APPENDIX K

Recommendations for Monitoring the Effectiveness of the North Coast Instream Flow Policy for Protecting Anadromous Salmonids

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APPENDIX K

RECOMMENDATIONS FOR MONITORING THE EFFECTIVENESS OF THE NORTH COAST INSTREAM FLOW POLICY FOR PROTECTING ANADROMOUS SALMONIDS

This appendix describes a framework monitoring program that is recommended for evaluating the effectiveness of the North Coast Instream Flow Policy for protecting anadromous salmonids and their habitats. The program specifically targets the Policy elements aimed at maintaining minimum bypass flows, protecting natural flow variability, avoiding cumulative impacts, providing suitable fish passage at diversions and on-stream dams, all with respect to protecting anadromous salmonids and their habitats. The program is focused on testing the overall hypothesis (Ho) that:

Ho – the combination of elements within the Policy as applied to a given stream or watershed, will protect existing, and/or allow for the recovery/restoration of historically present anadromous salmonids, whereby four secondary hypotheses testing specific Policy elements also include:

- Ho_1 – the minimum bypass flow standard provides flows that will allow for successful upstream passage of anadromous salmonids,
- Ho_2 – the minimum bypass flow standard provides flows that will allow for successful reproduction of anadromous salmonids,
- Ho_3 – the cumulative diversion rate or volume restriction will limit new or increased diversions from a stream unless remaining instream flows would be adequate to a) maintain the timing, form, and functional qualities of the natural flow variability, b) provide for channel maintenance and habitat formation, and c) protect anadromous salmonid habitats, and
- Ho_4 – the measures focused on restricting on-stream dams will ensure that the approval of new or existing unauthorized projects will not adversely affect existing anadromous salmonids or impede the restoration/recovery of historically present anadromous salmonids.

Although results of the technical analyses reported in the main report and preceding appendices indicated that Policy measures should be "protective" of anadromous salmonids, the assessment relied primarily upon existing data and information supplemented with a modicum of empirical field data collected from 13 streams within the Policy area. These data and information were the best available at the time and allowed for a quantitative evaluation of various Policy elements relative to specific anadromous fish passage, spawning, and rearing habitat criteria. Time constraints imposed by AB 2121 precluded conducting detailed long-term (multiple years) field experiments to directly evaluate potential biological responses to Policy elements. A few short-term (i.e., 6 to 12 months) experiments, such as tests of various flows vs. fish passage conditions and observations of fish passage success and tests of flows vs. spawning habitat availability over a range of channel sizes, might have rendered some useful information. However, it was not possible to implement such experiments under the legislative time constraints imposed for development of the Policy. Thus, questions remain as to whether implementation of the Policy would effectively protect anadromous salmonids over longer time scales, say, in the range of 10 to 20 year time horizons that would correspond to 3 to 6 generations of anadromous salmonids. This time frame should also be sufficiently long to allow detection of changes in channel morphology and composition of riparian vegetation. Such an assessment requires development and implementation of a longer-term monitoring program, as described below.

Due to the wide range of geographical and temporal scales exhibited in the Policy area streams, the recommended monitoring program is relatively general in nature, and should be viewed as the starting point from which more detailed, site-specific monitoring plans can be derived. Site-specific plans can be tailored to match a stream's unique biological, hydrological and physical characteristics, and to address stream and/or basin specific resource management objectives.

K.1 IMPORTANCE AND TYPES OF MONITORING

Given the complexity of aquatic ecosystems, it is difficult to predict with certainty how they will respond to anthropogenic influences. This uncertainty in response is compounded by a number of unknown influencing forces and interactions, as well as the unpredictability associated with factors influenced by climate and weather. Yet resource managers must still proceed even though they cannot fully predict the effects of their decisions on the ecological resources. Truly understanding these effects can only be accomplished via ecological monitoring, which has become important in both regulatory and scientific forums. With the recent ESA listings of a number of anadromous salmonids in California, Oregon and Washington, there have been many technical papers, reports, and books that have served to describe ecological monitoring concepts and types of monitoring generally, statistical considerations when designing monitoring programs, and more specifically the types and rationale for selected physical and biological metrics (e.g., Kershner 1997, Conquest and Ralph 1998; Roni 2005).

An increased emphasis on monitoring, while important from the standpoint of highlighting its role in understanding how management actions may influence aquatic ecosystems, has also created confusion regarding overall focus of monitoring. For example, the purpose of monitoring under an ESA context is to determine when listed ESUs or distinct population segments (DPS) have recovered sufficiently to no longer warrant protection (and could be de-listed), as well as to provide data to assess the status of other species (ISP 2000). Monitoring under this paradigm is generally focused at the scale of populations and, in the case of the NMFS Technical

Recovery Team process, is specifically focused on four characteristics of viable salmonid populations – 1) abundance and productivity, 2) status and trends, 3) spatial distribution, and 4) diversity (McElhaney et al. 2000; NMFS 2000). Contrast this with monitoring focused on evaluating watershed restoration actions in which responses are measured relative to different physical and hydrologic parameters (e.g., channel width and depth, grain size distribution, large woody debris, etc.), or with water quality monitoring programs that may focus on contaminants and other constituents (e.g., dissolved gases, temperature, etc.). The first challenge then, in developing a monitoring program applicable to evaluating actions of the Policy is to determine the most appropriate monitoring focus. In the case of evaluating protectiveness of the Policy for adaptive management purposes, monitoring of habitat conditions would provide results that could be related most directly to Policy elements. In contrast, monitoring of salmonid population attributes would need to be more extensive to include consideration of factors outside of the control of the Policy.

K.1.1 Monitoring Types

In general, monitoring programs can be assigned into one of three types, depending on the objectives and questions to be addressed. These include: 1) compliance/implementation monitoring; (2) effectiveness monitoring; and (3) validation monitoring. Some authors have refined these categories to include other types such as trend monitoring, baseline monitoring, status monitoring, and others (MacDonald et al. 1991; Roni 2005). However, the first three types are the most relevant with respect to assessing the protectiveness of the Policy.

Compliance monitoring is the simplest of the three, and is used to determine if an intended action was implemented as planned. Compliance monitoring can also be utilized to determine if a measured attribute (such as flow) is consistent with a prescribed requirement, and the degree to which regulated actions are in compliance with regulatory permits, laws, etc. An example of compliance monitoring would be the installation of a gage below a diversion point to ensure bypass flow requirements are met. Certain aspects of the Policy would be subject to compliance monitoring, the example just noted being one.

Effectiveness monitoring is intended to determine if implemented management actions actually achieve their goals and objectives. Effectiveness monitoring provides status assessments of the target resources and changes in key conditions/parameters over long temporal scales to assess whether management objectives have been achieved.

Validation monitoring, which is sometimes also called research monitoring, is used to test various hypotheses and conceptual models that have been used to predict relationships between/among variables. Validation monitoring evaluates whether the hypothetical relationship between actions and their effects (i.e., cause and effect) occurs as expected. Validation monitoring is often used to evaluate the assumptions used in choosing an action to implement. For example, validation monitoring would be appropriate for testing the hypothesis that gravel supplementation will increase salmonid production in a stream, or the hypothesis that increased stream flows during the spawning period will increase salmonid production. Validation monitoring could be incorporated into various elements of the Policy, but this would entail carefully identifying specific hypothesis to be tested and would be targeted at specific streams or rivers, rather than the entire Policy area.

