur Seasonal Flow Ac-Ft	Predicted Big Sulphur Diversion Ac-Ft	"Actual" Big Sulphur Diversion Ac-Ft	Predicted Impaired Flow Below Big Sulphur Diversion Ac-Ft	"Actual" Impaired Flow Below Big Sulphur Diversion Ac-Ft	Annual Difference in Impaired Flow Below Diversion Ac-Ft	Predicted Impaired Flow Less than "Actual" Impaired Flow Ac-Ft	Predicted Impaired Flow Greater than "Actual" Impaired Flow Ac-Ft	Days When Predicted Impaired Flow Less than "Actual" MBF	Percentage of Days When Predicted Impaired Flow Less than "Actual" MBF	Days With Maximum Difference Between Estimated Impaired Flow and "Actual" MBF
1962	84,472	16,403	18,278	68,069	66,194	1,875	-3,046	4,921	36	33.6%	14
1963	93,247	19,541	22,639	73,706	70,608	3,098	-2,635	5,733	34	31.8%	11
1964	30,350	4,839	4,969	25,511	25,381	130	-899	1,030	12	11.1%	7
1965	147,946	20,591	23,972	127,355	123,974	3,381	-3,457	6,838	32	29.9%	17
1966	97,466	20,147	19,874	77,319	77,593	-273	-5,237	4,964	55	51.4%	26
1967	93,647	22,506	25,538	71,141	68,109	3,032	-3,244	6,276	24	22.4%	12
1968	79,334	22,111	22,766	57,223	56,568	655	-4,490	5,145	49	45.4%	30
1969	188,121	38,404	49,482	149,718	138,639	11,078	-3,232	14,310	34	31.8%	17
1970	205,810	35,256	40,354	170,554	165,456	5,098	-5,560	10,658	55	51.4%	31
1971	72,040	22,066	22,738	49,975	49,302	672	-4,338	5,010	35	32.7%	17
1972	26,195	4,794	1,829	21,401	24,366	-2,965	-2,965	0	38	35.2%	15
Average	101,693	20,605	22,949	81,088	78,745	2,344	-3,555	5,899	36.7	34.2%	17.9
Total	1,118,628	226,657	252,438	891,972	866,190	25,781	-39,104	64,886	404	34.2%	197

February Median Flow

The Regionally Protective Criteria for proposed diversions on Class III streams require the calculation of the February median flow by the Scaling Method. Clearly, my previous comments about the failure of the Scaling Method to always produce flow estimates that err on the side of resource protection also apply to estimating the February median flows using the Scaling Method. If the Scaling Method overestimates the February median flow the Policy procedure in Section B.5.3.6 is likely to wrongly conclude that the proposed diversion does not affect the February median flow. Such an err would not be protective of the resource.

> B.5.3.6 Additional Analysis Step for Class III Points of Diversion - Does the proposed project affect the February median flow at POIs on downstream Class II streams?
>
> 1. Calculate the February median flow for each POI located on Class II streams downstream of the proposed project.
>
> a. Estimate the daily time series of unimpaired daily flow for each POI on the Class II stream(s) using the methods described in Section B.5.3.1.
>
> b. For each POI on the Class II stream(s), calculate the median of the estimated daily flows that occur in the month of February using the following steps.
>
> (1) Obtain the daily flow values that occur in February from the estimated daily time series of unimpaired daily flow.
>
> (2) Sort the daily February flow values from high to low.
>
> (3) The February median is the value of the data point that occurs in the middle of the sorted set of data points.
>
> 2. Impair the unimpaired daily flows at the POI locations using senior diversions without the proposed project. Use the methods described in Section B.5.3.2 to complete this part of the analysis.
>
> 3. Impair the unimpaired daily flows at the POI locations using senior diversions and the proposed project. Use the methods described in Section B.5.3.3 to complete this part of the analysis.
>
> 4. Is the number of days the February median flow is exceeded affected by the proposed project?
>
> For each POI on the Class II stream(s), calculate the following:
>
> a. The number of days that impaired flows without the proposed project meet or exceed the February median flow;
>
> b. The number of days that the impaired flows with the proposed project meet or exceed the February median flow.
>
> c. If the number of days counted in (b) is equal to or greater than the number of days counted in (a), the proposed project will not reduce the February median flow at the POI.

Summary

The Regionally Protective Criteria rely on the Scaling Method to estimate flow parameters at an ungauged site (POD or POI) based on the flow at the closest reference stream gauge. I have demonstrated that proximity of the reference stream gauge is insufficient to guarantee that the resulting flow estimates will give diversion parameters (MBF, MCD) that err on the side of resource protection.

The Regionally Protective Criteria do not meet their objective of always erring on the side of resource protection the SWRCB. The Regionally Protective Criteria should be modified so that a reference stream gauge is selected on the basis of watershed characteristic such as geology, soils, topography, vegetation and land use including the amount of diversion and other modifications of runoff processes. Simply choosing the closest reference stream gauge can not guarantee flow estimates that will err on the side of resource protection. If a screening procedure based on watershed characteristics is adopted it must be thoroughly tested to ensure that it always selects reference stream gauges that will allow the Scaling Method to provide flow estimates that are *always* protective of the resource.

Underestimates of the MBF are likely to harm salmonids and their habitat. So overestimating the MBF errs on the side of resource protection. On the other hand, overestimating the MCD will result in long-term channel changes will cause deterioration in salmonid habit so, to err on the side of resource protection requires underestimating the MCD. Simple procedures to transfer flow records from a stream gauge to an ungauged location (POD, POI) can not simultaneously overestimate the MBF and underestimate the MCD. Therefore, erring on the side of resource protection requires accurate predictions of the flow at an ungauged location.

Sincerely,

Dennis Jackson

Dennis Jackson
Hydrologist

References

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DENNIS JACKSON

HYDROLOGIST

Fluvial geomorphology

Sediment transport

River and watershed assessment and restoration

EXPERIENCE

Dennis Jackson is a consulting hydrologist. Mr. Jackson has over 15 years of experience in river and watershed restoration, mitigation planning, policy evaluation, and project implementation. Mr. Jackson has studied watersheds along the north coast of California and in the eastern Sierra Nevada.

Mr. Jackson has completed all the phases of successful stream and watershed restoration projects. His experience includes: obtaining restoration grant funding, design of restoration projects, obtaining permits, facilitating advisory committee meetings, and completion of project implementation and monitoring.

He taught an upper division class entitled Physical Hydrology and River Hydrology at California State University, Monterey Bay. These courses focused on runoff generating processes, streamflow measurement and detecting watershed change through an analysis of discharge records.

Mr. Jackson served on the City of Santa *Cruz's Watershed Management Technical Advisory Task Force*. The Task Force's charge is to guide the preparation of a watershed management plan for the 3,380 acres owned by the City.

EMPLOYMENT HISTORY

- Since 1995, Mr. Jackson has been a consulting hydrologist focusing on river monitoring and watershed dynamics. In addition to data collection and analysis he has also reviewed numerous CEQA documents on a wide range of projects included timberland conversion, timber harvest plans, fiber optic installations, and water rights applications.
- In 2003 and 2004 Mr. Jackson subcontracted with Environmental Science Associates (ESA) to perform a hydrologic analysis of the Pescadero-Butano Creek watershed, focusing on the USGS stream gauging record and a study of the changes in stream bed elevation at various locations in the watershed.
- In 2003 Mr. Jackson worked a subcontractor with Environmental Science Associates (ESA) to monitor the streamflow on Ferrari, Molino, Liddell, and San Vicente Creeks on the Coast Dairies property for the Trust for Public Land (TPL). TPL acquired the Coast Dairies property in the 1990's. TPL wanted to ensure that the all the agricultural surface water diversions on the Coast Dairies properties are in compliance with all environmental laws. Monitoring the streamflow help the State Water Resources Control Board determine bypass flows that would protect salmonids.
- In 2001-2003 Mr. Jackson subcontracted with Environmental Science Associates (ESA) to assist in evaluating the hydrology, geomorphology, and biology of the Pescadero Marsh, for the California Department of Parks and Recreation (DPR). In particular, the purpose was to repeat several surveys conducted by other parties for DPR in the 1980s, in order to ascertain

changes that have occurred in the Marsh since several restoration projects were undertaken in the 1990s. The overall goal of this report is to make recommendations for future management of the State Preserve.

- In 2002 Mr. Jackson subcontracted with Environmental Science Associates (ESA) to perform a hydrologic assessment of the Coast Dairies property to assist the Trust for Public Land development management guidelines prior to turning the land over to the State Parks system. The objectives of this hydrologic assessment are to determine: the characteristics of each of the six streams that cross the Coast Dairies property; the general condition of each stream and its watershed; the sensitivity of the watershed to disturbance; and hydrologic indicators for suitability for salmonids. Mr. Jackson established nine stream gauging stations, measured stream flow and interpreted the data. Mr. Jackson also extended an erosion hazard model developed for the neighboring San Lorenzo Valley to the Coast Dairies property.
- Mr. Jackson was an instructor for a week-long workshop in April 2002 to familiarize Department of Transportation (CalTrans) personnel about streams and the Department of Fish and Game's Streambed Alteration Agreement process. Mr. Jackson lectured about fluvial geomorphology in the classroom and in the field.
- During the spring semesters of 2006 and 2000, Mr. Jackson taught the upper division Physical Hydrology course at California State University, Monterey Bay. The courses focused on runoff generating processes, streamflow measurement and detecting watershed change through an analysis of discharge records.
- Mr. Jackson managed a 319(h) grant for the Sotoyome Resource Conservation District in 1995.
- From 1989 -1994, he was the Hydrologist/Director for the Mendocino County Water Agency where he studied the effects of in-stream gravel extraction on the rivers of Mendocino County. He also completed several stream restoration projects from concept to completion.
- From 1986 through 1989, he studied the studied the effect of upwind obstructions on the distribution of snow in the Mammoth Creek watershed for the Mammoth County Water District.
- From 1983 through 1986, he was a hydrologic technician with the U.S. Forest Service, in charge of a network of well, stream and spring monitoring stations.

PROJECT EXPERIENCE

- As Hydrologist/Director of the Mendocino County Water Agency, Mr. Jackson was responsible for advising the Mendocino County Board of Supervisors on all aspects of water policy. Mr. Jackson also commented on the hydrologic aspects of projects undergoing CEQA review by the County Planning Department.

  Mr. Jackson conducted a comprehensive study of the hydrology and fluvial geomorphology of the Russian River. Mr. Jackson was able to obtain 319(h) grants from the State Water Resources Control Board to prepare *Gravel Management Plans* for the Russian and Garcia Rivers.

  His study of in-stream gravel extraction revealed the importance of the shape of the riverbed and how it influences fish habitat. Mr. Jackson has applied his knowledge of river processes and hydrology to develop the basis for several stream restoration projects. His study of the natural shape of gravel bars helped him to successfully design the channel restoration required after a bentonite spill on the Garcia River near Point Arena. He also used his knowledge of gravel bar form to design successful stream restoration projects on Willits and Baechtel Creeks near Willits, CA.

