Appendix D. Effectiveness Monitoring Protocols

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INTRODUCTION

Currently, numerous studies are being implemented by state, federal and private industry biologists to monitor and assess stream conditions with respect to timber harvest and potential impacts to salmonid habitat. State and federal agencies in the Pacific Northwest use a variety of monitoring and assessment protocols. This inconsistency fuels the debate over the value and utility of various methods. This is due in part to the poor understanding of the inherent, regional variability of instream parameters associated with the unique and dynamic characteristics of geology, climate, vegetation and past management histories (Hughes et al. 1986). Study design is another limitation, along with the human and monetary resources to implement long-term studies (Hicks et al. 1991). For example, the temporal lag between hillslope processes (either natural or human induced) and measurable responses in the stream channel is highly variable and may be on the order of decades or longer.

Recently published monitoring and assessment protocols include:

- EPA's "Monitoring Guidelines to Evaluate Effects of Forest Activities on Streams in the Pacific Northwest and Alaska" (MacDonald et al. 1991);
- Ambient Monitoring Program Manual" (Schuett-Hames et al. 1994);
- "Methods for Stream Habitat Surveys" (Moore et al. 1993);
- "California Salmonid Stream Habitat Restoration Manual" (Flosi and Reynolds 1994).

This small sample from the many manuals and protocols available indicates the difficulty in quantifying conditions which reflect the dynamic variables of watershed processes across broad geographic ranges. There is also a wide range in the magnitude and intensity of monitoring proposed, indicating either different sets of objectives or a lack of consensus on how much information is needed to monitor watershed processes and channel conditions.

Simpson has carefully considered all of the above approaches in developing an appropriate methodology for its monitoring projects and this AHCP/CCAA (Plan). Simpson also is an active participant in the Fish, Forest, and Farms Communities (FFFC) Technical Committee, which provides an ongoing forum where monitoring and assessment protocols are being cooperatively developed and refined by industry, agency and academic biologists. The FFFC Technical Committee has compiled a set of field protocols to standardize data collection for assessing and monitoring salmonid habitat and populations in California. Simpson currently utilizes these adopted protocols in their assessment programs.

The Effectiveness Monitoring projects will measure the success of the conservation program in achieving the Plan's biological goals and objectives. Effectiveness monitoring will track trends in the quality and quantity of habitat for the Covered Species as well as the distribution and relative abundance of the Covered Species, and provide information to better understand the relationships between specific aquatic habitat elements and the long-term persistence of the Covered Species. The Effectiveness Monitoring projects are divided into four categories, Rapid Response Monitoring, Response Monitoring, Long-term Trend Monitoring/Research, and Experimental Watersheds Program. The first three categories are based on the minimum time frame over which feedback for adaptive management is likely to occur. The Experimental Watersheds Program provides a unique spatial scale for individual projects and for the development of new and refined monitoring approaches.

Each Effectiveness Monitoring project is based on current monitoring technology and methodologies and on current understanding of the limiting habitat conditions required by the Covered Species, i.e. LWD, sediment, and water temperature. It is reasonable to expect that monitoring techniques and related technology will change significantly through the fifty-year life of this Plan, and that our understanding of riparian function will also change. Therefore, it is essential to build flexibility into the monitoring program to respond to these changes. Some monitoring programs may be retired or replaced by more efficient and/or accurate techniques to address the same issues, and entirely new monitoring programs may be implemented to address currently unforeseen issues. Any changes to the monitoring program considered will be evaluated to insure that they do not reduce the ability of the program to achieve its objectives: to evaluate the effectiveness of the conservation measures and provide feedback for adaptive management. Periodic reviews, at least every ten years or following changed circumstances, of the monitoring and adaptive management program will provide the assessment needed to justify any changes. All changes to the monitoring program will be subject to the concurrence of the Services.

D.1 RAPID RESPONSE MONITORING

D.1.1 Introduction

Rapid Response Monitoring activities include:

- Summer water temperature monitoring
  -- Property-wide water temperature monitoring
  -- Class II (BACI) water temperature monitoring

- Spawning substrate permeability monitoring

- Road-related sediment delivery (turbidity) monitoring

- Headwater monitoring
  -- Tailed frog monitoring
  -- Southern torrent salamander monitoring

The Rapid Response Monitoring projects will provide the early warning signals necessary to ensure that the biological goals and objectives of the Plan will be met. Rapid Response Monitoring projects have the potential to provide feedback to adaptive management on a time scale of months up to two years. Each project has measurable thresholds which, when exceeded, initiate a series of steps for identifying appropriate management responses. To provide the ability to respond rapidly to early signs of potential problems while providing assurances that negative monitoring results will be adequately addressed, a two stage “yellow light, red light” process will be employed.

D.1.2 Property-wide Water Temperature Monitoring

D.1.2.1 Background and Objectives

Stream water temperature monitoring on Simpson Timberlands began in 1994 and is ongoing today. At the end of the year 2000, 400 summer water temperature profiles have been recorded at 150 locations within 108 Class I watercourses distributed throughout the Plan Area. An additional 210 summer temperature profiles have been recorded in 87 sites in approximately 70 headwater (Class II) watercourses within the Plan Area. As part of Rapid Response Monitoring, water temperature will be monitored on an annual basis within both Class I and II watercourses throughout the Plan Area.

The following objectives have been developed for water temperature monitoring:

- Document the highest

  a) 7DMAVG (highest 7-day moving average of all recorded temperatures),

  b) 7DMMX (highest 7-day moving average of the maximum daily temperatures),

  c) seasonal temperature fluctuations for each site for both Class I and Class II watercourses.

- Identify stream reaches with temperatures that have the potential to exceed the monitoring thresholds relative to the drainage area above the monitoring site for both Class I and Class II watercourses.

D.1.2.2 Class I and II Watercourse Monitoring Methods

D.1.2.2.1 <u>Calibration and Recorder Replacement</u>

The annual calibration of all thermographs is necessary to remain assured that all recorders (loggers) are operating within the manufacturer’s specifications and that batteries are in good condition. The calibration process is not an attempt at documenting precision beyond that of the manufacturer’s specifications or an attempt at establishing correction factors to be applied the data after retrieval. The manufacturer’s specification for the current models, Onset’s Hobo® or TidbiT®, is ± 0.2 ºC at -5ºC to +37ºC. Any recorder that fails the first calibration will be repaired and recalibrated. If a second calibration failure occurs, the thermograph will be retired and replaced. Technological advances and replacement intervals for temperature loggers will ensure that recorders used for the monitoring program will not be more than five years old. The TidbiT®’s battery is not replaceable and the unit is only expected to last about five years before being replaced. The unit records data with very little draw on the battery but the download process, through a Light Emitting Diode (L.E.D.), is very demanding on the battery. Therefore, it is recommended that units only be calibrated once a year prior to deployment and that deployments run as long as reasonable to avoid frequent downloading. Simpson still maintains a few HOBO® models that are used primarily for high profile sites, where the recorder may be stolen, or in streams that have already been documented as being well within suggested temperature thresholds.

At the beginning of each field-monitoring season every logger, that is not currently deployed, is subject to calibration in an ice bath using the following procedure.

1. Set and start each of the loggers at a recording interval of 10 seconds and an appropriate delayed start time.

2. Obtain an ice chest or large garbage can capable of holding all of the recorders to be calibrated at once.

3. Fill the container half way with crushed ice.

4. Place the recorders in a single layer on a plastic tray or screen and place on top of the ice.

5. Finish filling the container with ice and then fill ¾ of the container with cold water. If available, place the container in a walk-in cooler or at the minimum insolate it with blankets and place in a shaded area.

6. A small water pump (i.e., a fishtank pump) should be set at the bottom of the container to circulate the water and prevent any measurable thermal gradation developing in the container.

7. Using an ASTM certified lab thermometer, verify the water temperature at periodic intervals. The water will be at or slightly less than 0°C, depending on the purity of the water.

8. Continue to monitor for two to three hours allowing time for acclimation of both the recorders and the water.

9. Remove and download all of the recorders.

The available software for processing the thermograph data (Boxcar Pro 4.0©) does not allow for direct comparison of the data sets, therefore while downloading the thermographs each file should be exported as a text file (.txt extension) in an Excel© compatible format. Each text file will contain two columns: the date/time code in an Excel© format and the corresponding temperature data. Select a common one-half hour period in which the water temperature was stabilized at or near 0°C. For each individual thermograph calculate the average temperature recorded during the calibration run period and the standard deviation around those temperatures. Thermographs with identical average temperatures and deviations are matched up and used in paired watershed studies (see BACI Protocol for Class II monitoring below). Those recorders that operate within the manufacturer's specifications are assigned to Class I and II monitoring sites and those that do not pass are recalibrated or retired and replaced.