Although the analysis completed and reported on in the report indicates that the Policy should be "protective" of anadromous salmonid resources, some uncertainty still remains as to whether this protectiveness would actually be afforded to these resources when the Policy is put into action. Clearly, effectiveness monitoring is the most appropriate of the three types for addressing this uncertainty, subject of course to compliance monitoring that ensures the Policy elements are being followed in the first place.

K.2 ADAPTIVE MANAGEMENT IN MONITORING

Monitoring is often used in an adaptive management framework as a means to provide a feedback loop that links back to management actions. Adaptive management is an approach to resource management policy that assumes policies can be experiments from which scientists, policy makers and the public can learn (Lee 1993). Walters (1986), and Hilborn and Walters (1992) suggested that in the face of uncertainty regarding the response of a resource to alternative policies, resource managers can implement a probative policy that has a high likelihood of reducing that uncertainty. Such a policy does not have to be implemented everywhere. In fact, it might even be beneficial to enact different policies in different places to observe how they perform.

The overall flow related hypothesis of the Policy is that the restrictions imposed on timing and magnitude of diversions and the minimum bypass flow requirements are fully protective of anadromous salmonids. Once the Policy is implemented, the results of the monitoring program should be used to test whether the hypothesis should be accepted or rejected, and if the latter, what if any modifications are needed. Along these lines, Hilborn and Walters (1992) and Hilborn (1992) point out there are two other approaches to learning. One of them is passive learning, the second is reactive (active) or evolutionary learning. With passive learning, a "best guess" policy is chosen using the available data, assumed to be true, implemented and then monitored to determine any weakness or errors. If problems develop, some future management action is taken to hopefully correct the policy prior to any catastrophic consequences. Hilborn and Walters (1992) point out that passive management can be optimal when uncertainties are small or alternative learning approaches (assuming there is a cognizant choice in approach) are unlikely to add any additional information relative to a passive approach.

The second form of learning is reactive or evolutionary learning, which Hilborn (1992) associates with “blind faith” management. In this paradigm, management simply tries a variety of policies, with little or no targeted monitoring, until it becomes clear which policy works best. Hilborn and Walters (1992) and Hilborn (1992) also refer to this latter approach to learning as trial-and-error. Hilborn (1992) points out that a blind faith approach can be “a very reasonable policy under certain circumstances, particularly when monitoring and evaluation costs are high or the time required for evaluation is very long.” Hilborn and Walters (1992) identified six steps in adaptive fisheries management that utilizes active learning. Slightly modified to be more general, these are:

1. Identification of alternative resource response hypotheses;
2. Assessment of whether further steps are necessary by estimating the expected value of perfect information (i.e., is there a reasonable return on the effort to obtain better information?);
3. Development of models for future learning about hypotheses;
4. Identification of adaptive policy options;
5. Development of performance criteria for comparing options; and
6. Formal comparison of options using tools of statistical decision analysis.

In an active learning paradigm, each of these steps should be followed prior to implementing an experimental policy. Given that the State Water Board plans to implement the Policy soon, and that essentially none of these steps have been followed, it is apparent that a strict interpretation of adaptive management with active learning cannot be completed in the current context.

Rather, the form of the Policy is expected to be better suited to the “passive learning” model in which the specific elements were derived using the best available information, the Policy should be implemented, responses monitored, and adjustments in the Policy made as indicated by monitoring results. Indeed, the general premise of monitoring and adaptive management is that a properly designed and implemented monitoring program would provide future information regarding how targeted ecological resources are responding to management actions, and importantly, that such responses can guide decisions regarding future management actions.

K.3 EFFECTIVENESS MONITORING PROGRAM

The primary monitoring program for evaluating the protectiveness of the Policy should utilize an effectiveness monitoring approach subsumed within an adaptive management framework, hereinafter referred to as the Monitoring Program. This approach should be applied to the Policy in a fashion that would monitor the ecological responses of various Policy elements, and use the monitoring response information to evaluate the protectiveness of the elements and to make necessary adjustments.

There are a number of action items and components, some institutional and some technical, that should be addressed and/or incorporated as part of the Monitoring Program (Figure K-1). These include:

- Defining a set of clearly articulated goals and objectives that capture the major questions needing to be addressed;
- Establishing a centralized Monitoring Oversight Committee (MOC) to coordinate and oversee all monitoring activities related to implementation of the Policy;
- Developing appropriate, statistically derived sampling designs;
- Selecting and monitoring appropriate indicators and metrics that are sensitive to effects of flow regulation;
- Standardizing sampling protocols to allow comparisons among locations, times and site specific programs;
- Establishing appropriate Quality Assurance and Quality Control measures for data validation;
- Providing for data dissemination and access by other users and interested parties;
- Providing a funding base sufficient to sustain a long-term monitoring program; and
- Developing and implementing a Decision Analysis/Support process that can be used for evaluating monitoring results and determining whether and what changes are needed in the Policy.

These considerations and components are described further below.