As a private consultant, Mr. Jackson has completed numerous hydrologic studies and evaluated watershed functions. Some of these projects include:

- Suisun Creek Assessment: From 2001 through 2006 Mr. Jackson has monitored two channel reaches in the Suisun Creek watershed. He has also assessed the impact of Lake Curry on the flood regime of Suisun Creek. In 2007 he analyzed temperature records from 16 stations to determine the effect of releases from Lake Curry on summer water temperatures in Suisun Creek.
- <u>Russian River Projects</u>: From 1999 through 2004, Mr. Jackson has monitored several channel reaches in the Russian River. He has also done hydrologic assessments of the Copeland Creek and Maacama Creek watersheds in support of watershed assessments.
- <u>Coast Dairies Hydrologic Assessment</u>: In 2002 to 2003, Mr. Jackson performed a hydrologic assessment of the Coast Dairies property near Davenport, Ca to assist the preparation of a land management plan for Trust for Public Land.
- <u>Mitteldorf Watershed Assessment</u>: In 2002, Mr. Jackson participated with staff and students of CSUMB to perform a watershed assessment of the Mitteldorf Preserve owned by the Big Sur Land Trust.
- <u>Pescadero Watershed Assessment</u>: Mr. Jackson performed a hydrologic assessment of the Pescadero Creek watershed as part of an overall watershed assessment in 2003.
- <u>Restoration Assessment for the Pescadero Natural Reserve</u>: As a subcontractor, Mr. Jackson prepared a hydrologic assessment of the Pescadero Marsh preserved owned by State Parks Department in 2002-2003.
- Co-author of *Creating a Watershed Atlas and Monitoring Program: Watershed Stewardship Workbook*. The purpose of the book is to guide watershed groups to assess their watershed and help them design a monitoring program based on their assessment. The program is specifically aimed at the tributary watersheds of the Russian River.
- <u>Garcia River Monitoring and Enhancement Plan</u>: Mr. Jackson participated in preparing the Garcia River Enhancement Plan. In 1991, he laid out a series of cross sections on the Garcia River and estuary to monitor changes in the channel bed. Mr. Jackson has re-surveyed the cross section network each year since 1991. Mr. Jackson performed an extensive analysis of the USGS stream gaging records for the Garcia River. His analysis showed that a sediment wave moved past the USGS gaging station between 1969 and 1983. He also assisted in installing and maintaining a stage-recording device at the former USGS gaging station.
- <u>Garcia River Gravel Management Plan</u>: Increasing pressure for the gravel extraction industry created a need to prepare a gravel management plan for the Garcia River. Mr. Jackson was able to obtain a grant from the State Water Resources Control Board to prepare the gravel management plan. Mr. Jackson negotiated a contract with the USGS to collect total load sediment data on the Garcia River. As part of this effort, Mr. Jackson installed river stage recorders at two additional

locations on the Garcia. He also took stream flow measurements and constructed rating tables for the sites with stage recorders.

- Russian River Enhancement Plan: The Coastal Conservancy funded an extensive investigation of the entire mainstem of the Russian River. Mr. Jackson directed the Mendocino County portion of the study. Mr. Jackson facilitated the advisory committee meetings, collected field data, coordinated with the contractor preparing the enhancement plan and was the Mendocino County contact with the Coastal Conservancy.

- Russian River Gravel Management Plan: Mr. Jackson was hired by the Mendocino County Water Agency to study in-stream gravel extraction in the Russian River. The Russian River is severely incised resulting in unstable banks, loss of ground water storage and damage to public works such as bridges and pipelines. Mr. Jackson established a network of monitoring cross sections in 1989. He also conducted an extensive analysis of the USGS gaging station records on the Russian River. His analysis showed that the bed was incising prior to the construction of Coyote Dam. Mr. Jackson was able to obtain a grant from the State Water Resources Control Board to prepare a gravel management plan. The grant funding allowed Mr. Jackson to continue monitoring the cross section network and to retain the USGS to collect total load sediment data for the Russian River.

- Russian River Restoration Program: Mr. Jackson is currently participating in a multi-year effort to restore the riparian wetlands of the Russian River system in conjunction with local agencies and landowners. His work has included a regionalization of flood frequency data for the Russian River tributaries and developing a method to estimate channel dimensions based on watershed area. He is also providing technical assistance to an extensive volunteer monitoring program with watershed residents and landowners in creek and watershed restoration in the tributary basins. He is the co-author of a handbook for volunteer stream monitors prepared for the Sotoyome Resource Conservation District in Santa Rosa, CA. The handbook guides volunteers in obtaining a watershed perspective. The larger perspective is essential in designing a meaningful monitoring program.

- Russian River Watershed – A Voluntary Cooperative Approach for Attaining Water Quality Objectives: The Sotoyome Resource Conservation District had 319(h) grant to fund several water quality improvement. Mr. Jackson was the grant's Project Director. The grant included landowner/volunteer water quality monitoring, development of bioassessment reference conditions, cooperative projects with two high schools and work with dairymen to reduce water pollution from animal waste.

- Redwood Valley Ground Water Study: Mr. Jackson negotiated approval for a cooperative study of the ground water resources of Redwood Valley. The Redwood Valley Water District was under a court ordered moratorium until additional water supplies could be found. Mr. Jackson convinced the Water District's Board of Directors that it would be beneficial to engage the USGS to take a thorough look at the ground water supplies within their District. Mr. Jackson collected data and worked closely with the USGS during the study.

- Review of Proof of Water Tests: The town of Mendocino is on a coastal headland. Water supply is a critical issue within the Mendocino City Community Services District (MCCSD). The state of California granted MCCSD the authority to manage ground water within the District's boundaries. The District requires all new wells to perform a proof-of-water test to demonstrate that the new well will not impact existing wells. As the Hydrologist for MCWA, Mr. Jackson reviewed and commented on proof-of-water tests done for the MCCSD. Mr. Jackson also reviewed ground water studies for the Mendocino County Division of Environmental Health. He also reviewed and commented on the hydrologic aspects of projects before the Mendocino County Planning Department. The projects ranged from subdivisions to zoning changes and quarries.

- CEQA compliance: Mr. Jackson has extensive experience as a government project manager in the preparation and review of all aspects of EIRs.
- Public outreach and advisory committees: Mr. Jackson has directed projects involving regular meetings of project advisory committees and public workshops. These committees can be essential to the success of a large project, but are also often contentious and require considerable skill and experience to direct and gain any agreement among the members. Both the Garcia River and Russian River projects utilized committees, created and directed by Mr. Jackson.

EDUCATION

M.S. Physical science with an emphasis in hydrology
California State University, Chico

Graduate studies in hydrology
University of Arizona

B.A. Mathematics with honors
Humboldt State University

PROFESSIONAL WORKSHOPS

Stream Restoration & Classification

Course was taught by David Rosgen in South Lake Tahoe. The course covered a review of stream mechanics and an introduction to Rosgen's stream classification system. The also covered the design of stream restoration projects based on Rosgen's classification system and the principles of geomorphology. Several field trips to restoration projects in the Tahoe basin provided practical hands-on experience.

Sediment Data Collection Techniques

The U.S. Geological Survey in Vancouver, Washington gave the course. The course covered the theory of river mechanics and sediment transport; methods of collecting suspended sediment and bed load data; the design of sampling equipment; and field trips to sediment sampling stations on the Tousle River and the USGS sediment laboratory.

Alluvial Systems

The U.S. Geological Survey gave the course at their national training center in Boulder, Colorado. The course covered the role of fluvial processes in shaping the modern landscape with an emphasis on river morphology. The course combined lectures, discussion sessions, fieldwork and hands-on exercises.

Exhibit B

Dennis Jackson - Hydrologist
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March 23, 2010

Tom Lippe
329 Bryant Street, Suite 3D
San Francisco, CA 94107

Re: Proposed Instream Flow Policy for Northern California Streams

Dear Mr. Lippe:
You have asked me to comment on the Final Draft of the *Policy for Maintaining Instream Flows in Northern California Coastal Streams* (the Policy) date February 17, 2010 and prepared by the staff of the Sate Water Resources Control Board.

I served as the Hydrologist for the Mendocino County Water Agency from 1989 through 1994. I have a Master degree in Physical Science with an emphasis on Hydrology. I have been a private consultant since 1995.

This letter concentrates on the procedure to determine the diversion parameters for a point of diversion above the limit of anadromy. The Policy for diversions above the Upper Limit of Anadromy (ULA) relies on the definition of Stream Class so I begin by review the stream classification system.

Stream Classification System

The Stream Classification is defined in the following quote from Section A.1.6 of Appendix A of the Policy.

> **A.1.6 Stream Classification System**
>
> The presence or absence of fish or non-fish aquatic species in a stream affects the extent of the fishery protection needed at water diversions. Streams that contain fish require a higher level of protection than streams that do not contain fish, in large part because fish are mobile and require more physical aquatic habitat (living space) than non-fish species. In order to effectively apply protective measures, this policy uses the following stream classification system:
>
> Class I: Fish are always or seasonally present, either currently or historically; and habitat to sustain fish exists.
>
> Class II: Seasonal or year-round habitat exists for aquatic non-fish vertebrates and/or aquatic benthic macroinvertebrates.
>
> Class III: An intermittent or ephemeral stream exists that has a defined channel with a defined bank (slope break) that shows evidence of periodic scour and sediment transport.

The above definitions of stream class are not clear. The Stream Classification is based on the presence or absence of fish and fish habitat but the term fish is not defined. Page 1 of the Policy states that,

> This policy focuses on measures that protect **native fish populations**, with a particular focus on anadromous salmonids[1] (e.g., steelhead trout, coho salmon, and chinook salmon) and their habitat. Beginning in 1996, the National Marine Fisheries Services (NMFS) and the California Department of Fish and Game (DFG) listed steelhead trout, coho salmon, and chinook salmon as "threatened" under the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA), respectively. In 2005, the coho salmon's status was upgraded from threatened to "endangered" on both the ESA and the CESA lists. (Emphasis Added)

The Policy "focuses on measures that protect native fish populations". Does the Stream Classification system mean the current or historical presence of any fish whether it is a non-native fish, native fish or an anadromous salmonid be used to determine a Class I stream?

The above Stream Class definitions do not specify whether they apply to perennial, intermittent or ephemeral streams (see *Appendix I Glossary of Terms* for definition of these terms). Section A.1.6.1, quoted below, makes reference to seasonal presence/absence of water in a stream reach (perennial, intermittent or ephemeral streams). To be comprehensible to diversion applicants and the public, the definition of a Stream Class should be clearly stated and not scattered over different portions of the Policy document.

The historic presence of fish is part of the definition of a Class I stream but no guidance is given on what constitutes acceptable historical evidence. What documentation of historic presence of fish in a particular stream reach is required in the absence of a historic stream survey from DFG clearly stating the presence of fish at a particular location? A given land owner may have recently purchased the property and may not be aware that twenty years ago a creek on his/her property support fish but no longer does. Does a statement regarding the presence/absence of fish from a neighbor constitute acceptable historic evidence that fish had inhabited a stream reach in past? The Policy provides no standard for historical evidence of the presence of fish in a stream reach.

The Policy defining a Class I stream is not clear regarding the historical existence of fish habitat. What if fish habitat existed in a stream reach historically but was destroyed by a change in land use? What if it was possible to restore fish habitat in a stream reach?

The above Policy definition a Class II stream relies on the presence of non-fish aquatic habitat but does not define non-fish aquatic habitat nor does it reference a definition of the term in another part of the Policy. The above Policy definition a Class II stream relies on whether habitat for aquatic non-fish vertebrates and/or aquatic benthic macroinvertebrates currently exists and does not appear to allow for consideration for the historic presence of such habitat. This approach will tend to reduce the possibility that a degraded stream reach could be restored to Class I or Class II status.

The above Policy definition a Class III stream is not clear about whether a Class III streams has aquatic habitat. According to Section A.1.6.1 a Class III stream lacks aquatic habitat, both currently and historically. To be comprehensible to diversion applicants and the public, the definition of a Stream Class should be clearly stated and not scattered over different portions of the Policy document.

> **A.1.6.1 Determination of Stream Class by the State Water Board**
>
> The State Water Board shall make a determination of stream class at a POD using indicators of habitat, not simply the presence or absence of species. Examples of indicators of habitat include, but are not limited to, coarse gravel, channel width, depth, and slope, instream cover, canopy, surface water, aquatic plants, or hydric soils. Class I streams, which may include intermittent or ephemeral streams, may be indicated by the presence or seasonal presence of fish, either currently or historically, or by the presence of habitat to sustain fish. Streams that are designated

by NMFS as critical habitat for steelhead, chinook, or coho will be assumed to be Class I streams. However designated critical habitat does not encompass all Class I streams, and should not be relied upon as a basis for excluding streams from a Class I designation.

Class II streams, which may include intermittent or ephemeral streams, may be indicated by the presence of aquatic non-fish vertebrates or aquatic benthic macroinvertebrates or combinations of other indicators, such as free water, aquatic plants, or hydric soils. However, in Class II streams fish are never present, either currently or historically.

Ephemeral streams having defined channels with defined banks (slope break) that show evidence that sediment transport processes occur may indicate a Class III stream. For instance, evidence of periodic scour and deposition of sediment are indicators that a Class III stream exists. Class III streams also meet both of the following conditions: (1) fish are never present, either currently or historically, nor does habitat to sustain fish exist, and (2) the stream does not provide habitat for aquatic non-fish vertebrates and/or aquatic benthic macroinvertebrates.