A thermograph-tracking document will be maintained that documents each recorder's historical placement, calibration and maintenance history, deployment problems, and retirement date. When a logger is deployed the following will be documented in the tracking file: the stream, sampling interval, launch date and recovery. A record of all logger serial numbers, purchase dates, battery replacement dates, and battery life will be kept in a master temperature monitoring equipment file as part of the documentation.

D.1.2.2.2 *Stream Selection*

The streams and/or stream segments selected for water temperature monitoring will represent a variety of monitoring goals. Any particular monitoring site may serve multiple goals.

Simpson annually monitors:

- Individual streams with exceptionally diverse species composition or significant populations of torrent salamanders, tailed frogs or coho salmon.

- Individual streams that have been documented as having water temperatures potentially problematic for salmonids and amphibians.

- Stream segments (within those streams that have been documented as having elevated temperatures), to document the extent of the elevated temperatures.

Simpson will also periodically monitor:

- Streams and stream segments that have been documented as having no temperature problems. These streams are selectively monitored on a two-year schedule. This will provide a long-term database that allows for trend analysis.

- Streams and stream segments for which there are no temperature profiles in existence.

At a minimum, all 3^{rd}-4^{th} order Class I sub-basins (typically 3000-5000 acres) with >2500 feet of fish-bearing channel and >10% of the sub-basin harvested (average >1%/year using even age silviculture) over any rolling 10-year interval will have at least one monitoring site low in the sub-basin where summer water temperatures will be monitored on an annual basis. The monitoring may be discontinued after five years, if the highest 7DMAVG (7-day moving average of all recorded temperatures) for the stream falls below the trend line (least squares regression line) of 7DMAVG versus drainage area (see Summer Water Temperature Monitoring, Section 6.3.5) for all sub-basins in that particular HPA, and there is <5% additional harvest during that time interval. If at some future time the rate of harvest exceeds an average of 1%/year over a rolling 10-year interval, the monitoring will be re-initiated. In addition to the minimum described above, 10-15 streams from across the Plan Area that do not meet any of the criteria described above and were previously found to be below the temperature thresholds will be monitored on a three to five-year rotating basis to document general trends in water temperature throughout the Plan Area.

There are some previously established monitoring sites on Class I watercourses that have watershed areas greater than 10,000 acres. These monitoring sites will no longer be used since the scope of inference for the threshold equations is less than 10,000 acres. A new site will be established further upstream so the watershed size criteria will be met for the water temperature monitoring.

Water temperature monitoring of Class II watercourses will be distributed across the Plan Area as part of the Headwaters Amphibian Monitoring, Class II BACI Water Temperature Monitoring (see below) and other amphibian studies. In addition, if the highest 7DMAVG associated with a given 3^{rd}-4^{th} order Class I is at or above the yellow-light threshold level (see Summer Water Temperature Monitoring, Section 6.3.5), then a temperature profile for the mainstem and all the major Class II tributaries in the sub-basin will be determined at the warmest time of the year. Temperature loggers will be deployed in 2-3 of the warmest Class II watercourses to determine if they are within the threshold limits. Wherever possible, Class II watercourses in these sub-basins will be targeted for BACI water temperature monitoring sites.

D.1.2.2.3 Temperature Monitoring Site Selection

Within the stream or stream segment selected, the specific site for monitoring will be in the lowest portion of the stream on Simpson Property. Care will be taken to avoid tributary confluence's that may bias the temperature data. The temperature recorder will be either anchored to a length of steel rebar driven into the channel bed or secured to a cement block with cord or cable. In order to avoid any effects of thermal stratification within a Class I watercourse habitat unit, recorders shall be placed either in a deep well-mixed riffle or at the head of a pool in 1 - 2 feet of water. For Class II watercourses thermal stratification is generally not considered an issue, rather the goal would be to place the recorder in water deep enough that the unit will not be de-watered during summer low flow conditions. The intent is to monitor representative temperatures for the stream and avoid monitoring specific thermal refugia. In all cases each recorder shall be launched and deployed at a recording interval of no greater than 1.2 hours. This interval provides 20 recordings per 24-hour period. Recent upgrades in the memory capacity of the TidbiT® make it feasible to record at much shorter intervals but the increase in data volume does not add to the data quality. In addition the increased sampling interval requires more memory and thus longer to transfer the resulting data file. The file transfer operation is the most demanding on the logger's battery and can significantly reduce the life span of the recorder

Simpson's summer stream temperature monitoring activities are focused on documenting seasonal peak temperatures that can occur anytime from early June to late September. To document seasonal peaks in water temperature the recorders are deployed early in the year and left unattended until October or November. In a majority of the streams monitored, summer low flow conditions result in a dramatic lowering of the water surface elevation of what was a shallow pool or riffle during the spring. Therefore, care shall be taken in placing the recorder so that it does not become exposed to the air or to unrepresentative water conditions while deployed. Generally, the temperature recorder is placed in the stream with cobbles placed around it to help anchor and shield the recorder from direct solar radiation.

D.1.2.2.4 Collection of Site Specific Variables

Several variables will be collected and will contribute to a better understanding of the temperature data collected by the thermograph. These site-specific variables will be collected either while deploying the thermograph or upon its retrieval.

- Channel type using CDFG protocols (this will include bankfull width and depth measurements)

- Canopy Closure using CDFG protocols
- Water depth and discharge during placement and retrieval

These additional variables will be generated from GIS analysis and/or aerial photos:

- Site elevation
- Stream aspect
- Watershed area upstream of the thermograph
- Stand age

D.1.2.2.5 *Data Analysis*

The temperature monitoring data collected is intended to document the summer water temperature maxima. Several metrics shall be calculated from the data set in addition to the absolute maximum temperature. These metrics further describe the water temperature conditions during the summer period and the diurnal fluctuations immediately following the warm summer temperature conditions. The Seven-Day Moving Average (7DMAVG) is the seven-day period with the highest average temperature. The Seven-Day Mean of the Maximums (7DMMX) is the highest seven-day moving mean of the maximum daily temperatures. The absolute Maximum temperature (Max) may or may not occur during the 7DMAVG or the 7DMMX. The minimum temperature (Min) following the absolute maximum (Min. after Max.) is the minimum temperature on the day following the occurrence of the Max. This is intended to describe the diurnal range on the hottest day of the year. The raw temperature data is imported into Microsoft Excel to calculate every seven day moving average and every seven day moving mean of the maximum temperatures. The highest seven day moving average temperature (7DMAVG) and the seven day moving mean of the maximum temperature (7DMMX) is selected and the associated middle dates (Mid Date 7DMAVG and Mid Date 7DMMX) from both seven day period. The absolute maximum (MAX) is then selected along with the Min. after Max and the date of the maximum. This data is then entered into a spreadsheet along with the period of record, year, site name and number. A master list of all thermograph data processed is compiled and updated annually. Subsets of this data are submitted with Timber Harvest Plans to document water temperature conditions within the assessment area of that plan as shown in Table D-1 below. All new temperature summaries are analyzed in reference to the red and yellow light thresholds.

Table D-1. Example of temperature monitoring data set: summer water temperature monitoring summary for Little River HPA.

Stream Name	Class	Year	7DMAVG (°C)	Mid Date 7DMAVG	7DMMX (°C	Mid Date 7DMMX	Max (°C)	Max Date	Min after Max (°C)	Area (acres)
Little River, Upper SF	1	1994	14.5	8/19	15.9	8/16	16.2	8/3	14.0	3619.0
Little River, Upper SF	1	1995	14.7	8/3	16.5	8/3	17.0	7/31	13.7	3619.0
Little River, Upper SF	1	1998	15.0	8/14	16.5	7/20	16.8	7/18	13.7	3619.0
Little River, Upper SF	1	1999	14.8	8/27	15.2	8/27	15.6	8/29	14.5	3619.0
Little River, Upper SF	1	2000	15.3	7/31	16.5	7/31	16.8	8/1	14.6	3619.0
Little River, Lower SF	1	1994	14.6	7/24	16.3	8/5	16.9	8/3	14.5	3452.0
Little River, Lower SF	1	1995	15.2	7/30	16.7	8/3	17.2	8/1	14.0	3452.0
Little River, Lower SF	1	1998	15.9	7/23	17.4	7/23	18.1	7/26	15.2	3452.0
Little River, Lower SF	1	1999	15.6	8/27	16.5	8/23	17.2	8/22	14.5	3452.0
Little River, Lower SF	1	2000	16.1	7/31	18.0	7/31	18.5	8/1	15.2	3452.0
Little River (mid)	1	1994	15.2	7/30	16.4	7/29	16.9	7/31	14.4	13176.3
Little River (mid)	1	1996	16.0	7/28	17.5	7/28	17.9	7/29	14.8	13176.3
Little River (mid)	1	1999	15.5	8/27	16.2	8/27	16.6	8/29	15.3	13176.3
Little River (mid)	1	2000	15.8	7/31	17.0	7/31	17.4	8/1	15.0	13176.3
Little River (upper)	1	1994	13.4	8/21	14.2	8/21	14.5	8/19	13.3	8755.0
Little River (upper)	1	1995	14.0	8/3	15.2	8/3	15.8	7/31	13.3	8755.0
Little River (upper)	1	1996	14.1	7/28	15.3	7/27	15.8	7/30	12.6	8755.0
Little River (upper)	1	1999	14.1	8/27	14.7	8/27	15.3	8/29	13.1	8755.0
Little River (upper)	1	2000	14.3	9/18	15.1	9/18	16.1	9/19	13.9	8755.0