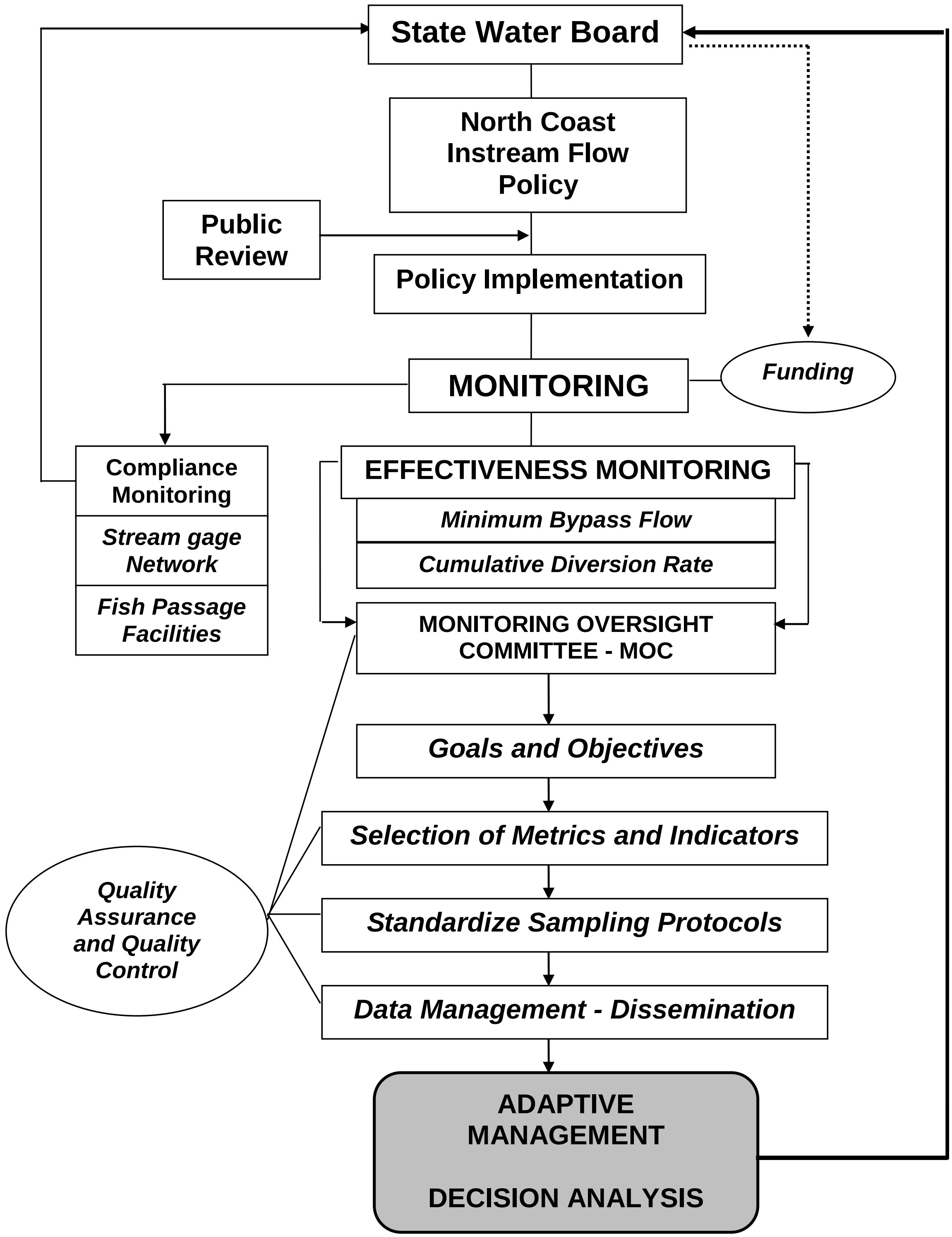

Figure K-1. General components and actions associated with monitoring the protectiveness of North Coast Instream Flow Policy elements.

K.3.1 Monitoring Program Goals and Objectives

The overall goal of the Policy is to establish principles and guidelines that are designed to allow the diversion of a certain amount of water from Policy area streams during certain periods of time, to the extent that such diversion would still be protective of anadromous salmonids (Chinook salmon, coho salmon, and steelhead trout) and their habitats. This represents the fundamental goal toward which the State Water Board will have to monitor the effectiveness of the Policy.

Policy objectives are to provide:

- Adequate stream flows for anadromous fish to utilize and maintain spawning habitat at existing levels, sustain egg incubation, and promote fry emergence;
- Adequate stream flows to allow successful upstream passage of anadromous salmonids throughout the length of stream of their current and historical distribution;
- Adequate stream flows to maintain existing levels of rearing habitat for fry and juvenile anadromous salmonids: Such flows will meet both the spatial and water quality requirements, as well as food production and supply that may even originate upstream above the upper extent of anadromous salmonids but is nonetheless important as food in the form of invertebrate drift and supplying the cascade of energy downstream (Vannote et al. 1980);
- Adequate stream flows for maintaining habitat form and function so that habitat quantity and quality are not degraded over the long term (primarily channel and riparian maintenance flows); and

These objectives collectively represent the major drivers governing the what, where, how, and how often questions associated with the development of sampling designs, selection of parameters and metrics to be monitored, standardization of sampling protocols, and the decision analysis for evaluating the adequacy (i.e., protectiveness) of respective Policy objectives.

K.3.2 Establishment of Monitoring Oversight Committee

It is recommended the State Water Board form a nine member Monitoring Oversight Committee (MOC) as a first step in the process of developing a coordinated monitoring plan, designed with input from a variety of state and federal agencies, and academic institutions, as recommended by Moyle et al. (2000). It is recommended that a State Water Board senior staff member with a high level of experience in water resources management and a good understanding of hydrology, fluvial geomorphology, and salmonid biology chair the MOC. The chairperson would act as the liaison between the MOC and the State Water Board and direct various MOC staff in preparation of the monitoring plan.

Membership – Recommended membership in the MOC should consist of, in addition to the chairperson, one more technical specialist from the State Water Board, and one representative from each of the following agencies/academic institutions: DFG, NMFS, USFWS, USGS, California Department of Water Resources (DWR), and two independent scientists from academic institutions. The MOC may also solicit input from other entities (e.g., county water districts and agencies) and stakeholders who may be involved in ongoing monitoring programs on certain streams and rivers, and therefore possess stream-specific information. Also, the MOC may engage the services of certain technical specialists (e.g., statisticians; aquatic ecologists, geomorphologists, fish biologists, and others) to assist in preparing parts of the Monitoring Program. The MOC would be tasked with preparation of a draft Monitoring Program designed to address the specific objectives noted above.

Activities – One of the first tasks completed by the MOC should be an evaluation of options for completing the Monitoring Program. This should include a review of past and ongoing biological and ecological monitoring programs within the Policy area, such as those being conducted by local, regional, state and federal agencies and other stakeholder groups that may be targeting specific watersheds or basins. Emphasis should be placed on determining the spatial extent and temporal duration of these monitoring programs, and the applicability of measured parameters for detecting flow induced effects of Policy implementation. The extent to which modifications to the programs could be made to better address flow effects would also be assessed. The option of adapting one or more existing monitoring programs to meet the objectives noted in the above section may prove useful in capitalizing on existing sources of funding, reducing potential redundancy in monitoring, and facilitate data and information exchange. However, if it is determined that existing programs will not address the stated goals and objectives, then the MOC should proceed with development of an entirely new program specifically designed to test the primary and secondary hypothesis related to Policy implementation.

Other activities (presented somewhat chronologically) to be completed by the MOC during development of a detailed plan should include, but are not limited to:

- Developing the process to be used and schedule to be followed for development of a detailed plan;
- Development and prioritization of hypotheses to be tested;
- Selection of parameters to be measured and metrics to be used to test hypotheses;
- Refining and understanding issues of temporal and spatial scale (see Moyle et al. 2000);
- Development of sampling designs, draft field protocols, and sampling schedules;

- Developing and implementing data and information management procedures;
- Preparing and implementing quality assurance and quality control protocols;
- Developing decision analysis procedures that link monitoring results back to Policy objectives and hypothesis;
- Identifying funding needs and potential funding sources; and
- Coordination with other federal, state, and local monitoring efforts.

In addition to preparation and administration of a detailed Monitoring Program, the MOC should also produce a number of issue-oriented white papers designed to describe specific components of the Monitoring Program, or address sampling and data analysis issues.

Science Review Panel – It is recommended that an independent science review panel be appointed by the State Water Board to review key work products (including the Monitoring Program) developed by the MOC before being released to the public and prior to implementation.

K.3.3 Selection of Appropriate Sampling Designs

As noted in Appendix B, the Policy area is large and contains over 3,400 classified stream segments of varying drainage area. Regardless of whether the Monitoring Program evolves from existing programs or consists of an entirely new program, monitoring of all systems is impractical from a funding perspective, and moreover, is not necessary provided the monitoring is founded on a strong statistically derived sampling design. The Monitoring Program should include sampling at a variety of spatial and temporal scales.