Not all indicators need to be present to suggest aquatic habitat for fish, aquatic non-fish vertebrates and/or aquatic benthic macroinvertebrates. Neither will the presence of isolated indicators always signify that waters contain aquatic habitat for fish, aquatic non-fish vertebrates and/or aquatic benthic macroinvertebrates.

Over what distance in the stream channel will the State Water Board make their determination of Stream Class? Will the State Water Board use the same methodology as described in Section A.1.6.2 in making their determination of Stream Class? How will the State Board make a determination that fish were historically presence in the affected stream reach? Will the State Board make a search of DFG's files for each diversion application? Will the State Board interview neighbors?

If the applicant challenges the State Water Boards Stream Classification they may elect to makes their own Stream Class determination by conducting a stream survey as described below in Section 1.6.2. If the State Water Board's Stream Classification of the project reach is done in a rigorous manner according to a standard methodology how, will the applicant be able to come to a different Stream Class determination? The Policy does not appear to have a mechanism for deciding which of the two competing Stream Classification for the project reach should prevail.

A.1.6.2 Determination of Stream Class by Stream Survey

If the applicant disagrees with the State Water Board's initial determination of stream class, the applicant shall conduct a stream survey to support a different determination. The stream survey shall be performed by a qualified fisheries biologist. Section A.1.5 provides the minimum education, knowledge, and experience requirements of a qualified fisheries biologist. Prior to conducting the stream survey, the applicant shall inform the State Water Board of the intent to conduct the stream survey, and shall provide the name(s) and qualifications of the individual(s) selected to perform the stream survey to the State Water Board for review and approval. All data, studies, analysis, and conclusions obtained from the stream survey shall be provided to the State Water Board for review and approval. The DFG shall be provided a reasonable period of time (not less than 30 days) to review and comment on the stream survey results.

Stream surveys shall be conducted as follows:

1. The stream survey shall extend in the channel a minimum distance of 25 bankfull widths upstream and downstream of the POD. The total stream survey length shall be a minimum of 50 bankfull widths.

2. Quarterly surveys using appropriate sampling and/or collection equipment shall be conducted to determine the presence of fish, aquatic non-fish vertebrates, and/or aquatic

benthic macroinvertebrates. These surveys shall be conducted in the spring, summer, fall, and winter, for at least two years; unless it is demonstrated that the presence of fish, aquatic non-fish vertebrates, and/or aquatic benthic macroinvertebrates can be determined in a shorter time period.

3. A survey of instream habitat conditions shall be made at low flows during the diversion season. Examples of instream habitat condition metrics that could be measured include:

a. Mean residual pool depth

b. Mean riffle crest depth

c. Mean riffle width

d. Mean channel bankfull width

e. Mean channel longitudinal gradient

f. Water temperature

g. Amount and type of cover

h. Substrate type

4. A visual survey shall be made after a storm runoff event for evidence of sediment transport. Such evidence may include, but is not limited to, the presence of gravel bars and deposits composed of gravel and sand. Annotated photographs must be provided for documentary evidence. Results of the stream survey shall be summarized and analyzed. A stream class determination shall be made using the following guidance:

A. A stream is a Class I stream if the results of the survey indicate any of the following:

1. Fish were observed during any of the quarterly surveys; or

2. Instream habitat conditions observed during the requested diversion season provide suitable habitat for fish based on habitat suitability criteria provided by the qualified fisheries biologist.

B. A stream is a Class II stream if the results of the survey indicate all of the following:

1. The stream reach is outside of the known historical distribution limits for fish species. The applicant shall provide evidence supporting this finding.

2. Instream habitat conditions for fish were not observed during the requested diversion season based on habitat suitability criteria provided by the qualified fisheries biologist.

3. Non-fish aquatic vertebrate or aquatic benthic macroinvertebrate species were observed during one or more of the surveys.

C. A stream is a Class III stream if the quarterly surveys showed evidence of sediment transport, instream habitat conditions for fish were not observed during the requested diversion season based on habitat suitability criteria, and habitat for non-fish aquatic vertebrate, and aquatic benthic macroinvertebrate species were not observed during any of the quarterly surveys.

Section A.1.6.2-1 requires that the Stream Classification stream survey be done over a reach that is 50 bankfull widths long. The bankfull width is a fluvial geomorpholgical parameter. The qualifications for a

Fisheries Biologist, in Section A.1.5, do not guarantee that fisheries biologist with minimal acceptable experience would have sufficient training in determining the bankfull width. The Policy gives no guidance in how to determine the bankfull width in the field.

The Stream Classification stream survey is to be 50 bankfull widths long. Will an applicant have legal access to the 50 bankfull channel widths of stream channel? Jackson (1999) did a statistical analysis of 50 bankfull widths measured by DFG stream survey crews or determined at USGS stream gauges in the Russian River watershed. Jackson (1999) determined that an upper bound for bankfull widths of the measured channels is given by:

$$\text{Bankfull Width} = 13.1\ (\text{Watershed Area})^{0.5} \qquad R^2 = 0.760;\ \text{Sample Size} = 50$$

According to this formula, the bankfull width for a 1.0 sq-mile watershed would be approximately 13.1 feet or less and a 50 bankfull width length would be up to 655 feet. At many project sites a stream survey 655 feet long would require access would from multiple landowners. The Policy does not give guidance on how to proceed with the required field stream assessment work when access is blocked by a neighboring landowner.

Section A.1.6.2-4-A does not consider historical presence of fish in determining if a reach is a Class I stream. The habitat that supported fish historically could have been destroyed by channel changes.

Sections A.1.6.2-4-A-2 and B-2 rely on "...habitat suitability criteria provided by the qualified fisheries biologist" instead of requiring that habitat suitability criteria be set by the Policy. Section A.1.6.2-4-C, which designates Class III streams, does not specify who establishes the habitat suitability criteria.

Upper Limit of Anadromy

Section A.1.4 defines the determination of the Upper Limit of Anadromy (ULA). The ULA is defined as the most upstream end of the current or historical range of anadromous fish. The ULA must be downstream of all Class II and Class III streams. The ULA will be in the upstream most Class I stream reach that supports or historically supported anadromous fish. There could be a Class I stream reach above the ULA where non-anadromous fish reside.

> A.1.4 Determination of the Upper Limit of Anadromy
>
> If there is sufficient unappropriated water to supply the proposed project after considering the rights of senior appropriators, the applicant must then evaluate the effects of senior diversions and the proposed project on instream flows needed for fishery resources to allow the State Water Board to determine if there is unappropriated water available for diversion. The upper limit of anadromy location will aid the State Water Board in selecting points to evaluate whether the proposed diversion may cause an effect on fishery resources.
>
> The upper limit of anadromy is defined as the upstream end of the range of anadromous fish that currently are, or have been historically, present year-round or seasonally, whichever extends the farthest upstream. The upper limit of anadromy may be located on a perennial, intermittent, or ephemeral stream.
>
> In some cases, the historic upper limit of anadromy is not known with certainty. In those cases, if the stream reach from which the applicant proposes to divert water appears to support fish under unimpaired conditions, the State Water Board will presume that the POD is located within the range of anadromous fish. This presumption might result in higher calculated minimum bypass flows than would be needed if the POD is actually upstream of the upper limit of anadromy. The

applicant may overcome this presumption by demonstrating that the upper limit of anadromy is at a different location on the stream reach between the POD and the basin outlet, based on one of the following:

1. A study, previously accepted by the State Water Board, NMFS, or DFG, that identifies the location of the upper limit of anadromy on the stream reach between the POD and the Pacific Ocean or to a flow-regulated mainstem river, depending on the water flow path. Previous studies or surveys that catalog only the presence or absence of anadromous fish might not accurately define the upper limit of anadromy.

2. Information demonstrating that the gradient of a segment of the stream reach between the POD and Pacific Ocean or to a flow-regulated mainstem river, depending on the water flow path, exceeds a continuous longitudinal slope over a distance of large enough magnitude that anadromous fish can not move upstream beyond the lowest point of the gradient. The gradient shall be a continuous longitudinal slope of 12%, or greater, over a distance of 330 feet along the stream (R2 Resource Consultants, 2007b).

3. Site-specific studies conducted by a qualified fisheries biologist. The applicant may refer to stream classification determinations that were made in accordance with the methods in section A.1.6 for preliminary refinement of the geographic extent of the site-specific study. Fisheries biologist qualifications are described in section A.1.5. Prior to conducting the site-specific study, the name(s) and qualifications of the individual(s) selected to perform the studies shall be submitted to the State Water Board for review and approval. All field work, modeling, analysis, and calculations performed as part of this study shall be documented in detail sufficient to withstand credible peer review. The site specific studies shall consist of any of the following:

a. Identification of an impassable natural waterfall. This policy assumes all natural waterfalls are passable unless the applicant provides information satisfactory to the State Water Board that the waterfall is impassable. This information shall include, at a minimum, an evaluation of waterfall drop height, leaping angle, and pool depth in comparison to the documented ability for the target anadromous fish species to successfully ascend the barrier. Available references for assessing whether a natural waterfall is impassable include but are not limited to: Part IX of the CDFG California Salmonid Stream Habitat Restoration Manual (DFG 2003), Powers and Orsborn (1985) and Bjorn and Reiser (1991).

b. Identification of an impassable human-caused barrier. The applicant may choose to demonstrate that the upper limit of anadromy is located below a human-caused barrier such as a dam, culvert, or bridge. This policy assumes that all human-caused barriers are passable or can be made passable unless the applicant provides information satisfactory to the State Water Board that a man-made barrier is impassable and will never be made passable.

c. Habitat-based stream survey that delineates the upper limit of anadromy based on quantifiable stream conditions. The applicant shall submit a report documenting the upper limit of anadromy determination. The State Water Board shall review the submitted information. If the State Water Board finds the information does not support the applicant's request to use a different location for the upper limit of anadromy, the applicant shall proceed with the assumption that the POD is within the range of anadromy. If the applicant conducts site specific studies to document the upper limit of anadromy, the State Water Board shall provide the study results to DFG for review and comment. The DFG shall be

> provided a reasonable period of time (not less than 30 days) to review and comment on the studies before the State Water Board makes a finding.

Section A.1.4-1, quoted above, does not set a minimum standard for, "A study, previously accepted by the State Water Board, NMFS, or DFG, that identifies the location of the upper limit of anadromy..." If a previously accepted study was not protective of the resource it could still be used to set the ULA.

For a project stream reach between the POD and Pacific Ocean Section A.1.4-2 defines the UAL as the downstream end of a stream reach with a continuous longitudinal slope greater than or equal to 12% over a distance of at least 330 feet. The Policy gives no guidance on how the continuous longitudinal gradient will be determined. There are several ways that the channel gradient can be estimated. The Policy should designate a field method with sufficient accuracy to ensure resource protection.

Section A.1.4-3-b does not specify what constitutes satisfactory evidence that a man-made barrier is impassable and will never be made passable.

Section A.1.4.3-c does not specify how to conduct a, "Habitat-based stream survey that delineates the upper limit of anadromy based on quantifiable stream conditions." Or what quantifiable stream conditions can be used to set the upper limit of anadromy.

Diversions Above the ULA

The ULA must be downstream of all Class II and Class III streams. The ULA will be in the upstream most Class I stream reach that supports or historically supported anadromous fish. There could be a Class I stream reach above the ULA where non-anadromous fish reside. Therefore, diversions on Class II and Class III are above the ULA. Some diversions on Class I streams may be above the ULA.

Diversions on Class III Streams

Section A.1.8.1 describes how diversions on Class III streams will be analyzed.