D.1.3 Class II BACI Water Temperature Monitoring

D.1.3.1 Background and Objectives

In summer 1996, Simpson initiated water temperature monitoring in nonfish bearing (Class II) watercourses to assess potential impacts of harvesting and adequacy of the riparian buffers. The goal of this effort was to examine changes in stream temperature after timber harvest by comparing maximum temperature differentials across fixed lengths of stream. These temperature differentials were measured on pairs of similar streams, one member of which ran through a harvest unit, the other of which was undisturbed. Measurements were initiated in both streams of a pair prior to harvesting timber surrounding one member of the pair. Monitoring of the stream pair will continue until the stream pair returns to pretreatment conditions. These data represent a BACI (Green 1979; Stewart-Oaten et al. 1986; Skalski and Robson 1992) observational study. While observational studies cannot infer cause and effect relationships, BACI studies represent the best available setup for detecting changes after disturbance. In 1999, three additional watersheds were added to the Paired Watershed (BACI) experimental design. Future paired watersheds may be added as needed to meet the Plan's Class II water temperature monitoring needs. New Class II BACI water temperature sites will be established across the Plan Area as opportunities exist. (New BACI sites cannot be initiated unless there is going to be harvesting in the area to create the treatment reach.) The goal is to have a minimum of 12-15 paired sites that are well distributed across the

Plan Area to represent different physiographic regions. If there is little variance among sites in the response of water temperature to the treatment effect, this minimum number will be adequate to reach a definitive conclusion on the impact of harvesting on Class II water temperature. However, if there is substantial variation in the treatment response, it will be necessary to add additional sites. The actual maximum number is a statistical question that cannot be answered until the data are collected and analyzed.

D.1.3.2 Methods for Class II BACI Studies

D.1.3.2.1 Calibration and Recording Interval

Temperature recording devices were/will be calibrated prior to deployment. For calibration, all thermographs will be calibrated as described above in the Class I summer water temperature monitoring program. Only instruments with identical readings after three hours in the calibration ice bath will be used for the BACI experiments. All thermographs will be programmed to record temperature (ºC) every 1.2 hours or 20 times every 24 hours.

D.1.3.2.2 Site Selection and Deployment

Streams in areas where timber harvest is planned were, or will be, identified and paired with separate streams in close proximity that has similar size, streamflow, aspect, elevation, stand type and age and streambed geology. The stream of each pair running through a harvested area is designated as the "treatment" stream. The other stream of each pair was/will be designated as the "control" stream because no timber harvest is planned around these streams. At least one year prior to timber harvest, paired temperature-recording devices (HOBO's® or TitBiTs®) will be placed in the treatment stream at the upstream and downstream edges of the harvest unit. At the same time, another pair of temperature recording devices was/will be placed in the control stream at locations which are the same (stream) distance apart as the recording locations in the treatment stream.

The upstream and downstream placement of temperature recording devices allow measurement of temperature differential across the treatment area and an assessment of the extent to which water temperature changed as it flowed through the treatment area. Interest is primarily in the amount of warming water experiences as it flows through the treatment area. Ground water inputs, climate, and microclimatic factors can all effect water temperature and consequently the paired stream design was adopted.

For all watershed BACI sites paired thermographs will be deployed to all streams in middle and late spring each year and collected after 15 September each year.

D.1.3.2.3 Watershed and Stream Selection

In the original monitoring program, data were recorded on five pairs of streams with each pair referred to as a site. As stated above three additional sites were added in 1999. Each stream pair (site) will be given a unique site name. The original five study sites were labeled Mitsui, D2010, D1120, 6001, and 5410. Mitsui was located in the headwaters of the Little River. D2010 was located in the Winchuck drainage. D1120 was located in the headwater tributaries of Dominie Creek. 6001 was located off the main stem of the Mad River. Site, 5410, was a pair of tributaries to Dry Creek. Timber harvest at Mitsui and D2010 took place in winter 1996/1997. Timber harvest at 6001 and 5410 took place in winter 1997/1998. As of winter 1999/2000, timber harvest had not occurred at D1120.

The sites added in 1999 are Windy Point, M1, and M155. Windy Point and the M1 are in tributaries to Maple Creek and the M155 is in a pair of tributaries to the Lower South Fork Little River. The Maple Creek units where harvested in winter 1999/2000 and the Lower South Fork unit has not been harvested yet.

D.1.3.2.4 Collection of Site Specific Variables

Several variables will be collected and will contribute to a better understanding of the temperature data collected by the thermograph. These site-specific variables will be collected either while deploying the thermograph or upon its retrieval.

- Canopy Closure
- Stream flow
- Water depth during placement and retrieval

These additional variables will be generated from GIS analysis and/or aerial photos:

- Watershed area upstream of the thermograph
- Site elevation
- Stream aspect
- Stand age

D.1.3.3 Data Analysis

For analysis, attention will be restricted to the time during the warmest water temperatures, which are generally late August to early September in coastal northern California.

Upstream and downstream temperatures collected on a single stream will be matched according to the time of day they were recorded and the difference between downstream and upstream temperature (downstream - upstream) will be calculated every 1.2 hours. The maximum downstream-upstream temperature differential will be computed each day. The time of day at which the maximum temperature differential was recorded will likely vary between days and streams.

The statistical analysis used to assess harvest impacts was/will be a modified BACI analysis. BACI analyses assess the lack of parallelness in response profiles through time. This lack of parallelness was/is measured by the treatment by time (year) interaction from an ANOVA with time as one factor and treatment as the other. The BACI analysis allows the level of responses to be different between control and treated sites both before and after treatment, but requires the after treatment difference in control and treated responses to be the same as the before treatment difference in control and treated responses. If the after treatment difference in responses is different from the before treatment difference in responses, the BACI analysis will conclude that there was significant change in treatment areas after application. Inference as to the cause of treatment differences is as a result of professional judgment based on a preponderance of evidence.

Differences between sites in the direction and magnitude of temperature differences after harvest can become apparent upon plotting of the data. In the face of these differences, each site was/will be analyzed separately and no statistical inference to other sites is possible. Discussion of other sites should be considered professional judgment and not directly based on inference from the data.

Details of the BACI estimation process can be found in McDonald (2000) (Attachment A to Appendix C3. The modification of standard BACI methods used here involves adjusting error estimates to account for estimated auto-correlations in the inter-day time series inherent in the data.

D.1.3.4 Literature Cited

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D.1.4 Spawning Substrate Permeability Monitoring

D.1.4.1 Background

Spawning gravel permeability will be monitored in selected Class I watercourses throughout the Plan Area to determine if conditions are currently suitable for the covered fish species and to track trends in permeability. Sedimentation can reduce the survival to emergence of the covered embryos by reducing subsurface flow (Reiser and White 1988). Permeability monitoring is a way to measure subsurface flow, and permeability has been correlated with survival to emergence of salmonids. Field measurements in streams across the Plan Area will be combined with the available literature and field data from additional streams, including pristine portions of the Prairie Creek watershed, to determine appropriate threshold and biological objective values. Approximately five years of initial trend monitoring is expected to be necessary for this process.

D.1.4.2 Threshold Development

Approximately five years of initial trend monitoring is expected to be necessary to determine appropriate permeability threshold values. At the end of the trend-monitoring interval a review and evaluation of the monitoring results will be conducted to set thresholds with agency collaboration. In addition, at other times agreed upon with the consensus of the Services, periodic reviews will be conducted to evaluate progress in determining substrate permeability thresholds. Concurrently with the initial trend monitoring efforts a literature re-evaluation and assessment will be conducted to assist in establishing threshold values for the protection of life-stages of anadromous salmonid sensitive to the effects of reductions in substrate flow and oxygen concentrations.

D.1.4.3 Monitoring Methods

D.1.4.3.1 <u>*Introduction and Permeability Theory*</u>

The condition of salmonid spawning habitat can be a factor limiting the success of salmon and steelhead populations. Assessing the quantity and quality of salmonid spawning habitat requires both field methods and analytical methods to first quantify the productive capacity of spawning gravels, then compare conditions in watersheds with different land use histories and remnant salmonid populations, and finally assess temporal changes in these factors. Suitable methods for spawning gravel assessment should allow quantitative prediction of egg survival to emergence (i.e., incubation success) with known accuracy and at reasonable expense to allow widespread application.