There is an inherent problem when attempting to detect responses of anadromous salmonids to Policy actions or habitat alterations within a given stream, in that the factors actually imparting an effect may be outside of the area for which Policy actions occur. For example, if population regulating factors relate more to ocean conditions and/or harvest limits than to effects imposed during the freshwater residency period of anadromous salmonids, then actions invoked and resulting responses that may occur may be masked due to the overriding effects of such conditions. In these cases, it does not mean that a particular action is not having an effect; it simply means it cannot be detected.

There are at least two approaches that could be used to attempt to account for or simply discount factors extrinsic to the Policy area. The first (account for) is to establish and monitor a range of watersheds that would include both test and reference streams, with test streams being subjected to Policy actions, while reference streams would not. In practice, reference and test streams need to share similar physical, hydrologic and chemical characteristics, except for the specific anthropogenic factor being considered. In this case, the test and reference streams should be as similar as possible except that the test stream would be subjected to the Policy action, while the reference stream would not. This type of approach is being applied in the state of Washington to assess effects of habitat restoration actions on anadromous salmonids. The approach, termed Intensively Monitored Watersheds (IMW) is focused in part on monitoring a suite of biological and physical parameters in test and reference stream segments, with restoration actions limited to the test streams (IMW Scientific Oversight Committee 2006). Although more focused on defining cause-effect relationships (i.e., validation monitoring), this type of approach could be useful for detecting effects of Policy implementation.

The second approach (discount) is simply to monitor selected metrics that are not influenced by factors external to the stream or watershed and that are not directly connected to population levels of anadromous salmonids. Such factors may include both biotic (e.g., benthic macroinvertebrates; resident fish) and abiotic factors (e.g., substrate composition, channel width, sediment concentration).

Both approaches (and others) would require monitoring of a sufficiently long duration to allow the detection of changes from Policy implementation. In the context of this Monitoring Program, short term is defined as periods of from 5 to 10 years, moderate term as 10 to 20 years, and long term as greater than 20 years.

To address these and other sampling design issues it will be critical for statisticians to be involved early on in the development of the Monitoring Program. In addition to the above issues, statisticians would be useful to address issues of sampling and sub-sampling, accuracy and precision of data, replication, and controls. Importantly, decisions adaptively made from the monitoring must be based on unbiased information that is representative of biological or physical responses due to Policy implementation.

K.3.4 Selecting and Monitoring Appropriate Indicators and Metrics

Choice of indicators and metrics to be measured will depend on specific Policy objectives and hypothesis to be tested. These would include metrics to assess Policy elements associated with the period of allowable diversion, minimum bypass flow, cumulative diversion rate, and to some extent fish passage and protection. In general, monitoring programs include a suite of metrics that collectively serve to evaluate the ecological response(s) of management actions. In terms of the Monitoring Program for the Policy, two types of indicators will be important; 1) effectiveness monitoring indicators that serve to detect potential changes in physical, geomorphological, and biological characteristics of streams attributable to Policy actions; and 2) compliance indicators, which address compliance activities associated with implementation of the Policy (can be done by the Division under the enforcement program established in the Policy).

K.3.4.1 Effectiveness Monitoring

There are four Policy elements for which effectiveness monitoring could be applied. These include the elements related to the diversion season, minimum bypass flows, the maximum diversion rate, and passage requirements. For each of these, there are a number of metrics/indicators that could be monitored, some of which are listed in Table K-1 and discussed below. In doing so, it must be emphasized that there is no single set of metrics that will address all of the objectives and hypotheses raised regarding effects of Policy activities. Rather, there will likely be a suite of metrics, some standardized across geographic areas, and some that are scale-specific.

Diversion Season

The selection of the diversion season as defined under the Policy (i.e., December 15 to March 31; or alternative – October 1 to March 31) presupposes that this period is the most biologically benign relative to incurrence of flow related impacts on anadromous salmonids. The intent is to allow the diversion of additional water from a stream only during periods of relatively high flows that typically occur during the wettest part of the hydrograph. Testing of the protectiveness of this element thus involves aligning the timing of the peak flow hydrographs and the selected diversion season with important life history periodicity information for anadromous salmonid species and lifestages of concern. Life history periodicity information is generally well understood for anadromous salmonids in the Policy area (see Appendices B and C), and is primarily related to adult upstream passage and spawning, and to some extent juvenile rearing. Since the underlying premise of protectiveness during this time would be implicitly tested as part of the evaluation of the minimum bypass flow element, there are likely few if any additional metrics/indicators (beyond those applied to the minimum bypass flow) needed to assess this element of the Policy.

Minimum Bypass Flow

Since it was determined that upstream passage should generally be protected by the minimum bypass flow element (see Appendices H, I, and J), effectiveness monitoring should focus on simple measures of spawning and reproductive success and persistence during base flows, as a means to test Policy protectiveness. In regards to spawning and incubation flows, habitat availability versus flow relationships can be examined at a variety of locations. Such an evaluation was conducted at a limited number of channel cross-sections and sites as part of this Policy assessment. This approach should be expanded to include a variety of streams of variable size and topographic settings across the range present in the Policy area.

Table K-1. Policy Elements and Potential Effectiveness Monitoring Metrics Useful for Assessing Protectiveness of the North Coast Instream Flow Policy on Anadromous Salmonids.

Policy Element	Potential Monitoring Metrics
Diversion Season	• Monitoring of this element captured in metrics specified under "minimum bypass flow."
Minimum Bypass Flows	• Derive spawning habitat vs. flow relationships from sites selected within a stratified subset of streams representative of Policy area streams; comparisons to Policy-imposed bypass flows. • Complete passage corridor analysis within the same subset of streams; comparisons with Policy-imposed bypass flows. • Spawning surveys within same subset of streams; monitoring for trends post-implementation of Policy; if possible – comparison with trends in similar streams not subjected to Policy. • Redd marking and monitoring to evaluate "watering" duration from creation to projected fry emergence. • Biological monitoring (e.g., fry/smolt production – via outmigrant traps, screw traps, snorkeling, etc.) of anadromous salmonid populations within subset of streams; if possible – comparison with trends in similar streams not subjected to Policy.
Maximum Diversion Rate	• Substrate quality monitoring – within subset of streams representative of Policy area streams; - Core sampling (bulk, grab, freeze-core) - Pebble counts - Ocular – embeddedness - Intragravel sediment monitoring • Cross-sectional profiles – subset of streams • Riparian corridor mapping/species composition – subset of streams • Benthic macroinvertebrate (BMI) monitoring – subset of streams
Passage Considerations	• Spawning surveys above on-stream reservoirs or diversion structures • Compliance monitoring of individual structures to ensure proper operation (or, enforcement)

For the assessment of spawning, the simplified approach described in Chapter 4 considered the number of cell-days from a habitat time-series prepared over the spawning season that met HSI depth, velocity, and substrate criteria across measured transects as a metric. Inclusion in the study of ungaged basins would require data collection over two or more (preferably three or more) flow levels to develop stage-discharge relationships and other hydraulic parameters for modeling the site. In addition to broadening the number of sites examined, the number of transects within a site should be expanded to represent more of the variability that could occur within a spawning reach. A statistically robust sampling scheme should allow for development of a more thoroughly derived regional, or stratified regional, relationship between basin size and flow needs for spawning. These empirically derived relationships can then be reviewed to determine whether bypass flow requirements as imposed by default via the Policy would be similar to those based on site-specific data.