> A.1.8.1 Diversions on Class III Streams
>
> Projects located on Class III streams may be allowed to operate with the minimum bypass flow and maximum rate of diversion values that result in compliance with all of the following conditions. The analysis may use any minimum bypass flow or maximum rate of diversion at the POD as long as all three conditions are met. Successful completion of the analysis may require iteration.
>
> 1. The project will not reduce the number of days the February median flow is exceeded at the POIs located on downstream Class II streams. This analysis shall be performed using the method described in Appendix B Section B.5.3.6. There is error associated with the estimation of daily flows. Because of this, on a case-by-case basis, the State Water Board may consider this condition to be satisfied when analyses show a minor change to the numbers of days the February median is exceeded, provided that the minor change is due to a slight variability in the estimation of flow; AND
>
> 2. The project will not change the existing number of days the flow needed for spawning, rearing, or passage occurs at the POIs located at and below anadromy. This analysis shall be performed using the method described in Appendix B Section B.5.3.4. Regional criteria or site specific criteria for the minimum bypass flow may be used in the analysis of flows at the POIs. The existing number of days that flow needed for spawning, rearing, and passage occurs shall be determined by including the effects of all senior diverters upstream of the POI. There is error associated with the estimation of daily flows. Because of this, on a case-by-case basis, the State Water Board may

consider this condition to be met when analyses show a minor change to the number of days that the flow needed for spawning, rearing, and passage occurs. Provided that the minor change is due to a slight variability in the estimation of flow; AND

3. Either

a. The project will not change the existing 1.5 year return flow at the POIs located at and below anadromy. The existing 1.5 year return flow shall be calculated considering the effects of all senior diverters upstream of the POI. Upon approval by the State Water Board, the applicant may substitute a site specific threshold for the 1.5 year return flow.

OR

b. The project, in combination with senior diverters, will not reduce the unimpaired 1.5 year return flow at POIs located at and below anadromy by more than 5 percent. Upon approval by the State Water Board, the applicant may use a site specific criterion in lieu of the 5% of the 1.5-year return flow criterion.

The details of these calculations are described in Appendix B Section B.5.3.5.

Section A.1.8.1-1 requires that the project not reduce the number of days that the February median flow is exceeded. To determine this, a calculation of the February median flow and the number of days the February median flow is exceeded with and without the project. The analysis shall be done using the methods of Section B.5.3.6.

Section A.1.8.1-1 goes on to state that;

> There is error associated with the estimation of daily flows. Because of this, on a case-by-case basis, the State Water Board may consider this condition to be satisfied when analyses show a minor change to the numbers of days the February median is exceeded, provided that the minor change is due to a slight variability in the estimation of flow.

It is true that there is error associated with the estimate of daily flows. I have demonstrated that the Scaling Method (Adjustment of Stream Flow Records) can produce large errors in the flow estimates at some sites. Since the POIs are ungauged there is no way to evaluate the magnitude or direction of the flow estimation error, regardless of the method used to make the estimates. Once the daily flow record is estimated, for a given POI, the calculated February median flow will be the only estimate of the February median flow for that POI. The State Water Board will have no independent way of determining if the estimated February median flow is greater than (less than) the true February median flow for the POI. The State Water Board has no objective basis to determine if "a minor change in the number of days the February median (flow) is exceeded" is from a, "slight variability in the estimation of flow". Furthermore, no quantitative measure of "minor change" or "slight variation" is provided in the Policy. Arbitrarily modifying the results of the calculation of the number of days the February median flow is exceeded with or without the project at the various POIs will diminish the Policy's ability to protect fishery resources.

Section 2.2.1.2 of the Policy defines the minimum bypass flow (MBF).

> 2.2.1.2 Minimum Bypass Flow
>
> The minimum bypass flow is the minimum instantaneous flow rate of water that is adequate for fish spawning, rearing, and passage, as measured at a particular point in the stream. The minimum bypass flow must be met on an instantaneous basis at the point of diversion (POD) before water may be diverted. The streamflow may naturally fall below the minimum bypass flow. A minimum bypass flow requirement prevents water diversions during periods when streamflows are at or below the flows needed for spawning, rearing, and passage.

Section A.1.8.1-2 requires that, "The project will not change the existing number of days the flow needed for spawning, rearing, or passage occurs at the POIs located at and below anadromy". This is equivalent to requiring that the project not change the number of days that the MBF is exceeded.

Therefore, a clearer phrasing of Section A.1.8.1-2 would be, "The project will not change the existing number of days on which the flow exceeded the MBF at the POIs located at and below anadromy." The analysis is to be done according to B.5.3.4 which requires that the daily flows be estimated at the POIs at and below anadromy and the number of days that the MBF was exceeded with and without the project are calculated.

Section A.1.8.1-2 goes on to state that;

> There is error associated with the estimation of daily flows. Because of this, on a case-by-case basis, the State Water Board may consider this condition to be met when analyses show a minor change to the number of days that the flow needed for spawning, rearing, and passage occurs. Provided that the minor change is due to a slight variability in the estimation of flow.

It is true that there is error associated with the estimate of daily flows. I have demonstrated that the Scaling Method (Adjustment of Stream Flow Records) can produce large errors in the flow estimates at some sites. Since the POIs are ungauged there is no way to evaluate the magnitude or direction of the flow estimation error, regardless of the method used to make the estimates. Once the daily flow record is estimated, for a given POI, the calculated MBF will be the only estimate of the MBF for that POI. The State Water Board will have no independent way of determining if the estimated MBF is greater than (less than) the true MBF for the POI. The State Water Board has no objective basis to determine if a minor change in the number of days the MBF is exceeded is from a, "slight variability in the estimation of flow". Furthermore, no quantitative measure of "minor change" or "slight variation" is provided in the Policy. Arbitrarily modifying the results of the calculation of the number of days the MBF is exceeded with or without the project at the various POIs will diminish the Policy's ability to protect fishery resources.

Section A.1.8.1-3-a allows that, "Upon approval by the State Water Board, the applicant may use a site specific criterion in lieu of the 1.5-year return flow criterion" without specifically requiring that the applicant conduct a site-specific study to justify the criterion used in lieu of the 1.5-year return flow.

Section A.1.8.1-3-b allows that, "Upon approval by the State Water Board, the applicant may use a site specific criterion in lieu of 5% of the 1.5-year return flow criterion" without specifically requiring that the applicant conduct a site-specific study to justify the criterion used in lieu of the 1.5-year return flow.

The applicant may chose to comply with either Section A.1.8.1-3-a or with Section A.1.8.1-3-b. Section A.1.8.1-3-a appears to be the stricter requirement since no change in the 1.5-year flow at the POIs is allowed whereas, Section A.1.8.1-3-b allows up to a 5% change in the 1.5-year flow at the POIs which, is equivalent to the definition of the MCD. Both sections require accounting for the affect of senior diverters.

The details of the calculations required for Section A.1.8.1-3 are described in Appendix B Section B.5.3.5

> B.5.3.5 Evaluate whether the proposed project contributes to reductions in instream flows needed for the maintenance of natural flow variability
>
> 1. Estimate the 1.5-year instantaneous peak flow using the methods described in section B.5.2.3 for each of the three time series generated in sections B.5.3.1 through B.5.3.3 for each POI located

at and/or below anadromy. These are the time series for unimpaired conditions, impaired conditions without the proposed project, and impaired conditions with the proposed project.

2. Calculate the following quantities at each POI:

a. $1 - \frac{\text{(1.5 year instantaneous peak flow for impaired conditions without the project)}}{\text{(1.5 year instantaneous peak flow for unimpaired conditions)}}$

b. $1 - \frac{\text{(1.5 year instantaneous peak flow for impaired conditions with the project)}}{\text{(1.5 year instantaneous peak flow for unimpaired conditions)}}$

3. At each POI evaluate the following two co nditions:

a. Whether the value calculated in 2a is equal to the value calculated in 2b, meaning that the proposed project causes no change to the existing instream flow con ditions; or

b. Whether the value calculated in 2b is less than 0.05, meaning the proposed project, in combination with senior demands, causes less than a 5 percent change to the 1.5-year instantaneous peak flow from unimpaired conditions.

One of these two conditions must be met at each POI in order to show that the proposed project does not cause a reduction in instream flows needed for the mainten ance of natural flow variability.

The procedure described in Section B.5.3.5 does not make hydrologic sense. The procedures in Section B.5.3.5 (*Evaluate whether the proposed project contributes to reductions in instream flows needed for the maintenance of natural flow variability*) are aimed at evaluating whether a project will impact the natural flow variability. Section B.5.3.5-1 directs the applicant to use the procedures of Section B.5.2.3 (Regional *Criteria for Cumulative Maximum Diversion*). Section B.5.2.3 describes how to calculate the 1.5-year instantaneous flow by using either the Peaks over a Threshold (Partial Duration Series) or the Log Pearson Type III distribution according to the methods of WRC Bulletin 17b. The discussion in Section B.5.2.3 clears calls for the use of instantaneous flows and defines the Regional Criteria for the Maximum Cumulative Diversion (MCD) as 5% of the 1.5-year instantaneous flow.

Section B.5.3.5-1 then directs the applicant to generate the three *daily* flow sequences described in each of the following Sections; Section B.5.3.1 (*daily* unimpaired flow at POIs at and below the ULA); Section B.5.3.2 (*daily* flow impaired by senior diverts but without the project); and Section B.5.3.3 (*daily* flows impaired by senior diverters and the project). Nothing in the Policy describes how a daily flow sequence can be used to impair the 1.5-year instantaneous flow.

The example calculation posted on the SWRCB's AB-2121 website (http://www.waterboards.ca.gov/waterrights/water_issues/programs/instream_flows/docs/ab2121_0210/policy_samplecalc.pdf) and the associated spreadsheets do not demonstrate the details of this calculation. Table 3 – CDA Results, of the sample calculation, just show the results of impairing the 1.5-year discharge but not how the impairment was done. However, the spreadsheet called Attachment 2 of the sample calculation does show using daily average flows to calculate the 1.5-year flow which clearly is not the 1.5-year instantaneous flow. The Policy is inconsistent and confused. The Policy needs to recognize that the calculation procedures to impair the 1.5-year *instantaneous* flow can not be done as described.

What can be done using the calculation procedures of the Policy is to calculate the 1.5-year daily average discharge and its impaired value. The 1.5-year daily average discharge will always be significantly lower than the 1.5-year instantaneous discharge. This is illustrated by the following example.

The annual maximum instantaneous (flood) discharge for the USGS Maacama Creek near Kellogg stream gauge is compared to the daily average flow that occurred on the day of the annual instantaneous maximum discharge in Table 1. The annual instantaneous maximum discharge ranges from about 1.5 times the associated daily discharge to more than 4.6 times the associated daily discharge. The 1.5-year instantaneous discharge, for Maacama Creek near Kellogg, estimated by the Log Pearson Type III distribution is 3,440 cfs. The 1.5-year daily average discharge, calculated from the daily average flows that occurred on the day of the annual maximum discharge, is 1,242 cfs at the Maacama Creek near Kellogg gauge.

The purpose of calculating a 1.5-year discharge is to ensure that the flows that maintain the channel form are not diminished by a diversion or by the effect of cumulative diversions. The 1.5-year instantaneous discharge is used as an approximation for the bankfull discharge. The bankfull discharge is, in turn, used as an estimate of the channel forming discharge. For diversions below the ULA, the Policy defines the Regionally Protective MCD as 5% of the 1.5-year instantaneous flow but, in the sample calculations for the Policy the 1.5-year daily average discharge is calculated. Using the 1.5-year daily average discharge to calculate the MCD errs on the side of resource protection since it is a much lower value than the 1.5-year instantaneous flow (see Table 1 below for an example).

Section B.5.3.1 gives three methods of estimating the flow at an ungauged site. I have already demonstrated that the *Adjustment of Streamflow Records* (Scaling Method) can not guarantee conservative estimates (err on side of resource protection). Precipitation-based models are also allowed but the Policy does not have any objective criteria for selecting which of the many Precipitation-Based Models has the least error. The Policy also allows method (C) Another Method Acceptable to the State Water Board to estimate flow at an ungauged site. Method (C) is completely arbitrary.

Class III streams are an important source of spawning gravel. Allowing diversions on Class III streams to operate without a maximum diversion rate will interfere with the sediment transport process. Class III streams have small watersheds and bankfull flow, estimated by the 1.5-year instantaneous discharge, tends to be on the order of a few tens of cubic feet per second. Any significant decrease in the 1.5-year instantaneous discharge will reduce the caliber of the bedload transported by the impaired discharge and will also reduce recruitment of large woody debris. A reduction in the 1.5-year instantaneous discharge on a Class III stream will tend to result in a higher proportion of fine material being transported down to Class II and Class I streams. Fine sediment is detrimental to aquatic habitat.