To date, the best methods available that partially meet these criteria are from Tappel and Bjornn (1983), who related survival-to-emergence of chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) eggs to two indices of the particle size distribution: the cumulative percentage of substrate finer than 9.5 mm and 0.85 mm. Their laboratory experiments provided regression equations allowing prediction of survival-to emergence with the cumulative percentage of particle size fraction as input variables. The Tappel and Bjornn (1983) method has proven extremely useful in the past decades primarily because it links a measurable physical condition of the watershed, i.e., the amount of fine sediment in spawning gravels, to a biological effect, the percentage of salmonid eggs that survive to emerge as fry (survival-to-emergence), in a cause and effect relationship. A significant weakness of this method is the enormous effort required to collect enough sediment samples to accurately assess variability in the cumulative percentage of fine sediment that regularly occurs at the reach--, tributary--, or watershed--scale. For example, if sediment samples collected for a particular site have a narrow range of particle size distributions (i.e., low variance), then predictions of survival-to-emergence can be useful. If variance is high, however, as is often found in impacted watersheds, the regression equations predict a broad range of survival, and the utility of the method is compromised.

Permeability may provide a better method of assessing the condition of spawning gravels for several reasons. First, salmonid egg incubation depends on the supply of oxygen delivered to incubating eggs, and removal of waste from the egg pocket. The rate of oxygen delivery and waste removal is determined in part by the permeability of the gravels surrounding the egg pocket. Permeability is thus a more direct measure of factors affecting egg incubation and survival. Second, as discussed below, permeability data are more easily obtained than particle size distribution; thus characterizing the range of variability with suitable accuracy requires less cost and effort than methods based on substrate composition analysis. Finally, permeability is independent of discharge, stage height, season, etc, and can therefore be measured accurately at any time.

The measure of permeability of spawning gravel has a relatively short history. Terhune (1958) recognized that to estimate the probability of survival (to emergence) of salmonid eggs, two quantities must be known: "the concentration of dissolved oxygen in the groundwater, and the apparent velocity of the water through the gravel in the immediate vicinity of the redd [egg pocket]." Apparent velocity is the rate of seepage, expressed as a volume of liquid per unit time passing a cross sectional area containing both solids and interstices. Apparent velocity of water flowing through gravel interstices depends, in turn, on two factors: the hydraulic head and gravel permeability (Pollard 1955). Hydraulic head in a spawning riffle is determined by the hydraulic gradient, which is the slope of the water surface ($S=\Delta h/L$). Because hydraulic head changes with discharge (via change in slope), apparent velocity also changes with discharge. Apparent velocity (V) is also difficult to measure. Pollard also showed that, for laminar flows occurring at the velocities usually encountered in spawning gravels, D'Arcy's coefficient of permeability, K, as defined by $K=V/S$, is independent of apparent velocity, V. Permeability depends only on the composition and degree of packing of the gravel, and viscosity of the water (viscosity is related to water temperature). In the equation $K=V/S$, slope is dimensionless, so permeability will have the same dimensions as apparent velocity (usually cm/hr). Terhune (1958) therefore suggested permeability as a surrogate measure to apparent velocity as an empirical measure of the quality of salmonid spawning gravels:

"The permeability of the gravel, the ease with which water can pass through it, may be used as a figure of merit for the gravel—the higher the permeability the greater the supply of oxygenated water that can reach the salmon eggs for a given river gradient." (Terhune 1958).

Determining the permeability of spawning gravels by mechanical analysis is not practical because it is impossible to evaluate the degree of packing of the streambed substrates *in situ* (Pollard 1955). The standpipe was thus developed as a way to measure permeability in the field (Pollard 1955). Several iterations and modifications to standpipe techniques resulted in the "Mark VI Groundwater Standpipe" (Terhune 1958). Terhune recalibrated the standpipe by constructing a permeameter (14-ft long flume) and performing multiple trials to relate the rate of water inflow into the standpipe to the permeability, as measured by the permeameter. Barnard and McBain (1994) performed additional calibration with their own permeameter and standpipe. The permeability calibration curve is shown in Figure D1-1. Techniques for measuring permeability will be discussed below, following an additional word about permeability theory.

As mentioned, past research has relied primarily on measuring the volume of fine sediment in gravels to assess the quality of spawning gravels. Intrusion of fine sediment into gravel reduces the intra-gravel flow of water by reducing permeability, which results in reduced rates of oxygen delivery to incubating embryos and removal of metabolic waste from the egg pocket. The volume of fine sediment in spawning substrates is thus an indirect measure of gravel conditions that affect survival to emergence, whereas permeability directly measures conditions affecting embryonic survival. Chapman's (1988) review of the effects of fine sediments on the survival to alevin emergence noted that survival relates positively to both temperature and apparent velocity, and that survival also relates positively, and significantly, to permeability: for McCuddin (1977) data, r^2=0.83; for Koski (1966) data, r^2=0.33. Data from McCuddin (1977) and Tagart (1976) were plotted together (Figure D1-2), and show a significant correlation between permeability and survival-to-emergence. While plotting these data together shows a strong relationship exists between permeability and survival-to-emergence, this regression should be considered preliminary and used with caution, as the data are from studies involving two different salmonid species using different data collection methods. Additional studies are warranted to confirm/strengthen this important link. Despite this information, few researchers or resource managers have employed permeability techniques to assess salmonid spawning gravel quality.

Until recently, permeability measurement relied on Terhune's (1958) methods, which employed a hand pump (a bicycle or bilge pump) to extract water from a 4.5 cm stainless-steel standpipe into a 2.0 L graduated cylinder. The quantity of water withdrawn into the cylinder and the corresponding time interval were used to calculate the "inflow rate" of water into the standpipe from the surrounding substrate. A correction factor was necessary to account for the 2.54 cm pressure head at the top of the standpipe, and the operator was required to pump vigorously and consistently for up to several minutes in low permeability conditions. Young (1988) demonstrated significant imprecision in this technique. He found significant differences in permeability samples withdrawn by different individuals (sampling bias), resulting in substantial variability in permeability estimates. Young also pointed out that previous research relied on only one replicate per sample to estimate permeability, when variation in permeability may be expected at a particular sample location.