Selection of specific sites could be coupled with spawning/redd surveys to verify habitat suitability of the study areas. Verification of modeled results and regional relationship(s), if developed, could occur by comparing flow, depths, velocities, and substrate at unmeasured sites where spawning is occurring, to the models. Water depths at marked redds could likewise be tracked to determine if they remain covered with water over the period of incubation. Some biological monitoring focused on assessing anadromous salmonid production over time could also be implemented at a subset of sites. This could include fry/smolt outmigrant trapping, snorkel surveys, etc., that are designed to evaluate yearly smolt production. Ideally, to account for ocean effects, this monitoring would be conducted using a paired-reference stream approach, where one set of streams would be subjected to Policy elements, and a second set would not. The design and implementation of spawning surveys should capitalize on data and information from historical as well as ongoing surveys, with the goal of avoiding duplication of efforts.

Similar to spawning and incubation, an expansion of the number of basins and sites examined for passage flow needs could supplement and refine the current analysis for protectiveness. Spawning surveys can be used to identify the upstream extent of spawning under different flow conditions, but could be confounded by escapement size (i.e., the number of adult anadromous salmonids returning to a given stream will influence the ability to detect redds). It can be assumed that all riffles downstream of the upper extent of observed adult anadromous salmonid migration met minimum passage criteria at some time during the period of upstream migration. However, it cannot be assumed that all flows up to that point were passable. Cursory observations during spawning surveys coupled with spot measurements of velocity and depth could be used to identify a group of potential critical riffles possessing marginal passage conditions that could be selected for more focused investigation. A combination of high flows and escapements could expand spawning to areas that would not otherwise be used during lower flow conditions. However, the timing, intensity and locale of storm/flow events can create widely disparate passage conditions in streams even within a single basin. To the extent possible, the identification of critical riffle areas should occur in conjunction with spawning surveys. However, these should be supplemented as needed with surveys specifically focused on identifying critical passage riffles. The experience of local field biologists and use of spawning surveys, if sufficiently detailed spatially, can be a great aid to identifying critical riffles and limiting the amount of area to be surveyed for spawning.

Maximum Cumulative Diversion Rate

Analysis of the potential effects of the maximum cumulative diversion rate restriction suggests that with the reduction in channel maintenance flows, there may be an increase in the characteristic grain size in the surface layer of the stream bed in the near term (~10 years), and an eventual shrinking of the channel over the longer term (~10-30 years), which may result in changes in riparian vegetation species composition, density and diversity. The degree and extent of such changes, if they occur, will likely vary depending on prevailing stream/channel characteristics (e.g., slope, substrate composition, local geology, riparian vegetation, etc.), and the timing and number of individual diversions within a basin. Metrics to be monitored should therefore largely focus on those sensitive to detecting changes in substrate composition (in particular, fine sediment accumulation), channel size and form, and riparian community composition.

Changes in substrate size characteristics can be monitored using a variety of techniques (Table K-1; Reiser 1998a). Detecting change implies there is some pre-defined baseline condition that will be used to compare with future conditions. Since the focus of the Monitoring Program is on evaluating the effects of the Policy elements on various physical and hydraulic parameters, pre-Policy implementation sampling will be needed to establish baseline conditions from which to compare post-Policy implementation conditions.

Changes in the presence of fines in spawning gravels can be examined by sieving bulk substrate samples collected using a McNeil type sampler (McNeil and Ahnell 1964) or other devices (Grost et al. 1991), subject to sample weight constraints to increase precision (Church et al. 1987). Although more costly, use of freeze core substrate samplers (Everest et al. 1980; Walkotten 1976) may prove useful for some systems where it is important to discriminate and quantify sediment deposition within different layers of the substrate. Installation and monitoring of intergravel sediment traps (Wesche et al.1989; Lachance and Dube 2004; Hedrick et al. 2005) may also prove useful in some stream systems. Where the desired resolution does not include fine materials or extremely large particles, pebble counts (Wolman 1954) could be used to monitor potential changes in substrate size distributions over time. Another ocular assessment technique (although largely qualitative) that could be used to assess sediment deposition is the measurement of embeddedness (Platts et al. 1983; Plafkin et al. 1989) defined as the degree (expressed as a percentage) to which larger particles (boulders, cobble, gravel) are surrounded or covered by fine sediment. There are a variety of metrics that have been developed/derived that relate the results of substrate characterizations to effects on salmonid egg survival and fry emergence. These include computations of the percentages of fine sediments (of different size classes), the fredle index, sorting coefficient, geometric mean diameter and others (Platts et al. 1983).

In terms of channel shape and size, bed elevation measurements taken at specified intervals across permanently marked transects can serve as reference points from which to gauge channel aggradation and degradation, as well as changes in channel width. These same transects, when extended beyond the channel, can provide interval markers from which to assess changes in the composition, diversity and density of the riparian community.

Some potential ecological effects of withdrawals may also be worth monitoring. For example sampling of the benthic macroinvertebrate (BMI) community may provide an indication of significant flow alteration or changes in substrate characteristics including increased sediment deposition. BMI are a mainstay to anadromous trout and salmon diets during the freshwater residence period. Consequently, changes to BMI density and/or diversity could have secondary effects on Chinook salmon, coho salmon, or steelhead trout. Monitoring BMI in smaller, non-fish or non-anadromous salmonid bearing streams could likewise be important, since the invertebrate communities in these systems may be the primary providers of food to downstream salmonids via invertebrate drift. There are a variety of BMI sampling protocols that could be followed, including the DFG's (2003b) Aquatic Bioassessment Procedure, the Rapid Bioassessment Protocol (Plafkin et al. 1989), and others. Currently, there is no standardized multi-metric Index of Biotic Integrity (IBI) for the Policy area. Barbour et al. (1999) and Karr (1999) discuss the development of IBI metrics and provide an existing pool of potential BMI metrics that could be used.

The potential effects of surface flow withdrawals under the Policy on riparian function are anticipated to be insignificant, but some monitoring to verify this conclusion may be warranted. Riparian functions include stream bank stabilization, sediment filtration, shade, leaf and litter inputs, and large woody debris. If water withdrawals under the policy change the density or diversity of riparian vegetation, one or more of these functions could be impaired. For example, if bushy vegetation is replaced with herbaceous vegetation and a decrease in root strength along stream banks, increases in bank sloughing and fine sediment input that could be transported downstream might result. Monitoring the riparian community (density, diversity) along extended cross-channel transects over time, coupled with photographs taken from permanently marked photo points provides one way of detecting changes resulting from Policy implementation. Similar to the substrate metrics, it will be important to first establish a baseline that represents pre-Policy conditions and to which post-Policy effects can be compared.