The Policy exempts diversions on Class III streams from a setting a MBF and MCD if the diversion meets all three requirements of Section A.1.8.1. A qualifying diversion on a Class III stream is also exempted from the onstream dam provisions contained in Policy Section 2.4.3. The Policy has not demonstrated that the Class III exemption will adequately protect the fisheries resource.

> A.1.8.1.1 Class III Exemption
>
> If the analysis in Section A.1.8.1 shows a project can meet all three conditions without a minimum bypass flow and without a maximum rate of diversion limitation, that project shall also be exempted from the policy's season of diversion regional criteria and the onstream dam provisions contained in Policy Section 2.4.3.

Table 1. The annual maximum instantaneous (flood) discharge for the USGS Maacama Creek near Kellogg stream gauge is compared to the daily average flow that occurred on the day of the annual instantaneous maximum discharge. The annual instantaneous maximum discharge ranges from about 1.5 times the associated daily discharge to more than 4.6 times the associated daily discharge. The 1.5-year instantaneous discharge estimated by the Log Pearson Type III distribution is 3,440 cfs. The 1.5-year discharge calculated from the daily average flows that occurred on the day of the annual maximum discharge is 1,242 cfs.

Date of Annual Maximum Flood	Annual Maximum Flood Discharge cfs	Daily Average Flow on Day of Annual Maximum cfs	Ratio of Annual Maximum Flood Discharge to Daily Average Discharge
1/31/1961	3700	1190	3.11
2/13/1962	6370	2490	2.56
1/31/1963	7700	4110	1.87
1/20/1964	3180	1160	2.74
12/22/1964	8920	5510	1.62
1/4/1966	5650	2970	1.90
11/19/1966	5620	1210	4.64
1/10/1968	4670	1150	4.06
1/23/1970	6760	3580	1.89
12/3/1970	4250	2240	1.90
1/22/1972	642	234	2.74
1/16/1973	7460	3290	2.27
3/28/1974	5630	3670	1.53
3/21/1975	4770	1320	3.61
2/29/1976	1030	326	3.16
1/2/1977	194	55	3.53
1/16/1978	7360	4130	1.78
2/13/1979	3110	1370	2.27
2/17/1980	4760	1670	2.85
12/3/1980	4290	1810	2.37

Diversions on Class II Streams

Diversions on Class II streams are above the ULA.

A.1.8.2 Diversions on Class II Streams

Projects located on Class II streams may be allowed to operate with the minimum bypass flow and maximum rate of diversion values that result in compliance with all of the following conditions. The analysis shall be performed with a minimum bypass flow at the POD that is at least equal to the February median flow estimated at the POD. If the conditions below cannot be met by bypassing a February median flow, the bypass flow shall be increased until all of the conditions are met. Successful completion of the analysis may require iteration.

1. The project will not change the existing number of days the flow needed for spawning, rearing, or passage occurs at POIs located at and below anadromy. This analysis shall be performed using the method provided in Appendix B Section B.5.3.4. Regional criteria or site specific criteria for the minimum bypass flow shall be used in the analysis of flows at POIs located at and below points of anadromy. The existing number of days that flow needed for spawning, rearing, and passage occurs shall be determined by including the effects of all senior diverters upstream of the POI. There is error associated with the estimation of daily flows. Because of this, on a case-by-case basis, the State Water Board may consider this condition to be met when analyses show a minor change to the number of days that the flow needed for spawning, rearing, and passage occurs. Provided that the minor change is due to a slight variability in the estimation of flow; AND

2. Either

a. The project will not change the existing 1.5 year return flow at POIs located at and below anadromy. The existing 1.5 year return flow shall be calculated considering the effects of all senior diverters upstream of the POI. Upon approval by the State Water Board, the applicant may substitute a site specific threshold for the 1.5 year return flow.

OR

b. The project, in combination with senior diverters, will not reduce the unimpaired 1.5 year return flow at POIs located at and below anadromy by more than 5 percent. Upon approval by the State Water Board, the applicant may substitute a site specific threshold for the 1.5 year return flow.

The details of these calculations are described in Appendix B Section B.5.3.5.

The procedure to evaluate diversions on Class II streams is very similar to the procedure used for Class III streams. The main difference is that the required MBF is equal to or greater than the February median flow. The procedure uses an iterative approach to determine the smallest bypass flow that does not change the number of days the flow exceeds the MBF at all POIs downstream of the ULA. However, Section A.1.8.2-1 introduces an undefined level of arbitrariness into the process with the following statement.

> There is error associated with the estimation of daily flows. Because of this, on a case-by-case basis, the State Water Board may consider this condition to be met when analyses show a minor change to the number of days that the flow needed for spawning, rearing, and passage occurs. Provided that the minor change is due to a slight variability in the estimation of flow.

The MBF is, "…the flow needed for spawning, rearing, and passage". So, the number of days that the flow needed for spawning, rearing, and passage occurs is equivalent to the number of days the MBF is equaled or exceeded.

It is true that there is error associated with the estimate of daily flows. I have demonstrated that the Scaling Method (Adjustment of Stream Flow Records) can produce large errors in the flow estimates at some sites. Since the POIs are ungauged there is no way to evaluate the magnitude or direction of the flow estimation error, regardless of the method used to make the estimates. Once the daily flow record is estimated, for a given POI, the calculated MBF will be the only estimate of the MBF for that POI. The State Water Board will have no independent way of determining if the estimated MBF is greater than (less than) the true MBF for the POI. The State Water Board has no objective basis to determine if a minor change in the number of days the MBF is equaled or exceeded is from a, "slight variability in the estimation of flow". Furthermore, no quantitative measure of "minor change" or "slight variation" is provided in the Policy. Arbitrarily modifying the results of the calculation of the number of days the MBF is exceeded with or without the project at the various POIs will diminish the Policy's ability to protect fishery resources.

Diversions on Class I Steams

Some diversions on Class I streams may be above the ULA and some diversions on Class I streams will be below the ULA.

> A.1.8.3 Diversions on Class I Streams
>
> Proposed diversions on Class I streams shall be allowed to operate using the minimum bypass flow and maximum rate of diversion that demonstrates compliance with all conditions below. Successful completion of the analysis may require iteration. If regional criteria are used, minimum bypass flows that are at least equal to the regional criteria at the proposed POD and the POIs shall be used in the analysis.
>
> If site specific criteria are used, the analysis at the POIs may use the site specific minimum bypass flows and maximum cumulative diversion obtained in lieu of the regional criteria, and the proposed POD may be allowed to operate with the minimum bypass flow and maximum rate of diversion values that result in compliance with all three conditions.
>
> 1. The project will not change the existing number of days the flow needed for spawning, rearing, or passage occurs at POIs located at and below anadromy. This analysis shall be performed using the method provided in Appendix B Section B.5.3.4. The existing number of days that flow needed for spawning, rearing, and passage occurs shall be determined by including the effects of all senior diverters upstream of the POI. There is error associated with the estimation of daily flows. Because of this, on a case-by-case basis, the State Water Board may consider this condition to be met when analyses show a minor change to the number of days that the flow needed for spawning, rearing, and passage occurs. Provided that the minor change is due to a slight variability in the estimation of flow; AND
>
> 2. Either
>
> > a. The project will not change the existing 1.5 year return flow at POIs located at and below anadromy. The existing 1.5 year return flow shall be calculated considering the effects of all senior diverters upstream of the POI. Upon approval by the State Water Board, the applicant may substitute a site specific threshold for the 1.5 year return flow. OR
> >
> > b. The project, in combination with senior diverters, will not reduce the unimpaired 1.5 year return flow at POIs located at and below anadromy by more than 5 percent. Upon approval by the State Water Board, the applicant may substitute a site specific threshold for the 1.5 year return flow.
>
> The details of these calculations are described in Appendix B Section B.5.3.5.

My previous comments about estimating flows apply to diversions on Class I streams. And, again, the procedure for evaluating diversions on Class I streams introduces an arbitrary level assessment by including the following passage. Please see my comments on Diversions on Class III and Class II Streams.

> There is error associated with the estimation of daily flows. Because of this, on a case-by-case basis, the State Water Board may consider this condition to be met when analyses show a minor change to the number of days that the flow needed for spawning, rearing, and passage occurs. Provided that the minor change is due to a slight variability in the estimation of flow

Flow Estimates

The Policy allows estimates of the flow at ungauged PODs and POIs to be made by one of three methods. The methods are (A) *Adjustment of Streamflow Records* (Scaling Method) (B) *Precipitation-Based Streamflow Model* and (C) *Another Method Acceptable to the State Water Board.*

The Policy sets no standard that can be used to judge if a particular method to estimate flow performs well or poorly. The most accurate method of estimating streamflow at an ungauged site is required in order to meet the Policy's goal of always erring on the side of resource protection. As I have previously demonstrated, to err on the side of resource protection requires overestimating the MBF and underestimating the MCD. Simple methods to estimate flow at an ungauged location will to either overestimate both the MBF and the MCD or will underestimate them both. In either case, one of the diversion parameters will tend to err on the side of resource protection while the other diversion parameter errs on the side of adversely impacting the resource.

I have demonstrated that, at some sites, method (A) *Adjustment of Streamflow Records* (Scaling Method) can generate flow estimates that error significantly in comparison to measured values. The Policy failed to analyze the ability of method (A) *Adjustment of Streamflow Records* (Scaling Method) to estimate streamflow at an ungauged site.

The Policy allows the use of method (B) Precipitation-Based Streamflow Models to estimate streamflow. Section B.2.1.3 describes the general requirements of a Precipitation-Based streamflow model. And Section A.1.1.1 describes Model submittal requirements.

> Section B.2.1.3-B. Precipitation-Based Streamflow Model
>
> Subject to State Water Board approval, the applicant may propose using standard hydrologic techniques or public domain computer models for estimating the average seasonal unimpaired flow volume. Precipitation input data shall be provided over a minimum of ten complete and continuous water years. Model results shall be validated by comparison with recorded flows on or near the POD watershed. The recorded flows do not have to be unimpaired but the applicant shall take the impairment into consideration when calibrating the model. The modeled output flows shall be summed in units of acre-feet to obtain an average seasonal unimpaired volume. Model submittal requirements are described in Appendix A Section A.1.1.1 of the policy.
>
> A.1.1.1 Data Submissions
>
> The raw data, spreadsheets, and models used to perform the water supply report and cumulative diversion analysis shall be provided for State Water Board review and approval, and shall meet the following requirements.
>
> 1. Analysis reports shall describe the assumptions used, and include a functional electronic version of the spreadsheet(s) that was used to perform the analysis, including the equations, input data and assumptions, and outputs used to complete the analysis.

2. Input files, calibration results, validation results, and output files shall be provided in electronic format with supporting documentation that describes the model's assumptions, underlying modeling principles, and operation.

3. Generally, no proprietary spreadsheets or proprietary computer models will be accepted; however output from proprietary programs used solely to visually summarize or demonstrate the output data or results from public domain spreadsheets or public domain computer programs that meet the above two requirements may be accepted by the State Water Board if the underlying data and assumptions are also submitted.

Section B.2.1.3-B requires that, "Model results shall be validated by comparison with recorded flows on or near the POD watershed" but the Policy gives no guidance on what metric to use to determine if the Precipitation-Based model has been adequately validated against the reference stream gauge record. Validating a Precipitation-Based streamflow model means that the "best" set of model parameters have been found in the sense that some metric shows the least overall error in the estimates of flow at the site with a record of stream flow (reference gauge). Validating the Precipitation-Based streamflow model does not require meeting some specified level of accuracy. So, an applicant could chose a Precipitation-Based Streamflow model that is validated against a reference stream gauge but produces significant errors in its estimate of the flow at the gauge.

The Policy does not require that the Precipitation-Based streamflow model account for the watershed characteristics of the watershed being model or of the watershed used to validate the model. As I demonstrated in my critique of method (A) the *Adjustment of Streamflow Records* (Scaling Method), failure to account for the difference in Runoff Efficiency between the reference stream gauge and the ungauged watershed upstream of the POD (POI) has the potential to result in large errors in the estimated flow at the POD (POI).