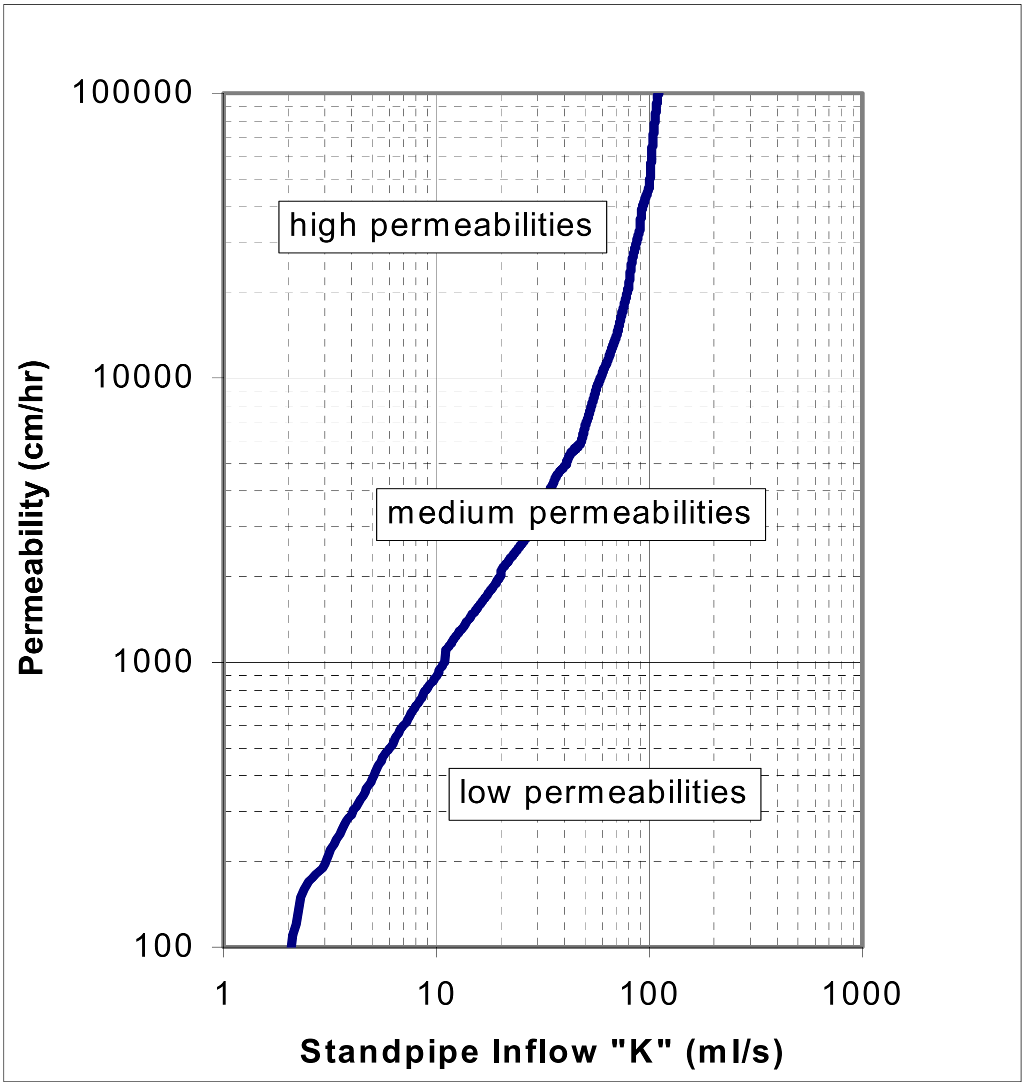

Figure D-1. **Relationship between inflow rate (ml/s) and permeability (cm/hr) used to convert field inflow measurements into permeability. Note that permeability ranges across three orders of magnitude, from 0 cm/hr to 100,000 cm/hr.**

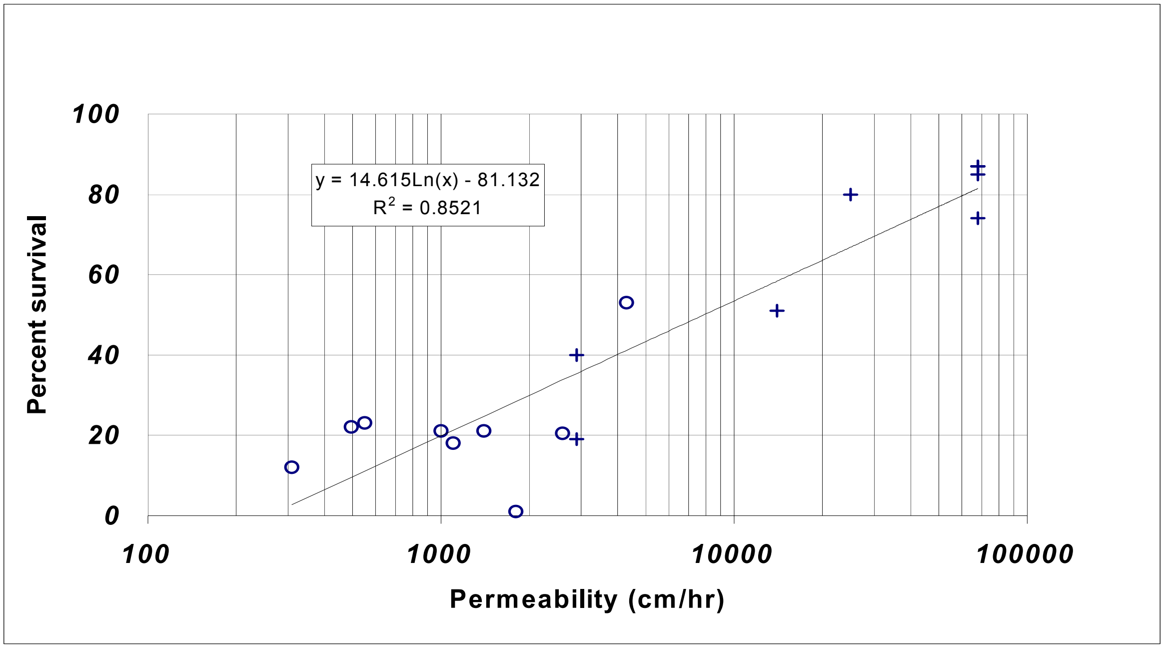

Figure D-2. **Data from Tagart (1976) and McCuddin (1977) showing a highly significant relationship between survival of chinook (McCuddin data, "+") and coho salmon (Tagart data, "o"), and permeability of the incubation substrate [Figure provided by Stillwater Sciences].**

D.1.4.3.2 Equipment, Operation, and Maintenance

To improve the accuracy of permeability measurements and eliminate potential user bias, several researchers have begun using a hand-made electric pump device to draw water from the standpipe into a volume chamber calibrated to measure the volume of water inflow per unit time (i.e., inflow rate). The device is mounted on a backpack frame for convenient use in the field. This new device allows consistent, replicate sampling in a short time (approximately 20-100 seconds per replicate), from which a mean permeability and variance can be computed for a single sample location. Collection of 5-10 replicates for each sample, and several samples (at least three) within a single spawning area or sediment facies can be completed in approximately one hour. Use of this new device in several independent studies and monitoring programs (Mendocino Redwood Company, B. Klatte 1998 HSU Master's Thesis, McBain and Trush 2000, Mesick 2000, Lower Tuolumne River Spawning Gravel Assessment, in progress,) has shown consistent and reproducible permeability measurements.

A detailed description of the equipment is provided here. The electric pump, a Thomas Inc. diaphragm vacuum pump (model 107CDC20), is mounted inside a box and connected to a 12-volt deep-cycle battery (e.g. Interstate® Battery model PC1270/ 7.0 AH). A toggle switch is connected in the circuit and mounted through the side of the toolbox so the switch can be turned on/off externally. A ⅜ inch diameter plastic hose connects from the pump to a plastic overflow bottle, then through the box to the vacuum chamber cylinder. The vacuum chamber is constructed of 3½ inch diameter clear PVC pipe (from Ryan Herco, Inc.), measures 20 inches in length, and has 3½ inch x 1½ inch PVC bushings on each end. The top bushing has a threaded plug, which allows easy access into the chamber to rinse out silt and sand that accumulates. The bottom bushing has a ¾ inch threaded nipple and a ¾ inch brass ball valve, which allows water to be drained off after each replicate measurement. A piece of ⅜ inch clear, rigid plastic tubing is installed to the vacuum chamber side to facilitate reading the meniscus (stage height) as accurately as possible. A ruler calibrated in millimeters/centimeters is attached next to the rigid tubing, and is used to read the stage height of water inside the vacuum chamber. A second piece of ⅜ inch plastic tubing, 6 ft long, is connected to the vacuum chamber and leads to a 5 ft piece of ⅜ inch copper tubing (stainless steel also works). This rigid copper tubing is inserted down into the standpipe and contacts the water surface. When the switch is turned on, the pump draws water into the vacuum chamber via the copper and plastic tubing.

The standpipe is constructed of one inch interior diameter Schedule-40 stainless steel pipe, approximately 4½ ft in length, open at the top and with a driving tip welded into the bottom (Figure 5, drawing of standpipe equipment). The heavy-duty stainless steel is used because it is durable and will not corrode. This one inch standpipe is smaller in diameter than the original Terhune (1955) model (1¼ inch), which slightly reduces disturbance to the gravel. A 3 inch band of perforations is located several inches from the bottom, and includes forty-eight ⅛ inch diameter holes drilled through the pipe to allow water to flow into the standpipe. Vertical grooves are cut into the pipe connecting the holes, to prevent small substrate materials from plugging the holes. To drive the standpipe into the streambed, a sledgehammer and a driving head of solid stainless steel or lead, machined to fit into the top of the standpipe, is used. The driving head protects the rim of the standpipe from becoming damaged by the hammer. Place duct tape 10-12 inches up from the middle of the band of perforations to indicate the depth to which the pipe should be driven into the substrate.

D.1.4.3.3 <u>General Field Methods</u>

A permeability measurement is made by pumping water from the standpipe into the vacuum chamber, and measuring the change in stage height in the vacuum chamber (mm) per unit time (sec). The only field data required for a permeability measurement are therefore the start and ending stage, time, and water temperature. Record detailed information about the site location, extent of spawning habitat and evidence of spawning usage, photograph, etc. A sketch map of the site is also useful. The stage height change (mm) is later converted to volume (ml) using a Microsoft Excel© spreadsheet, then the inflow rate (ml/sec) is converted to permeability (cm/hr) using the calibration curve developed by Terhune (1958) and refined by Barnard and McBain (1994). The permeability is also adjusted for water viscosity in the spreadsheet by a conversion factor using water temperature.