Fish Passage

Effectiveness monitoring for fish passage may not be warranted unless new innovative methods are utilized or a unique application is needed with a complex design. This element requires primarily compliance monitoring. Criteria for passage design at low-head diversion dams are fairly well established, and required permits for their construction will result in design review by regulating agencies. If compliance monitoring demonstrates that a passage facility was built as designed, there should be a high likelihood that the facility is also effective at passing fish.

K.3.4.2 Uncertainty and Compliance Monitoring

Moyle et al. (2000) described a number of uncertainties potentially confounding the success of implementation of the DFG-NMFS (2000) Draft Guidelines, at least two of which related to surface hydrology and that could be addressed via compliance monitoring. Perhaps the most important of the two relates to surface flow in ungaged headwater streams and is linked to the issue of spatial scales. As Moyle et al. (2000) noted, stream gages are typically located in the lower reaches of streams even though orographic effects can cause substantial variability in precipitation, particularly in higher elevation headwater streams. Consequently, there is some risk that hydrologic models calibrated to distant downstream flow gages, or generalized relationships (e.g., to drainage area) may result in erroneous conclusions regarding the available unallocated surface flow in headwater streams. Because the amount of surface flow is a key metric, and most new permit applications for diversions are likely to occur on headwater streams, reducing the uncertainty regarding the magnitude of surface flow in these streams is critical for not only implementing the Policy properly, but also for determining its effectiveness.

It is recommended that a compliance monitoring program consisting of the installation and monitoring of a stream gage network at varied watershed elevations be considered as a means to reduce this uncertainty and refine the discharge relationships.

The second important hydrologic uncertainty is the amount of surface flow being withdrawn by unauthorized diversions and the actual amount of withdrawals by authorized diversions. This uncertainty can again be addressed to some extent, through installation and monitoring of a more robust stream gage network designed to monitor stream flows at key locations within a watershed. There will be limits to how much this uncertainty can be reduced because of the number and difficulty of monitoring withdrawals at authorized diversions, let alone unauthorized diversions.

It is recommended that the MOC consider options to address this that may include inventories based upon aerial photographic analysis and field surveys, as well as implementation of a stream gage network.

K.3.5 Standardization of Sampling Protocols

Replication and repeatability are fundamental precepts in the design and conduct of statistically rigorous monitoring programs. Unless standards are implemented it will be more difficult to compare data sets collected at different times and places in the Policy area and draw appropriate conclusions. To the extent possible, the monitoring of all metrics should be completed using standardized sampling protocols and data analysis techniques. If new protocols are developed to measure particular attributes it may be useful to test the protocols prior to implementing them on a wide-scale study effort. This will ensure statistical replication, reduce measurement error, and increase the reliability of the data so collected for use in decision-making. The MOC should ensure that detailed sampling protocols are drafted, reviewed and approved for each of the metrics selected for inclusion in the Monitoring Program. All personnel proposed to lead and direct the collection of monitoring data within a specific stream should be familiar with sampling protocols, trained and demonstrate proficiency in the collection of respective data, and receive written approval by the MOC, before actively engaging in monitoring activities.

Specific protocols to be applied will depend on metrics to be assessed. It is anticipated that in general, protocols for monitoring the metrics identified in Section K.3.4 have already been developed and described in one or more reference documents. For example, numerous field protocols are described on the website of the Environmental Protection Agency (EPA) Environmental Monitoring and Assessment Program (EMAP), and are also available in a variety of reference documents including Flosi and Reynolds (1994), Stolnack et al. (2005), Johnson et al. (2001), Platts et al. (1983), Calfish[1], USGS Technical Memoranda[1], and DFG's bioassessment procedure, etc.). These and other protocol descriptions should be referred to when developing the details of a monitoring plan. Compatibility with other monitoring programs in the Policy area should be a consideration when selecting protocols.

K.3.6 Establishment of Quality Assurance/Quality Control Program

Since the data collected as part of the effectiveness monitoring program would be used by the State Water Board in a decision-analysis framework, the validity of those data is critical. The MOC should therefore establish a rigorous Quality Assurance/Quality Control (QA/QC) Program designed to ensure that all data to be relied on have been collected and compiled in accordance with QA/QC protocols, and hence have been validated for use in the decision analysis process. The QA/QC program should have the following general components:

- *Program Organization* – describes overall reporting relationships and responsibilities among agencies and other stakeholders relative to data collection and management, data flow, and database development and management;

- *Sampling Protocols* – presents and describes detailed sampling methodologies to be followed when collecting data required as part of the monitoring program; the sampling protocols should be those as identified and approved by the MOC;

- *Quality Assurance (QA) Objectives for Measurement Data* – lists hypotheses to be tested and objectives for data collection, and defines characteristics of the data to be collected including accuracy, precision, completeness, representativeness, and comparability;

- *Data Transfer Protocols* – describes methods for data transfer from the field, laboratory (if applicable) etc. into a designated data repository, ensures traceability of information and data from its origin to final end users;

- *Calibration and Preventative Maintenance Procedures and Frequency* – ensures that all field data are maintained in accordance with manufacturers specifications;

- *Data Reduction, Validation, and Reporting* – defines process to be followed that will render data as collected under the monitoring program as valid or invalid; and

- *Quality Assurance Audits and Corrective Actions* – outlines the process the MOC should use in conducting periodic audits of the overall program or program components, designed to document proper adherence to the monitoring program and collection of data in accordance with specified sampling protocols.

K.3.7 Data Dissemination

It is envisioned that many agencies and entities would be involved in the implementation of various components of the Monitoring Program. It is also anticipated that the data so collected would be of interest to a wide range of personnel, including agency representatives, scientists, and the general public. The MOC should explore ways to facilitate the dissemination of these data, while at the same time preserving data integrity. The State Water Board could serve as the central holder/organizer of the Monitoring Program data and database; individual entities/agencies conducting stream-specific monitoring could be responsible for managing and disseminating those data, provided electronic linkages between database sources are established; or an existing regional information management system (e.g., California Environmental Resources Evaluation System) could be used.

The general types of information and data to be managed include numeric and text data collected in the field, raw output from data analysis, digital photos, GIS map coverages, and electronic documents (e.g., study plans, reports, meeting notes, etc.). The creation and maintenance of metadata is an important part of an information management system. Metadata provides documentation about a dataset including its structure, data units, source, points of contact, and other information. Metadata is critical for understanding the limitations of a dataset, and for enabling use of the data in ancillary analyses not performed by the original study scientists. Relative to data types, the MOC should consider the scope and context of the Monitoring Program, in general, and plan for the appropriate level of coordination, infrastructure (computer hardware and software), and staff needed to enable efficient input and dissemination of data and information, while still maintaining the integrity of the data. Development of stream-specific study designs will need to consider their compatibility with data structures that may already exist in the management system, while development of an overall management system would need to consider the types of data likely to be collected or produced by the various monitoring components.

K.3.8 Funding Support

It is recommended that the State Water Board commit sufficient funding support to allow implementation and continuance of the Monitoring Program described herein, and as may be modified and expanded in the future. It is also recommended that the State Water Board seek to retain existing and create new collaborative partnerships with other agencies and stakeholders as a means to increase monitoring efficiency while at the same time reducing costs. Identifying the exact amount and sources of funding needed for this program will require a high level of detailed planning. Although monitoring can be expensive, obtaining adequate funding will be critical to the success of the Monitoring Program.