Method (C) *Another Method Acceptable to the State Water Board* is arbitrary and is so poorly defined that there is no way to objectively assess what it means. Method (C) appears to have a large potential to be misused.

All methods to estimate flow at an ungauged site will produce estimates that differ from the true flow. The Policy must set objective criteria for deciding if a proposed method to estimate streamflow has sufficient accuracy in estimating the flow at an ungauged site.

Flow models produce results that need to be verified against real data. Even models that have been calibrated can have significant bias. For example, in October of 2008 I critiqued the use of the WinTR-55 to estimate various return period flood discharges (paper attached). I found that the model did not agree with USGS flood measurements at an adjacent stream gauge. The WinTR-55 model gave significantly higher results.

Summary

The Stream Classification System has the following problems.

- Stream Class definitions are not clear. Some key portions of definitions are scattered about the Policy document.
- What constitutes acceptable proof of historical presence of fish is not defined.
- The methods that the State Water Board will use in determining Stream Class are not specified.

- No minimum qualifications are set regarding determination of the bankfull width.
- No alternative provision is made for field work blocked by lack of legal access to the stream channel.
- Section A.1.6.2-4-B-2 relies on "habitat suitability criteria provided by the qualified fisheries biologist" instead of requiring that habitat suitability criteria be set by the Policy.

Problems with the definition of the upper limit of anadromy

- No quality standard is set for "previously accepted studies" that define the upper limit of anadromy.
- No minimally acceptable methodology is defined for determining stream gradient in excess of 12% over a 330 foot stream reach.

Problems with diversion analysis on different Class streams.

- Accurate flow estimates are essential. The Policy does not set objective standards for methods to predict ungauged flow.
- There is confusion about the meaning of the 1.5-year instantaneous flow. The calculation example uses the 1.5-year daily average flow.
- The diversion analysis procedures insert a clause that allows the State Water Board to allow an arbitrary change in the number of days a diversion may impact the fisheries resource.
- Allowing diversions on Class III streams is likely to decrease the caliber of sediment transported down to Class II and Class I streams . Fine sediment is detrimental to aquatic habitat.
- The Policy has not demonstrated that the Section A.1.8.1.1 Class III Exemption is protective of the fisheries resource.

Sincerely,

Dennis Jackson

Dennis Jackson
Hydrologist

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October 19, 2008

Tom Lippe
329 Bryant Street, Suite 3D
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Re: DEIR for Rodgers/Upper Range Vineyard Project Conversion #02454-ECPA

Dear Mr. Lippe:
You have asked me to comment on Supplemental Draft Environmental Impact Report of the proposed Upper Range Vineyard Project (Rodgers) conversion from oak woodland and grassland to vineyard. The original Draft Environmental Impact Report (DEIR) was dated December 2006. The Supplemental DEIR is dated August 2008. The DEIR describes the project as follows.

> This EIR analyzes the potential environmental impacts of implementing an Erosion Control Plan (#02-454-ECPA) for earthmoving activities associated with a new vineyard in Napa County, California. The Upper Range Vineyard Project – Rodgers Property would involve installing erosion control features and measures and the subsequent operations for a new approximately 161-acre vineyard on privately owned properties. (APNs 030-200-002, 030-130-008, 030-220-009, and 030-220-027/028/029/030 (formerly 030-220-001). The new vineyard would be situated on seven contiguous parcels totaling approximately 678 acres.
>
> The project site is located in the hills between the Silverado Trail and Lake Hennessey, about 2 miles northeast of Rutherford and 13 miles north of the City of Napa. The erosion control measures would be implemented in the proposed vineyard area, which would cover 161 acres (approximately 24 percent of the total 678 acres), while the existing site conditions would remain as is on 517 acres (approximately 76 percent of the total 678 acres). The vineyard layout was designed by the property owners to minimize the need for grading and tree removal.
>
> A new 10,000-gallon water tank and irrigation line would be installed for the vineyard. Ground water would be pumped from an existing well and be stored in the water tank. The existing well would also be shared and provide water to the Rutherford Volunteer Fire Department facility on Silverado Trail. The Rutherford Volunteer Fire facility would have their own separate 10,000-gallon water tank that would be screened from view by existing trees.

The comments in my January 21, 2007 letter still apply and I incorporate those comments by reference.

WIN TR-55 Model

Mathematical models to estimate storm peak discharge are powerful tools but they need to be carefully calibrated before their results can be trusted. The Draft Hydrologic Evaluation Rodgers Upper Range Vineyard Conversion prepared by HIS, October 2005 page 2-6 concurs.

> Due to the potential for flooding of Silverado Trail, if there is any increase in runoff from the project, it is recommended that a hydraulic model of the project site be developed. **The model should be calibrated to measured data collected at the project site**. The runoff characteristics for the post-project condition should be collected from runoff measured from an adjacent vineyard with similar geology, soils, and topography. (Emphasis Added)

The WIN TR-55 model (Trso, November 2006) does not appear to have been calibrated to local pre-project conditions. The peak flood flows predicted by the WIN TR-55 model for pre-project conditions do not appear to agree with USGS data collected in a nearly adjacent Lake Hennessey Tributary watershed between 1959 and 1973. See Figure 1 for a map showing the location of the USGS Lake Hennessey Tributary gage watershed. Figure 2 shows the soil map from the Upper Range DEIR showing the stream that the USGS measured the flood peaks on. The Lake Hennessey Tributary stream gage (USGS Station Number 11456400) was operated to collect data on the flood response of small watersheds. The watershed area of the Lake Hennessey Tributary stream gage is 1.04 square miles (665 acres). The soils, land use, vegetation, and topography of the watershed of the Lake Hennessey Tributary stream gage are similar to those of Rodgers Upper Range, especially the Lake Hennessey Gulch sub-basin.

Figure 6 shows the soil map (Figure 3-8 of HIS' Draft Hydrologic Evaluation) with the location of the USGS Lake Hennessey Tributary stream gage. The soil types mapping symbol is a three-digit number.

Table 1 shows the predicted peak flood discharges for pre-project conditions from Table 2, page 12, of Trso's November 2006 report. Table 1 also shows the peak flood discharges for the USGS flood peak data for the same return period storms Trso estimated. Note that the predicted discharges for Lake Hennessey Gulch on the Upper Range project are much higher than the discharges estimated for the USGS Lake Hennessey Tributary data, even though the watershed area of the Lake Hennessey Gulch is 34.7% of the USGS watershed.

The peak storm discharges predicted by the WIN TR-55 model do not appear to agree with regional peak discharge data from other USGS stations in the Napa River watershed. Table 2 shows data about the location and length of record for the USGS gaging stations used to construct the regional peak discharge graphs shown in Figures 3 and 4. Table 3 shows watershed area and peak storm discharges for the same return period storms used by Trso (November 2006). Figure 3 shows the 2-year peak storm discharge for the Rodgers Upper Range watersheds and for the USGS stream gages versus the watershed area. Figure 4 shows the similar data for the 10-year storm.

In both Figure 3 and 4 the peak flood discharges predicted by the WIN TR-55 model plot higher than the data for the USGS stream gages indicating that the WIN TR-55 model predicts a greater storm peak discharge for a given watershed area than the storm discharges measured by the USGS. It is important to note that the Lake Hennessey Tributary gaging station discharges plot below the regression line for the USGS stations in the Napa River, indicating that the storm runoff from that station is lower than would be expected based on the other USGS Napa River stations.

The pre-project WIN TR-55 storm discharge model does not appear to have been adequately calibrated since it greatly overestimates the storm discharge relative to the regional USGS data, for all flood frequencies. Table 1 compares the Lake Hennessey Tributary storm discharges to the storm discharges for the Upper Range sub-basins. The predicted storm discharges for both the Rodgers Southeast Gulch and the Lake Hennessey Gulch are greater than the storm discharges measured by the USGS even though the watershed upstream of the USGS stream gage (665.6 acres) is much larger than either the Rodgers Southeast Gulch (107.8 acres) or the Lake Hennessy Gulch (231.2 acres)

Table 1. Estimated peak discharge for selected return period storms modeled by the WIN TR-55 model. Data from Martin Trso, November 2006, Table 2, page 12 for existing conditions. The Lake Hennessey Tributary stream gage peak discharges for the give return period events were calculated from measure runoff events between 1959 and 1973. Note that the predicted discharges for Lake Hennessey Gulch on the Upper Range project are much higher than the discharges estimated for the USGS Lake Hennessey Tributary data, even though the watershed area of the Lake Hennessey Gulch is 34.7% of the USGS watershed.

	Area acres	Area sq-mi	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Rodgers Southwest Gulch	24.4	0.038	14.7	20.7	26.7	38.8	44.9	51
Rodgers South Gulch	52.5	0.082	29.5	42.2	55.3	81.8	95.1	108.4
Rodgers Southeast Gulch	107.8	0.168	63.1	88.5	114.4	166.7	192.8	219.1
Lake Hennessey Gulch	231.2	0.361	134.4	188.6	243.8	355.5	411.3	467
Sage Canyon Gulch	20.4	0.032	11	15.8	20.9	31.2	36.4	41.5
USGS Lake Hennessey Trib	665.6	1.04	56	103	134	173	203	231

Table 2. Location and length of record for USGS gaging stations in the Napa River watershed with peak discharge records.

Napa River Streams	Station #	Latitude	Longitude	Start of Record	End of Record	Years of Record
Lake Hennessy Tributary	11456400	382900	1222115	1959	1973	14
Sulphur Creek Nr St Helena	11455950	382916	1222850	1956	1973	18
Redwood near Napa	14458200	381904	1222035	1959	1973	15
Tulucay Creek near Napa	11458350	381709	1221629	1972	1983	12
Napa Creek at Napa	11458300	381807	1221810	1971	1983	13
Milliken Creek near Napa	11458100	382019	1221606	1971	1983	13
Dry Creek near Napa	11457000	382123	1222150	1952	1966	15
Napa River near St. Helena	11456000	382952	1222537	1929	1996	58

Table 3. Peak storm discharge for selected return period events for USGS stream gages in the Napa River watershed listed in Table 2.

Napa River Streams	Watershed Area (sq-miles)	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
Lake Hennessy Tributary	1.04	56	103	134	173	203	231
Sulphur Creek Near St Helena	4.5	528	724	854	1,018	1,140	1,261
Redwood near Napa	9.79	1,007	1,341	1,563	1,843	2,051	2,257
Tulucay Creek near Napa	12.6	898	1,682	2,201	2,857	3,343	3,826
Napa Creek at Napa	14.9	1,472	2,441	3,083	3,893	4,494	5,091
Milliken Creek near Napa	17.3	1,649	2,778	3,525	4,470	5,171	5,867
Dry Creek near Napa	17.4	1,456	2,308	2,872	3,585	4,114	4,639
Napa River near St. Helena	81.4	5,879	9,276	11,526	14,368	16,477	18,570