To initiate a measurement at a selected site, the standpipe is first driven into the substrate to the appropriate depth, using the driving head and sledgehammer. Once the pipe is in place, the driving head is removed and the copper tube (connected to the pump) is inserted into the standpipe. To locate the exact stage height of the groundwater inside the standpipe, perform a “slurp test”, in which the pump is turned on and the copper tube is slowly lowered until the copper tip contacts the water and makes a slurping-straw sound. Then insert a one-inch spacer on the rim of the standpipe, and clamp needle-nose vise-grips on the copper tube precisely above the spacer. In this way, when the spacer is removed and the vise-grips rest on top of the standpipe rim, the tip of the copper tube gets lowered exactly one inch deep below the water surface elevation inside the standpipe. Pumping this one-inch fraction of water out of the pipe creates a pressure head outside the pipe, thus causing water to flow continuously into the standpipe through the perforations. The rate of inflow into the pipe is determined by the permeability of the surrounding gravels. The original calibration of inflow rate to permeability by Terhune (1955) employed the one-inch pressure head, and is essential to proper permeability measurements.

When the slurp test and vice-grips procedure is complete, the first permeability replicate sample can be taken. The pump is turned on to fill the volume chamber with water from outside the standpipe to the level of the bottom of the ruler. The copper tube can then be replaced into the standpipe to begin pumping water from the standpipe. Allow a few seconds to draw out the first one-inch volume of water to create the pressure head and stabilize the rate of water pumping, then record the initial stage and start the timer. Generally, allow at least 20 seconds and/or a change in stage of approximately 10 cm for each replicate. After the end stage height is noted and the timer stopped, turn off the pump and record the data. Drain the water back to the level of the bottom of the ruler, and begin the next replicate measurement. In the field, if the stage change is the same for each replicate measurement, then the time (seconds) is a surrogate for the actual permeability, and replicates can be compared to each other. Simpson has observed a general trend of increasing permeability during the first several replicates, noted by the decrease in time required to fill the same volume of the chamber. For example, the time to fill 10 cm in stage change might require 24.2s, 23.1s, 21.5s, 22.0s, and 20.8s. A general rule is to collect at least 5 measurements, and continue beyond 5 reps until the last rep is not the highest permeability. In the example above, if the 6^{th} rep is 21.4s, then 6 reps would satisfy the general rule and therefore sampling could stop. When enough replicates are collected, the sample is complete, and the operator can move to the next sample location.

D.1.4.3.4 Data Entry and Analysis

Collect at least three samples at a given spawning site, so that a variance and confidence intervals can be computed. The included Microsoft Excel© spreadsheet will compute the inflow rate and convert it to permeability with the necessary adjustment for viscosity based on water temperature. The spreadsheet requires only the input values of the initial stage reading, end stage reading, time, and temperature. Up to 10 replicate measurements can be entered for each sample, and the spreadsheet will generate the mean permeability and several statistics that describe the variability of the sample. Once data for several samples have been entered, the spreadsheet will compute the mean, variance, and confidence intervals for the entire site. Ideally in the future, with a solid relationship established between permeability and egg survival-to-emergence, the spreadsheet could be designed to estimate or predict a range of survival values for eggs incubated in those particular gravels. Note that the conversions of raw data to true permeability, and statistical calculations make use of the “look-up tables” in the Excel© Workbook, and cannot be changed or removed from the file. Create a separate worksheet for each stream sampled by copying and pasting the template sheet and renaming the sheet with the stream name. Each new worksheet will continue to reference the look-up tables. Maintain the template file blank. Once several different streams are entered, copy the entire column Q and "Paste-Link" or "Paste-Values" (Excel operations) into a new sheet as a summary sheet. This allows comparisons between different streams.

D.1.4.3.5 *Sampling Design*

The primary objectives of permeability sampling are to:

- quantify the condition of salmonid spawning substrates in a manner that will allow prediction of egg survival-to-emergence or incubation success;
- document the variability in baseline or initial conditions of a particular river or stream reach with suitable precision to allow comparison to other reaches/stream, and to detect changes in conditions in subsequent years' monitoring; variability may occur within a chosen spawning site, from site to site within a stream, and/or from stream to stream;

To meet these objectives, the monitoring data should assess the mean or average condition of a particular study reach, and the variance in the mean. These variables can then be used to determine the confidence interval around the mean, and to compare two or more streams to determine if the means are statistically similar or different (generally with a t-test or ANOVA). In other words, the mean and confidence interval must be defined narrowly enough that a statistical comparison will detect a significant difference, if a difference exists. The confidence interval is dependent on the sample size and the variance (or standard deviation), according to the formulae:

$$\text{SE (Standard Error)} = s\sqrt{n};$$

and

$$CI_\alpha \text{ (Confidence Interval)} = y \pm t_\alpha * SE$$

where "s" is the standard deviation, "n" is the sample size, "y" is the sample mean, and "t" is the student t distribution at α significance level.

The standard approach to estimate the sample size necessary to ensure a level of variance that will allow meaningful statistical comparisons is to perform a power analysis. A power analysis uses a preliminary estimate of the expected variance (s^2) to determine the sample size necessary to achieve a specified level of variance. In other words, use an estimate of variance to estimate the sample size necessary to achieve the variance desired. The estimate of variance can be collected in a pilot-level assessment of a particular stream, or from the range of variability obtained in other studies. In addition to the estimated variance, three additional terms must be specified: "α", the significance level, "β", the power (or Type II error), and "δ", the minimum detectable difference. The minimum sample size can be computed from the following equation:

$$\text{Sample Size (n)} = (s^2/\delta^2) * (t_{\alpha(2),df} + t_{\beta(1),df})^2 \qquad \text{(Zar 1974)}$$

Sample size estimates based on this equation should be rounded up to the next highest integer. A conventional combination of significance and power is 95% significance (α=0.05$_{(2\text{-tail})}$) and 80% power (α=0.20$_{(1\text{-tail})}$). The standard deviation term (s^2) is the standard deviation of residuals from an ANOVA test, with log-transformed data. The minimum detectable difference, "δ", is a decision made depending on the study objectives (i.e., a subjective decision). The δ can be interpreted, for example, as the percent difference in permeability that the research expects to detect, with the sample size then determined by the above formula. If two tributaries are sampled with the objective of determining a significant difference of at least 10% (with 95% confidence and 80% power) between the means of permeability, then δ=0.10. With these initial objectives, the proposed study may not then detect a 9% or less difference in the mean permeability.

From ANOVA tests with permeability data from the Garcia River (McBain and Trush, 2000; with assistance from Stillwater Sciences), an estimated standard deviation of 0.7, was applied in the above equation to determine the sample size necessary to detect a difference between tributaries of: (a) a factor of 10, or the difference between 1,000 cm/hr and 10,000 cm/hr, and (b) a factor of 2, or the difference between 1,000 cm/hr and 2,000 cm/hr. These estimates yielded a sample size of 2 and 17 samples per tributary, respectively, to detect the corresponding level of difference between different tributaries:

Minimum Detectable Difference	Sample Size (n) Based on Z Values
Factor of 10	2
Factor of 2	17

A sample size of at least 20 samples per tributary, distributed among several different pool-tail or spawning sites within a reach is recommended. This initial level of sampling should allow an adequate number of samples to define the variability within a study reach with good precision. Additional samples may improve the precision in the data. Sample sites should be selected and distributed randomly throughout the spawning habitat or particle facies (i.e., a pool-tail) identified for sampling. Once the variability has been assessed within each study site, subsequent sampling may require fewer samples to define the desired range of variability. Each sample should consist of numerous replicate measurements, as discussed above. Selection and collection of at least 20 samples within a stream study reach should be possible in a single field day's work for a crew of two technicians.

Substrate permeability will be initially employed in the long-term channel monitoring reaches and the four streams in Little River where summer and winter populations are estimated. Additional Class I watercourses within each HPA will be monitored so there will be an adequate zone of monitoring influence once thresholds values are established.

D.1.4.4 Literature Cited

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D.1.5 Road-related Sediment Delivery (Turbidity) Monitoring

D.1.5.1 Introduction

Increases in suspended sediment and turbidity are potential impacts associated with various land management activities. Primary sources associated with timber harvest practices are road erosion runoff, hillslope erosion and inchannel inputs (inner gorge slides and displacement of stored sediment). The road erosion runoff can be considered to be all management related while hillslope erosion and inchannel inputs have a natural or background component as well as management influenced inputs. This monitoring is intended to isolate and quantify suspended sediment inputs from the surface and inboard ditch of roads (not mass wasting events associated with roads and culverts). Road upgrading measures and winter use limitations are expected to reduce road erosion and resulting turbidity (suspended sediment). To monitor the effectiveness of the reduction of road erosion, turbidity and suspended sediment monitoring will be conducted.

Turbidity monitoring will be focused on the four watersheds that make up the Experimental Watershed Program: the Little River, South Fork Winchuck River, Ryan Creek, and Ah Pah Creek). Within each of the 4 experimental watersheds, turbidity will be measured immediately above and below selected road crossings in 1st and 2nd order streams that have consistent flows during winter. The difference in observed turbidity between the monitoring locations is assumed to due to surface runoff (erosion) from the road. The road surface erosion monitoring will also compare this change in turbidity on individual road segments before and after road upgrading, and between roads which have been upgraded and those which have not. Continuous turbidity monitoring stations will also be employed within specific streams in the four experimental watersheds (see Section D-3: Suspended Sediment and Continuous Turbidity Monitoring. Continuous turbidity monitoring stations will be monitoring all changes in the experimental watersheds (i.e. all effects). These data can be used for comparing all changes within each of the experimental watersheds.