K.3.9 Adaptive Management – Decision Analysis

The Monitoring Program described above was framed within an adaptive management construct that embodies decision analysis. Thus, it is recommended that the State Water Board develop a formal decision-analysis process to address questions related to which (if any) Policy elements warrant modification; what type of modification is needed (i.e., is the element over or under-protective); and whether changes in the Monitoring Program are warranted in order to be able to detect potential response. Monitoring describes what is biologically possible under a given set of Policy conditions. From this, scientists can estimate the probability of different biological conditions evolving, such as suitable spawning habitats, population increases etc. These estimates can prove useful in helping to formulate decisions regarding the extent to which the Policy elements should be modified. However, in general, recommendations from the MOC should be limited to objective determinations of the protectiveness of different Policy elements rather than recommending specific adjustments. The degree of adjustment to be implemented is largely a policy decision that would require broader input than the MOC, and would require specific action by the State Water Board.

K.4 MONITORING PROGRAM: PRELIMINARY STUDY DESIGN

This section provides suggestions relative to study design development and the selection of study sites and metrics for evaluation, and is intended to assist the State Water Board in planning the overall scope and budget for the Monitoring Program. It is anticipated that the implementation of the Monitoring Program as described above will occur in phases, with initial efforts focused on 1) establishing the MOC and 2) identifying the overall goals and objectives (Figure K-1) that will form the basis for selecting study sites and the specific metrics to be monitored. To the extent possible, monitoring sites should be established that can be used to assess both the effectiveness of specific Policy elements, and from an enforcement standpoint, compliance with specified instream flows, diversion rates, and passage requirements. Clearly, efficiencies are gained and overall monitoring costs reduced when sites can be selected that serve more than one purpose.

The Monitoring Program study design should focus on answering the null hypotheses identified at the beginning of this appendix. In addition to measurements of flow, a variety of other metrics may be monitored for each hypothesis, with the final list dependent on specific questions to be addressed (Table K-2). Of the four hypothesis noted in Table K-2, the third has the greatest uncertainty associated with it in terms of what maximum level of change equates with protectiveness. Monitoring will thus be a critical part of the Policy for establishing protectiveness of the MCD. In addition, data collection and analysis related to this hypothesis will be useful for Division staff at a later date as they process future applications for water rights.

While there is no firm guide on the number of streams to sample and study sites to establish, the large geographic area encompassed by the Policy and the diversity of streams within suggests the need to stratify the area based on drainage area classes and hydrologic sub-regions, and then selecting a subset of sites from each for detailed monitoring. This approach is intended to ensure some representative sampling within different basin size classes and hydrologic sub-regions, and thus, would lend itself to statistical analysis.

At a minimum, sampling should include the 13 streams listed in Table 4-1 that were used to assess protectiveness. The list would need to be expanded, however, as the 13 evaluated were selected, in part, because of their easy accessibility. Sites that were considered for the protectiveness analysis but not sampled because of access, time, and/or water availability limitations included: Redwood Creek near Muir Beach (National Park Service gage), San Geronimo Creek (Marin Municipal Water District gage), Morse Creek near Bolinas (USGS gage 11460160), Pudding Creek near Fort Bragg (Soda Creek near Boonville (USGS gage 11467850), Russian River near Redwood Valley (USGS gage 11460940), and Big Sulphur Creek (two sites near USGS gages 11463160 and 11463170). With suitable planning and discussion with biologists from various institutions, additional sites can likely be identified for sampling.

For purposes of statistical replication, it is necessary to sample a number of streams with similar characteristics forming a group often called a class or stratum. Similarity may be established any number of ways, ranging from the use of formal stream classification schemes (e.g., Montgomery and Buffington 1997) to statistical stratification and multivariate analyses (e.g., cluster analysis of various physical attributes of the stream). The number of streams necessary to represent each class will reflect in part, inherent variability within a class; that is, the greater the variability within a class, the greater the number of sites required for a specified level of statistical power. In addition, replication is necessary within a given stream. At least three samples of a given metric would be required per stream to be able to describe variability. A greater number of samples is desirable but may not be practicable depending on budget.

As an example of the above, assuming that: a) the Policy area is stratified into six drainage area classes including <1 mi^2, 1-3 mi^2, 3-5 mi^2, 5-10 mi^2, 10-30 mi^2, and >30 mi^2; b) the Policy area contains a minimum of three basic hydrologic sub-regions (coastal north, coastal south, and inland); and 3) a minimum of three sites are established per stream-hydrologic class combination, a total of 6 x 3 x 3 = 54 sites would be established for monitoring (Table K-2). This number would vary depending on the final number of drainage area and hydrologic classes selected. The actual number of sites would also need to be adjusted to account for existing stream gaging stations as well as other sites that may be part of other biological monitoring programs that are already collecting data relevant to assessing the Policy effectiveness. These latter sites could include those used by CDFG or other agencies and stakeholders as part of long-term biological monitoring programs.

Given the importance of flow quantification to the Policy, most/all of the active and inactive stream gage sites should be considered for incorporation (either from an effectiveness or compliance standpoint) into the Monitoring Program. Given that there are currently 88 USGS stream gages within the Policy area, 31of which are active (Figure K-2), and assuming that the above 54 sites could be represented by a subset of the gaging stations, an additional 34 sites (represented by gage sites – i.e., 34 sites + 54 = 88) should be considered for inclusion into the Monitoring Program (Table K-2). However, the final number of sites and overall scope of the program would clearly need to be based on additional considerations including costs and funding support. It is in this matter that the MOC can be instrumental in achieving consensus on an acceptable Monitoring Program.