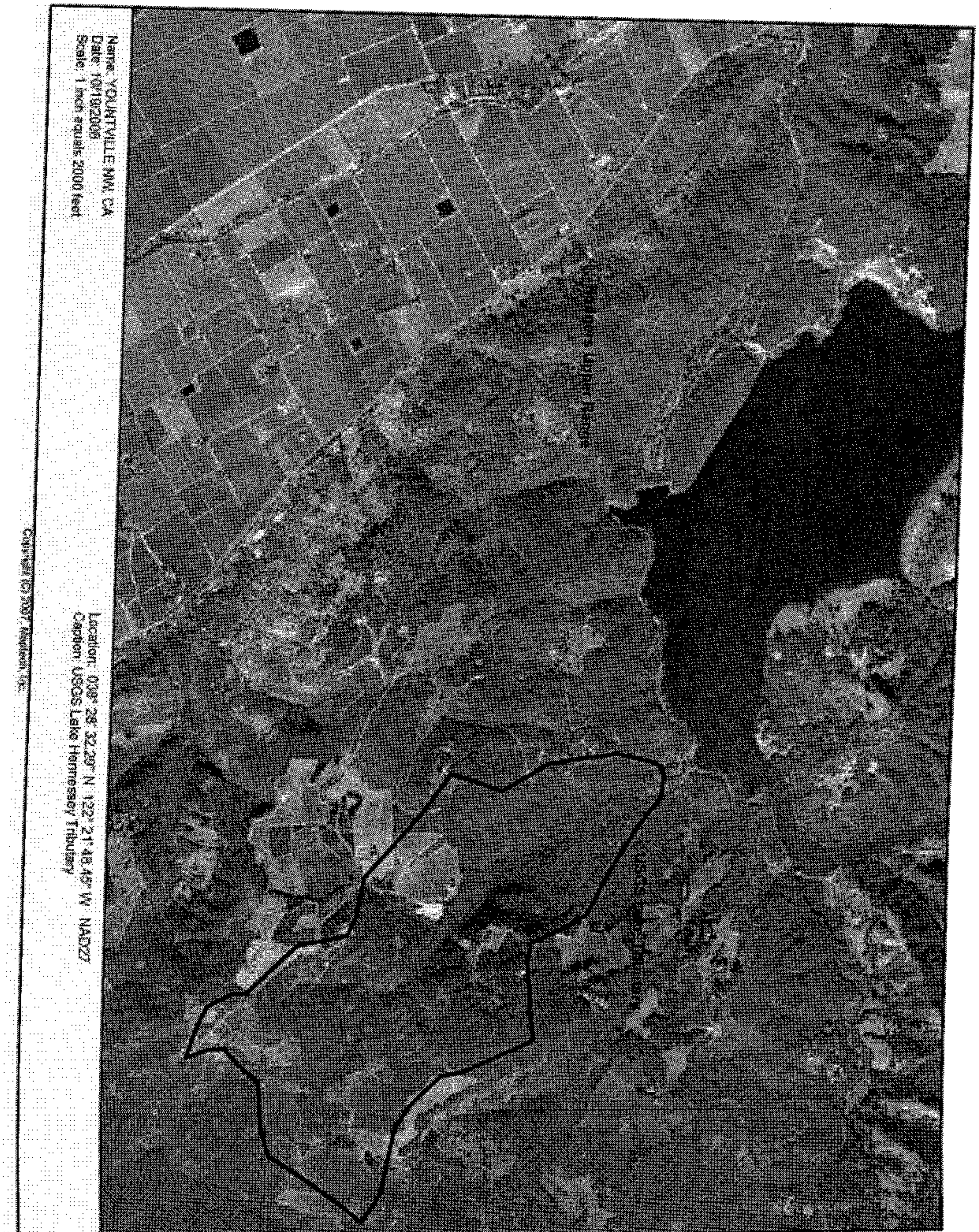

Figure 1. The USGS Lake Hennessy Tributary stream gage is almost adjacent to the Rodgers Upper Range project. The watershed area of the Lake Hennessey Tributary stream gage is 1.04 square miles.

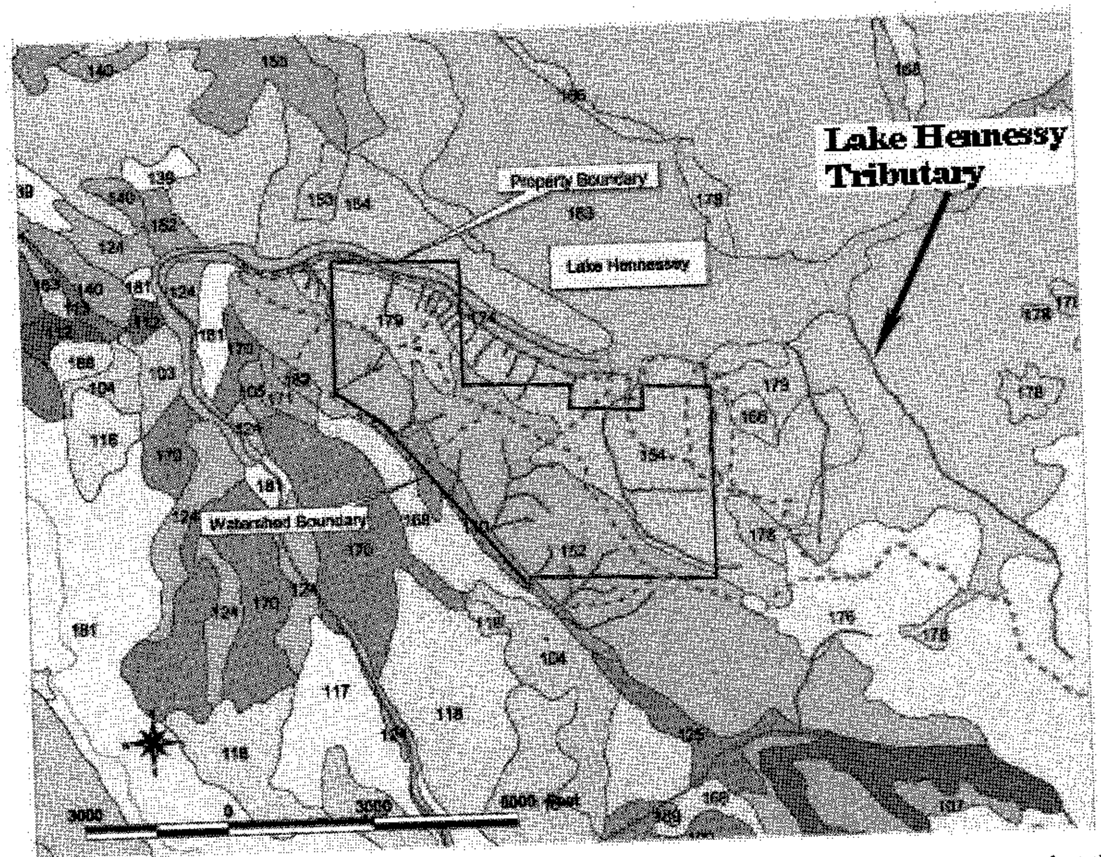

Figure 2. Soil map of the Rodgers Upper Range project showing the location of the stream that the USGS measured flood peaks on from 1959-1973. The stream gage name is Lake Hennessey Tributary and its station number is 11456400. The soil types in the watershed draining to the USGS gage are given below.

Napa County, California (CA055)
Map Unit Symbol Map Unit Name Acres

154 Henneke gravelly loam, 30 to 75 percent slopes.

176 Rock outcrop-Hambright complex, 50 to 75 percent slopes.

178 Sobrante loam, 5 to 30 percent slopes

179 Sobrante loam, 30 to 50 percent slopes

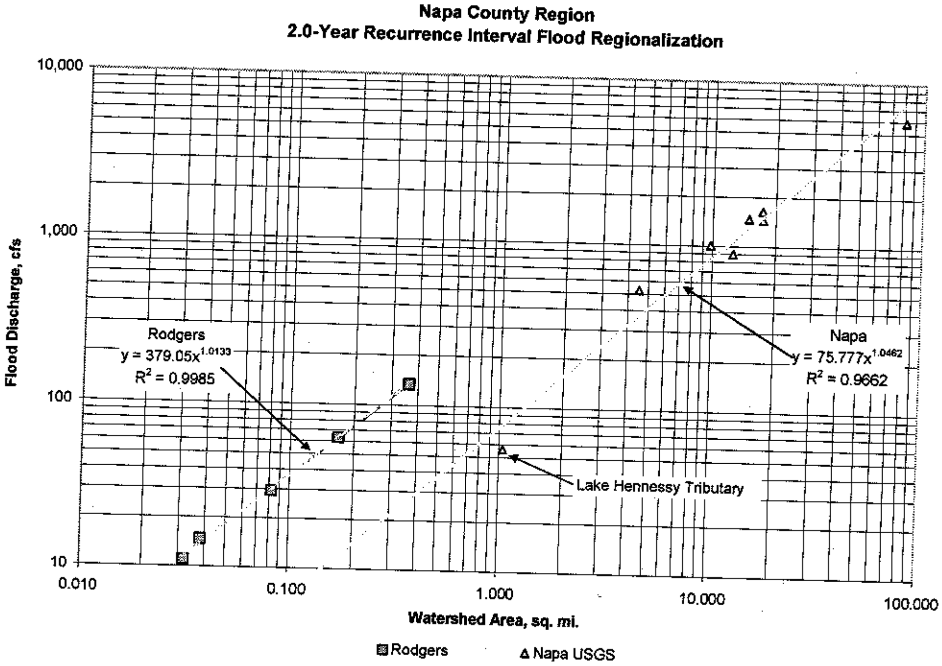

Figure 3. The estimated 2-year peak storm discharge for the Rodgers Upper Range watersheds do not agree with the 2-year storm discharge measured at USGS stream gages in the Napa River watershed.

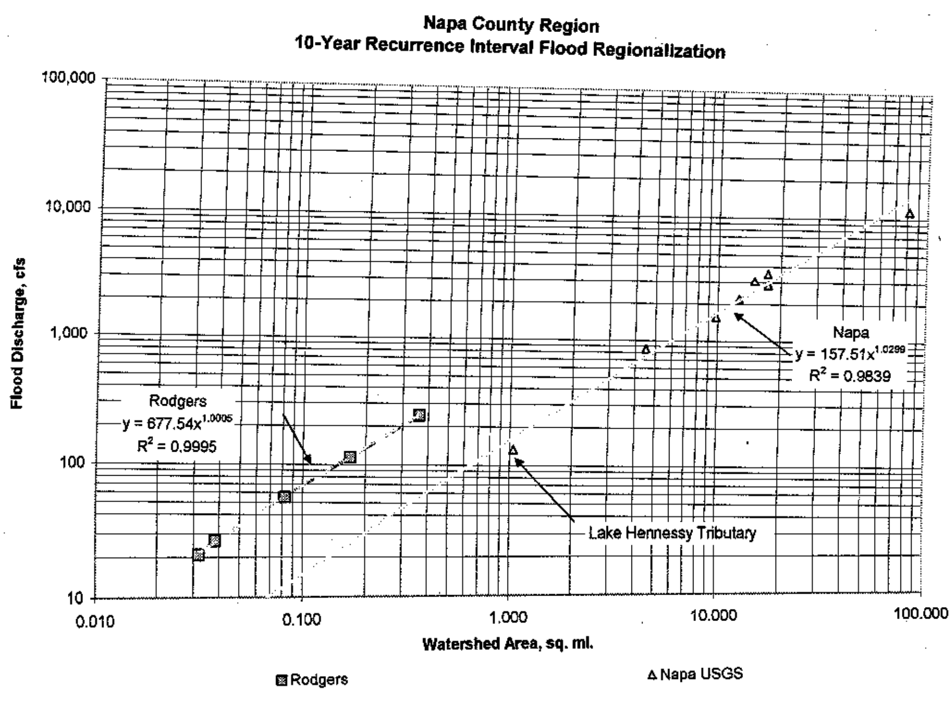

Figure 4. The estimated 10-year peak storm discharge for the Rodgers Upper Range watersheds do not agree with the 10-year storm discharge measured at USGS stream gages in the Napa River watershed.

Since the WIN TR-55 model does not appear to have been calibrated against locally available measured data that represent the pre-project condition its results for the post-project condition are highly suspect. In my opinion, all conclusions based on the WIN TR-55 model should be discarded.

Estimates of Mean Annual Rainfall

The December 2006 DEIR has three different estimates for the mean annual rainfall at the project site. Each of the mean annual rainfall values given in the DEIR are listed below. The mean annual rainfall is an important value since the groundwater recharge is estimated from it by subtraction estimates of evapotranspiration and annual runoff. The conclusions in the DEIR regarding groundwater recharge are suspect until a firm well-documented estimate of the mean annual rainfall is presented.

Author	Page	Mean Annual Precipitation	Reference
DEIR	4.4-4	24.28	City of Napa
HIS	2-4	26.40	Napa Hospital E30 607400
HIS	3-4	24.28	Table 3-1
HIS	3-6	27.08	ratio to Atlas Road Gage E20 0368

Groundwater Recharge Rates

The Supplemental DEIR does not include any discussion of groundwater recharge rates or water availability. The December 2007 DEIR discussion of Impact 4.4-3 on page 4.4-18 states:

> For CEQA purposes, the long term average natural rainfall recharge of the **groundwater body in question** should be greater than or equal to the estimated consumptive water use rate. (Emphasis Added)

The "groundwater body in question" is the groundwater body that the project production well is drawing water from. Figure 5 shows DEIR Figure 4.3-1, Soils, Fault Lines and Catchments. I have added the location of the project well from the Draft Hydrologic Evaluation (HSI, 2005) Figure 5-1. Figure 5 shows that the project well is in the Rodgers Southeast Gulch which drains an area of 107.8 acres. Only precipitation that falls on the Rodgers Southeast Gulch sub-basin is expected to recharge the well. The DEIR has not presented any information that demonstrates otherwise.