Appropriate threshold values for turbidity monitoring cannot be determined at this time. Approximately five years of initial trend monitoring are expected to be necessary to set the appropriate biological objectives and threshold values. At the end of 5 years a review and evaluation of trend monitoring results will be conducted and threshold values determined.

D.1.5.2 Monitoring Methods

Two samples will be taken in the watercourse: one upstream of the crossing above the influence of any inboard ditch contribution and one just downstream of the watercourse crossing. Successive samples (flow and grab) must be taken at the same location each time. The difference between the upstream sample and the downstream sample is the contribution of the road surface and connected inboard ditches. Suspended sediment measured at watercourse crossings along road segments is the response (dependent) variable that will be used in the analysis. However, the amount of sediment that enters at a watercourse crossing will also depend on the following independent variables: rainfall intensity, length (or area) of road contributing to a watercourse, amount and type of road use, age/construction of the road, and status of the road (upgraded or not upgraded). Rainfall will be measured with collecting gages at the sample road segments and a primary event recording rain gage located at an appropriate location (e.g. Pollnow Peak in the Little River HPA) will measure rainfall intensity. The length of inboard ditch (or road surface area) contributing sediment will be measured at each sample site. Road segments will be selected based on road status (upgraded vs. not upgraded) with a wide range of anticipated use. Sites on roads that have not been upgraded will be used to establish a "baseline condition" from which a treatment effect could be determined when the road is upgraded. Road upgrading will involve rocking or re-rocking road surfaces intended for winter use and hydrologically disconnected inboard ditches from watercourses. Road upgrading involves other treatments as well, however, the measures described above will likely have the greatest effect at controlling road-related surface erosion.

D.1.5.2.1 Site Selection

Various road segments representing categories of road use and road condition will be selected. The categories will be low and moderate-use versus high-use roads, and road segments scheduled for upgrade in an upcoming year versus roads that have already been upgraded. For each of these road sections, a random starting point will be selected from the first 5 crossings with every fifth crossing systematically selected for sampling beyond that point. This sampling intensity may change depending on how many crossings are available for sampling in a given area. The selection of sites will be reviewed by the agencies.

D.1.5.2.2 Field Measurements

Inexpensive plastic rain gauges will be dispersed throughout the monitoring area. A record log will be associated with each gage to track daily, site specific rainfall quantity. The date, time and quantity will be recorded during every sampling event. A separate rain gage will be maintained at a crew member's residence in order to track relative rainfall and possibly provide a trigger to initiate sampling at higher intensity rainfall events. For example; if the target is a 1" storm event, current rainfall at the off-site location can be tracked until the threshold is approached, at which time field sampling can begin.

Flow will be measured at each site during each sampling event. Standard flow measurements for low flow streams will be employed. Flow will be measured as the product of cross-sectional area and water velocity over a known length (usually 1-2 m) of channel with relatively uniform depth and width. Stream depth will be estimated by measuring at 1/4, 1/2, and 3/4 intervals across the stream and dividing by four (Platts et al. 1983). Water velocity will be estimated by timing the surface speed of a small floating object for three trials over the pre-determined length of stream. If site selection allows for flow measurements at culvert outlets then that method may be preferable. A calibrated bucket can be placed at the outlet and the amount of time it takes to fill to a certain level will provide a flow measure. The total length of the contributing inboard ditch to the watercourse will also be measured.

The grab samples will be collected in 0.5 L plastic bottles from a well mixed area of the stream that will remain consistent for all sampling events. The bottle should be filled as much as reasonably possible, especially if the sample is relatively clear, to insure that a measurable amount of sediment will be available following the filtration process. This grab sample will be taken back to the lab for processing. Sample processing and analysis will follow the Redwood Sciences Laboratory protocols.

D.1.5.3 Literature Cited

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D.1.6 Headwaters Monitoring

D.1.6.1 Introduction

Most of the research and protocols developed for monitoring forest aquatic systems in the Pacific Northwest have focused on anadromous fish populations and their habitat conditions within third order or larger streams. Using the fish populations as indicators of watershed health is problematic, as factors outside the freshwater system have a major impact on population levels. As a result, much of our monitoring program is focused on the habitat conditions within the fish-bearing reaches of streams. However, it is possible that habitat conditions will be shown to improve throughout the life of the plan, but fish populations will continue to decline. It is critical to the monitoring program to provide a definitive biological link to freshwater habitat conditions.

The headwaters monitoring project will provide this biological link by focusing on the populations of the two obligate headwater species (tailed frog and southern torrent salamander) that are the most sensitive to the potential impacts of timber harvest. These species are unique relative to anadromous fish species in lower stream reaches in that they have relatively limited vagility and typically live out their entire lives in or immediately adjacent to a relatively short reach of stream. Therefore, the population levels of obligate headwater species are influenced by the conditions that exist within or immediately adjacent to the stream course. Although there are many demonstrated risks associated with the use of biological indicator species, the population levels of the headwater amphibian species covered in this plan should provide a good biological indicator of the general effectiveness of the plan in achieving the biological goals of maintaining cold water temperatures and reducing excessive sediment inputs into streams.

In addition to the need to provide a biological indicator, the focus of the headwaters monitoring will be on populations because there are no well defined protocols that can be directly applied to monitor the habitat conditions within headwater streams. Research in smaller headwater streams has typically focused on the populations and habitat associations of the species that live in these streams. In comparison to numerous studies designed to monitor the impact of watershed processes on stream morphology in fish bearing streams, little has been done to monitor the impact of those same processes on headwater streams. It is known that headwater streams typically have higher gradients and more confined channels than lower stream reaches, and as a result are primarily sediment transport reaches. There are no readily implemented techniques to monitor how sediment movement through these systems impacts the quality of the habitat in the stream. Although Simpson will monitor some elements of habitat conditions in headwater streams, the headwaters monitoring program will be primarily focused on populations of the two obligate headwater species covered under this

AHCP/CCAA, the tailed frog and southern torrent salamander. Populations of tailed frogs and southern torrent salamanders should provide the best indicator of overall habitat conditions in headwater streams.

D.1.6.2 Tailed Frog Monitoring

Tailed frog habitat has been characterized as perennial, cold, fast flowing mountain streams with dense vegetation cover (Bury 1968; Nussbaum et al. 1983). To support larval tailed frogs, streams must have suitable gravel and cobble for attachment sites and diatoms for food (Bury and Corn 1988). Streams supporting tailed frogs have been found primarily in mature (Bury and Corn 1988; Welsh 1990) and old growth coniferous forests (Bury 1983; Welsh 1990). Bury and Corn (1988) reported that the frogs seem to be absent from clearcut areas and managed young forests (Welsh 1990). Although these authors did not establish a cause and effect relationship, it can be hypothesized that tailed frog populations could be affected by both direct (on site) and indirect (off site) impacts of timber management. Direct impacts could include activities such as excessive canopy removal at the site leading to elevated water temperature or changes in the algal community of the stream, or direct physical disturbance by operating heavy equipment within the site. However, tailed frogs may be vulnerable to indirect impacts that occur off site from the upper reaches of watersheds that result in elevated water temperatures or excessive sediment loads. In this regard they are similar to the salmonid species except that such indirect impacts could affect tailed frog populations before cumulative impacts can be manifested in the lower fish-bearing reaches of the watershed.

The primary focus of the tailed frog monitoring will be on the larval population. While the adults can move between the stream and adjacent riparian vegetation, the larvae respire with gills and are tied to the stream environment. They require a minimum of one year to reach metamorphosis (Wallace and Diller 1998), which necessitates over-wintering in the streams. They feed on diatoms while clinging to the substrate with sucker-like mouth parts (Metter 1964) and have limited swimming ability. This makes them potentially vulnerable to excessive bed movement of the stream during high flows, which have previously been documented to drastically reduce the larval cohort (Simpson unpublished data). As a result of their life history requirements, the larvae provide the most immediate and direct response to changes in stream. In addition, larval tailed frogs can be captured with ease while causing minimal disturbance to the site. Ongoing studies have allowed us to develop a protocol that has been shown to be highly effective in estimating larval populations. Adults can also be captured with minimal disturbance to the site, but in contrast to the larvae, their population size cannot be readily estimated. As a result of all the factors discussed above, the primary response variable for the tailed frog monitoring will be the size of the larval population.