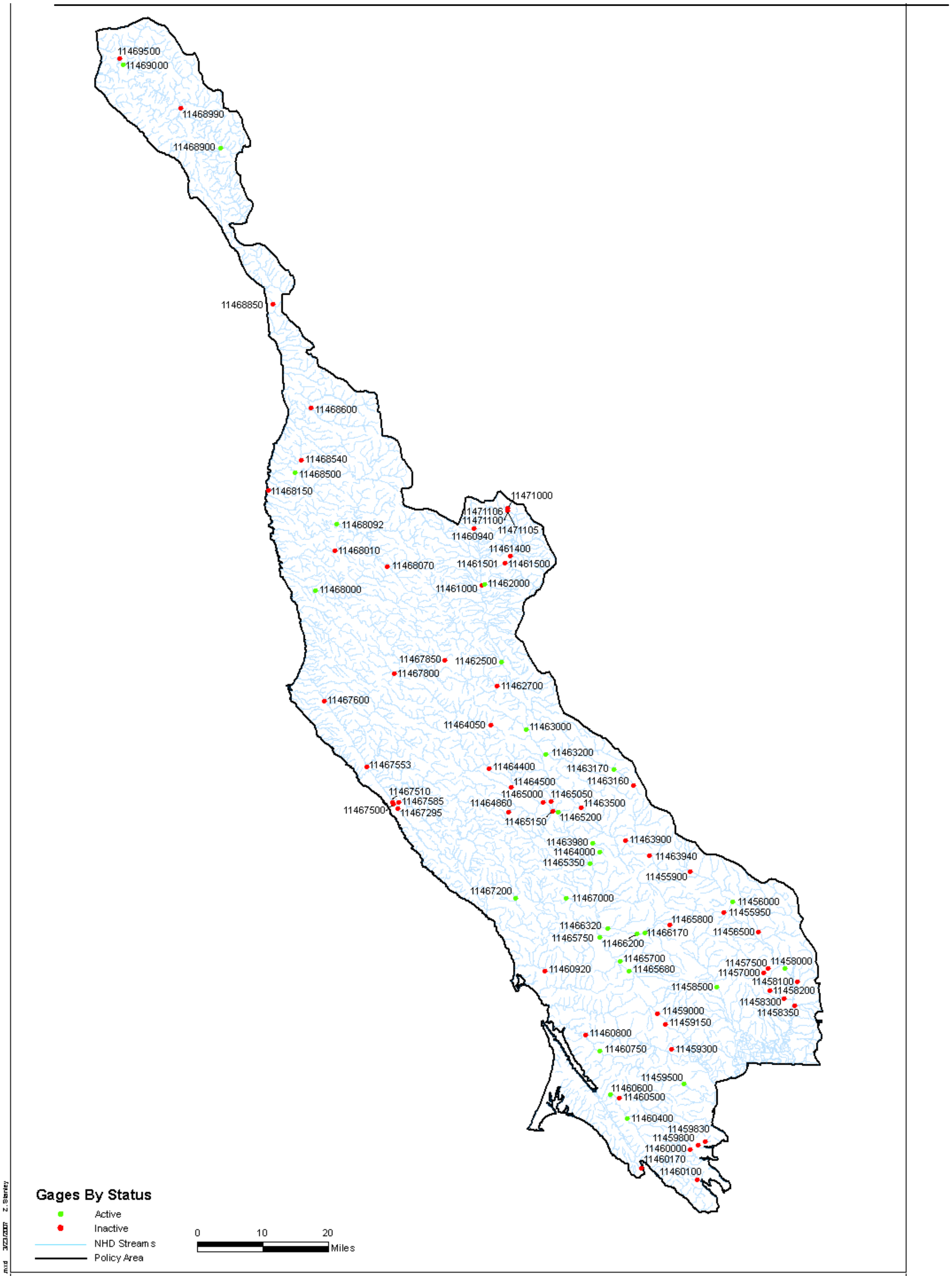

Figure K-2. Active and inactive stream gages in Policy Area.

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Table K-2. Potential Monitoring Metrics and Estimated Number of Monitoring Sites Needed to Evaluate the Effectiveness of Various Elements of the North Coast Instream Flow Policy.

Policy Element/Hypothesis	Potential Metrics for Monitoring Effectiveness	Estimated Number of Monitoring Sites
Minimum Bypass Flow (MBF): **Ho_1** – *the MBF standard provides flows that will allow for successful upstream passage of anadromous salmonids*	• Flow gaging • Spawner and redd counts, timed to occur between high flow events (in streams used currently). • Identification and physical characterization of critical passage constriction locations, including developing depth-flow rating curves. • Observation of passage attempts at critical passage locations coupled with flow and depth measurements (in streams used currently).	• Need representation of streams based on drainage areas, hydrologic sub-regions, and replication = 1) six drainage area classes: <1 mi^2, 1-3 mi^2, 3-5 mi^2, 5-10 mi^2, 10-30 mi^2, and >30 mi^2; 2) a minimum of three basic hydrologic sub-regions within the Policy area (coastal north, coastal south, and inland); 3) a minimum of three sites per stream-hydrologic class combination results in recommendation of a total of 6 x 3 x 3 = 54 sites for monitoring • Assume monitoring at/near all existing (active and inactive) stream gages = **88 sites (includes 54 sites plus additional 34)** • Final number of sites may increase or decrease depending on extent of existing monitoring programs

Table K-2. Potential Monitoring Metrics and Estimated Number of Monitoring Sites Needed to Evaluate the Effectiveness of Various Elements of the North Coast Instream Flow Policy.

Policy Element/Hypothesis	Potential Metrics for Monitoring Effectiveness	Estimated Number of Monitoring Sites
Minimum Bypass Flow (MBF): **Ho_2** – *the MBF standard provides flows that will allow for successful reproduction of anadromous salmonids*	• Flow gaging • Spawner and redd counts, timed to occur between high flow events (in streams used currently). • Monitoring of redd inundation at index sites over the incubation period (in streams used currently). • Physical characterization of redds (if present) and spawning habitat availability relative to location in the channel at index sites, involving: o Mapping of depths over spawning habitat at different flow levels, or (in some cases) o A spawning habitat-flow modeling analysis (e.g., PHABSIM).	• Need representation of streams based on drainage areas, hydrologic sub-regions, and replication = 1) six drainage area classes: <1 mi^2, 1-3 mi^2, 3-5 mi^2, 5-10 mi^2, 10-30 mi^2, and >30 mi^2; 2) a minimum of three basic hydrologic sub-regions within the Policy area (coastal north, coastal south, and inland); 3) a minimum of three sites per stream-hydrologic class combination results in recommendation of a total of 6 x 3 x 3 = 54 sites for monitoring • Assume monitoring at/near all existing (active and inactive) stream gages = **88 sites (includes 54 sites plus additional 34)** • Final number of sites may increase or decrease depending on extent of existing monitoring programs

Table K-2. Potential Monitoring Metrics and Estimated Number of Monitoring Sites Needed to Evaluate the Effectiveness of Various Elements of the North Coast Instream Flow Policy.

Policy Element/Hypothesis	Potential Metrics for Monitoring Effectiveness	Estimated Number of Monitoring Sites
Maximum Cumulative Diversion Rate (MCD) or Cumulative Flow Impairment Index (CFII): **Ho_3** –*the MCD or CFII restriction will limit new or increased diversions from a stream unless remaining instream flows would be adequate to a) maintain the timing, form, and functional qualities of the natural flow variability, b) provide for channel maintenance and habitat formation, and c) protect anadromous salmonid habitats,*	• Channel width, depth, and grain size distributions and sinuosity measurements at index sites, coupled with a regional assessment of variation in these metrics. • Riparian zone transect surveys for community composition and health. • Macroinvertebrate sampling to document community composition and health	• **Same as MBF =88 sites**, although may only need to monitor stated metrics at a subset of sites.
On-stream Dams: **Ho_4** – *the measures focused on restricting on-stream dams and providing fish passage and screening facilities will ensure that approval of new or existing unauthorized projects will not adversely affect existing anadromous salmonids, or impede the restoration/recovery of historically present anadromous salmonids*	• Annual gravel and cobble accumulations in existing on-stream reservoirs, and quantification of channel storage in spawning habitat downstream. • Spawner and redd counts above and below selected reservoirs and diversions meeting Policy requirements (in streams used currently). • Macro-invertebrate sampling in Class II streams to verify status.	• Dependent on number of on-stream reservoirs and mainstem channel diversions within Policy area

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