The December 2006 DEIR (page 4.4-4) gives the mean annual rainfall is 26.4 inches. As noted above, two other estimates of the mean annual rainfall are given in the DEIR. The true mean annual rainfall for the project area still needs to be determined and clearly presented.

Recognizing that the value of the mean annual rainfall in the following calculation may change, I proceed to go through the process used to estimate the groundwater recharge to show that it is flawed. The DEIR estimates that runoff is 7 inches per year and that evapotranspiration rate is 14 inches per year. The DEIR estimates the groundwater recharge by the following equation:

$$\text{Groundwater Recharge} = \text{Rainfall} - \text{Evapotranspiration} - \text{Runoff}$$

Putting in the numerical values gives:

Recharge = 26.4 inches rainfall – 14 inches evapotranspiration – 7 inches = 5.4 inches.

The estimated groundwater recharge is 20.45% of the mean annual precipitation. Groundwater recharge on the hillslopes in the Rodgers Upper Range project area is expected to only a fraction of the estimated 5.4 inches. Figure 5 shows that the runoff from both the Rodgers South Gulch and Rodgers Southeast Gulch soak into the valley floor to the west of Silverado Trail which is off the project property and upslope of the project well. The groundwater recharge estimated by the DEIR does not represent the level of recharge on the Rodgers Upper Range property. The estimated groundwater recharge may represent the recharge to the area that includes the area where the streams from Rodgers South Gulch and Rodgers Southeast Gulch soak into the valley floor west of Silverado Trail.

The Draft Hydrologic Evaluation (HIS, 2005) and the DEIR have not adequately defined the groundwater recharge to the project well. A significant portion of the Rodgers Upper Range property drains towards Lake Hennessey (HSI's Zone 1) and Conn Creek just downstream of Conn Dam (HSI's Zone 2). It is highly unlikely that any precipitation that falls on Zone 1 or Zone 2 would be able to provide recharge the project well. Solid geologic evidence needs to be presented that definitively shows where the recharge to the project well comes from. Until such evidence is presented it is reasonable to assume that the groundwater recharge that supplies the project well comes from the Rodgers Southeast Gulch sub-basin with an area of 107.8 acres. Assuming that the groundwater recharge to the Rodgers Southeast Gulch watershed is 10% of the mean annual rainfall and assuming that the actual mean annual rainfall for the project area is 26.4 inches we get a recharge of 2.64 inches (= 10% x 26.4") or 0.22 feet. Thus the total recharge from the Rodgers Southeast Gulch sub-basin is 0.22 feet x 107.8 acres = 23.7 acre-feet per year. This is far less than the estimated project water demand of 131 acre-feet per year (page 2-5 of HIS, 2005).

This indicates that the water production rate from the well (131 acre-feet) is over five times the estimated recharge rate from the Rodgers Southeast Gulch sub-basin.

Well Test

The Rodgers/Upper Range Vineyard groundwater pumping test was a mix of a step-drawdown test and a constant-rate discharge test. However, instead of progressively *increasing* discharge, as in a standard step-drawdown test, the step-drawdown portion of the Rodgers/Upper Range pumping test was done by successively *decreasing* the discharge.

Standard texts such as Driscoll (1986) or Walton (1987) recommend that the pumping should have stopped after the step-drawdown test to allow the water surface to recover to the pre-test level prior to conducting the constant-rate discharge test. Driscoll (1986) notes that:

> Beginning a pumping test when the static water level is below normal may eliminate early data that show discharge or recharge boundaries. Without the early drawdown data, it may be impossible to obtain the correct transmissivity and storage parameters for the aquifer.

The phrase, "when the static water level is below normal" means when the water level in the well has not recovered to the pre-pumping level. In addition to conducting the well test in a way that clouds the value of the data collected. The first 6.5 hours of the actual pump test data for the Rodgers well (from 9:30 am on November 15, 2004 until 4 pm on November 15, 2004) are not reported in Appendix C of the Draft Hydrologic Evaluation (HIS, 2005). This prevents independent analysis of the well test data.

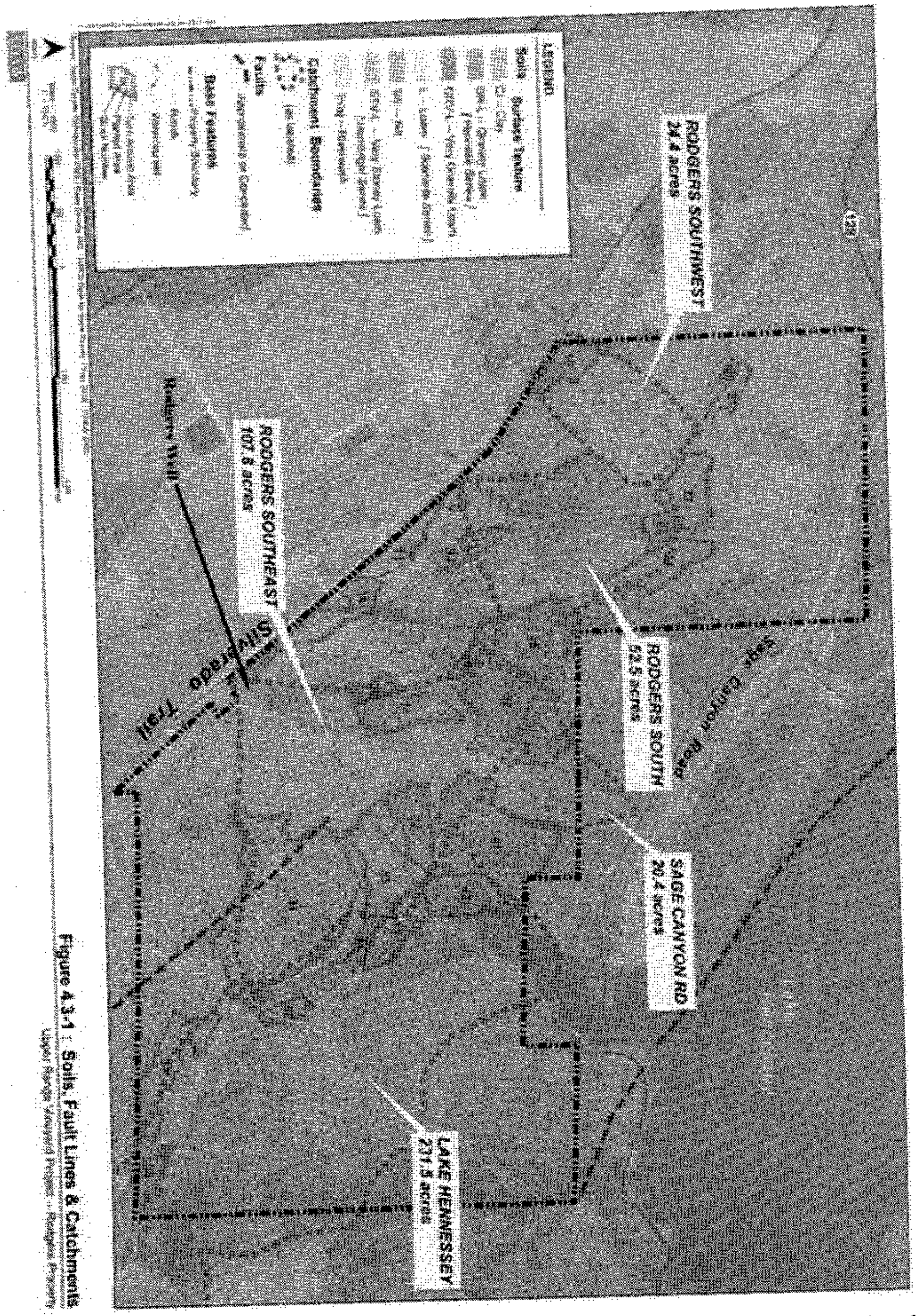

Figure 5. The Rodger Upper Range property boundaries, sub-basin boundaries and well location. Map is DEIR Figure 4.3-1. The location of the project well was taken from Figure 5-1 on page 5-2 of HSI's Draft

Hydrologic Evaluation from the DEIR. The project well is in the Rodgers Southeast sub-basin and is east of Silverado Trail.

A new 72-hour constant-discharge test needs to be performed at a discharge rate of about 205 gpm which appears to be the sustainable pumping rate of the project well. The neighboring wells need to be monitored for at least 96 hours (24 hours after pumping ends) using recording water level equipment. The drawdown in the production well also needs to be record electronically. The resulting data should be analyzed by standard methods such as though presented in Driscoll (1986) to estimate the size of the zone of influence and the groundwater levels at the end of the pumping.

Given the fact that the realistic estimate of groundwater recharge to the Rodgers well is only a fraction of the project water demand, it is imperative that a new properly conducted 72-hour constant-discharge aquifer test be done to demonstrate that the aquifer supplying the well can adequately supply the project water demand and the water demand of the Rutherford Volunteer Fire facility and that the project will not progressively lower local groundwater levels over time in the and that pumping the project well does not adversely impact the neighboring wells.

The well test as conducted and analyzed does not support the conclusion that there will be no adverse impact to static groundwater levels or to the neighboring wells from pumping the project well.

Cumulative Impacts

Page 2-2 of the DEIR states that:

> A new 10,000-gallon water tank and irrigation line would be installed for the vineyard. Ground water would be pumped from an existing well and be stored in the water tank. The existing well would also be shared and provide water to the Rutherford Volunteer Fire Department facility on Silverado Trail. The Rutherford Volunteer Fire facility would have their own separate 10,000-gallon water tank that would be screened from view by existing trees.

Sharing the water pumped from the project well is a cumulative impact. The estimated annual water demand to supply the Rutherford Volunteer Fire facility needs to be estimated and included when determining if the project will adversely impact groundwater levels or neighboring wells.

Conclusion

The pre-project storm runoff peak discharges predicted by the WIN TR-55 model do not agree with USGS flood peak data collect just to the east of the Rodgers Upper Range project area. The predicted pre-project storm peaks also do not agree with regional USGS flood data. The WIN TR-55 model needs to be calibrated to the actual data collected by the USGS at the Lake Hennessey Tributary stream gauge. All conclusions about storm runoff and sediment loads in the project streams that use the uncalibrated WIN TR-55 model should be discarded.

The estimates of the mean annual rainfall are conflicting. The confusion regarding the true value makes it difficult to evaluate the merits of the Hydrologic Evaluation (HIS, 2005).

The groundwater recharge rates presented in the DEIR do not represent conditions on the Rodgers Upper Range project site. The groundwater recharge rates reflect the off-site recharge to the valley floor west of Silverado Trail.

I estimate that the groundwater recharge from the Rodgers Southeast Gulch sub-basin to the project well is on the order of 23.7 acre-feet per year. The DEIR does not present any solid geologic evidence that demonstrates that the project well would receive recharge from any other source other than the Rodgers Southeast Gulch sub-basin.

The well test was not performed or analyzed in a way that supports the conclusion that groundwater levels and the neighboring wells would not be adversely impacted at the end of the irrigation season from pumping the Rodgers well. A new 72-hour constant discharge test should be conducted at 205 gpm and the neighboring wells should be monitored for at least 96 hours. The drawdown data from the Rodgers well and all of the pertinent neighboring wells should be collected electronically with manual spot checking. The data should be analyzed by standard methods presented in Driscoll (1986).

Sharing water from the Rodgers well with the Rutherford Volunteer Fire facility is an unidentified cumulative impact of the project and should be analyzed. The water demand of the Rutherford Volunteer Fire facility should be included in the pumping demand and the impact of the combined pumping volume should be ascertained.

Sincerely,

Dennis Jackson

Dennis Jackson
Hydrologist

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