D.1.6.2.1 Study Design

The primary monitoring approach will employ a paired sub-basin design. The goal will be to compare changes in larval populations of tailed frogs in randomly selected streams in sub-basins with (treatment) and without (control) timber harvest. Paired sub-basin will be based primarily on geographic proximity, because this increases the likelihood of similar weather patterns, elevation and geologic formations. However, geology can show dramatic local differences, which would preclude utilizing some potentially paired sub-basins that are in close proximity and otherwise quite similar. Finding a large number of streams in paired sub-basins from which to randomly choose will be difficult. Therefore, sampled streams will sometimes be selected based on being the only available stream for pairing within an adjacent sub-basin. When possible, streams in sub-basins scheduled to be harvested (treatment streams) will be paired with streams in sub-basins scheduled for little or no harvest (control streams). However, finding a control stream to match with every harvest stream will not be critical to the statistical validity of the overall project. In some cases, control sub-basins with no timber harvest will not be available in which case changes in larval populations will be compared to the amount of timber harvest in the sub-basin. The advantage of pairing is that statistical power may be increased if the variable (timber harvest) which forms the basis for pairing affects the response variable of interest (larval population).

All of the streams within the study area have been impacted from past land management activities. Many of these streams were heavily impacted from unregulated timber harvesting and other land management activities, which presumably adversely affected tailed frogs. Since the inception of the California forest practice rules in the mid 1970s, protection of headwater streams has increased and it is our assumption, corroborated by review of past aerial photographs, that stream conditions have generally improved for tailed frogs in recent years. Therefore, Simpson also assumes that populations of tailed frogs that currently exist in streams either managed to survive the heavy impacts of the past or recolonized the stream some time after the initial impacts occurred. In either case, Simpson also assumes that lacking any new impacts, current populations of tailed frogs will continue to persist into the future. Therefore, the assumption is that tailed frog populations in control streams will persist at or above their current levels, for the life of the Plan and that statistically significant changes in tailed frog populations in treatment streams relative to control streams will be due to the treatment effect. Assumptions of persistence of the control populations will be further tested through future graduate studies of the adult populations to estimate demographic parameters. Specifically, Simpson will use mark-recapture methods to estimate the size of the adult population, mean fecundity and age-specific survival.

Within each treatment and control stream, one tailed frog reach within the primary breeding zone for tailed frogs will be selected for sampling. The sampling reach in treatment streams needs to be located below the treatment area such that the stream reach has the potential to be influenced by all direct and indirect impacts of the treatment. Control reaches should be located in a similar position in the sub-basin relative to the paired treatment reach. Logistical constraints will be used to limit the potential placement of the monitoring reach, but the specific starting point will be randomly chosen from some reasonable access point. The monitoring reach within each sub-basin will be sampled at least one year prior to operations that could influence the treatment sites and every year thereafter. New sub-basins will be added across the ownership as the opportunities exist. (New sites cannot be created unless there is going to be harvesting in the area to create the treatment reach.) The goal is to have a minimum of 12-15 paired sites that are well distributed across the Plan Area to represent different physiographic regions. If there is little variance in the treatment effect among sites, this minimum number will be statistically adequate to reach a definitive conclusion on the impact of harvesting on tailed frogs. However, if there is substantial variation in the treatment response, it will be necessary to add additional sites. The actual maximum number is a statistical question that cannot be answered until the data are collected and analyzed. The duration of the monitoring will be dependent on the inherent within and among stream variation in tailed frog abundance along with annual variation among and within streams (i.e. statistical power of the monitoring). The amount of harvesting in the treatment sub-basins may also influence the duration of the monitoring, since one cannot conclude that no treatment effect has occurred until the maximum treatment level has been achieved. All of these unknown variables make it impossible to set a minimum duration for this monitoring, but it will likely take at least 5 years before the minimum number of sites have been established, and it is anticipated that each monitoring site will be monitored for at least 10 years.

D.1.6.2.1.1 Monitoring Protocol

Chronology

Sampling will begin in the late spring or early summer when flows are sufficiently low to allow working efficiently in the stream. The animal sampling must be completed by late July to avoid sampling after larvae have begun metamorphosing and leaving the stream. Substrate sampling can be most efficiently done in late summer or early fall during minimal flows and after the larvae have metamorphosed. Flow measurements will be done in August to get a standardized low flow estimate among all streams. Stream temperature profiles will be obtained from mid-summer to early fall (July – October).

Physical Stream Characteristics

Water temperature data recorders will be placed near the lower end of each monitoring reaches from mid-summer (July) until early fall (October) to determine temperature profiles during the warmest time of the year. In addition, potential differences in mainstream water temperatures due to side tributaries will be measured and recorded with a hand-held thermometer.

Discharge (flow) will be measured as the product of cross-sectional area and stream velocity over a known length (usually 1-2 m) of stream with relatively uniform depth and width. Stream depth will be estimated by measuring at ¼, ½, and ¾ intervals across the stream and dividing by four (Platts et al. 1983). Water velocity will be estimated by timing the surface speed of a small floating object for three trials over the pre-determined length of stream. This will be measured on all streams in late August during minimal flows to reduce the effects of seasonal variation.

Changes in substrate composition will be estimated by assessing material deposited at the tail-out of pools. From the beginning of the sample reach, walk upstream sampling each low gradient riffle (0-5%) at the tail-out of the pool. Riffles will be excluded from sampling if bedrock, LWD or some other stream feature prevents the substrate from being deposited by normal hydrologic scouring and depositional processes of stream flow. In addition, riffles should not be sampled if they have been recently disturbed by the stream layout or sampling procedures.

At each site chosen for substrate sampling, measure and record the gradient using the "measuring stick" and clinometer, and record canopy closure using a concave densiometer (4 cardinal directions measured at the center of the stream). Place a 45x45cm grid with 5cm mesh in the center of the stream at the pools tail-out. Record each substrate type, based on particle size, at each intersection on the grid. The particle size is determined by measuring the secondary axis of the substrate. This results in a total of 100 readings for each sample. Continue upstream repeating this process until the end of the monitoring reach has been reached. Table D-2 provides the particle size and types classification.

Table D-2. Particle size and type.

Size	Particle Type
<0.06mm	Fine (F)
0.06-2mm	Sand (S)
2mm-6cm	Gravel (G)
6-13cm	Small Cobble (SC)
13-26cm	Large Cobble (LC)
26-51cm	Small Boulder (SB)
>51cm	Large Boulder (LB)

<u>Stream Reach Layout (Selection of Habitat Units)</u>

1. The sample reach of the treatment stream is located below the treatment area so that the stream reach has the potential to be influenced by all direct and indirect impacts of the treatment.

2. A similar stream reach needs to be designated in the same watershed position in an adjacent watershed to serve as the control stream. The logistics of getting to the designated stream reaches will normally dictate the general of the monitoring reach, but the specific starting point of a stream reach will be randomly chosen.

3. Habitat units will be delineated by hiking up the designated stream reach with a hip chain and recording fast and slow-water stream habitat units that are at least 1.5m in length (fast-water = riffles and cascades; slow-water = pools and runs).

4. Selection of sites where sampling belts will be placed is as follows: all fast-water habitat units in a stream reach will be identified and measured for length. All fast-water habitat will be in theory placed end-to-end as if it was all contained in one long habitat unit. A random start, labeled m, between 1 and 3 will be chosen, the m-th belt from the beginning of the linear assemblage of fast water habitat will be sampled, the (m+3)-th belt from the beginning of the linear assemblage will be sampled, the (m+6)-th belt from the beginning of the linear assemblage will be sampled, and so on. In the end, every third belt after the m-th will be sampled.

5. Each fast water unit is considered to be 3m in length. Therefore, every ninth meter of fast water will be sampled as a 1.5 to 3m belt. Sample every tenth slow-water unit of at least 1.5m in length from a random starting point.

6. For long slow water units, such as more than 6m, the large unit can be broken up into smaller units of approximately 3m each in order to maintain consistent sampling intensity. If the designated unit is unsearchable due to water depth, organic debris or excessive gradient, go on to the next available unit.

7. Continue up the stream until 30 sample belts are identified. Record and sum the total number length of each of the habitat types within the sample reach.

8. The starting point of the monitoring reach will be permanently monumented, but the first belt to be sampled will be randomly selected each year that the reach is re-sampled.

Animal Sampling

1. If the selected slow-water unit is between 1.5-3.0m in length, delineate the entire unit for sampling. If the unit is greater than 3.0m, randomly select the starting point based on 1m increments and sample a 3.0m belt.

2. If a fast-water belt crosses a habitat unit boundary and more than 1.5m of a belt is in one of the habitat units, then sample that length for the belt. If less than 1.5m of a belt is in one unit while the rest is in another, then sample the next belt or, if possible, move that belt back within that unit to sample 1.5 to 3m.

3. Prior to any disturbance of the unit to be sampled, place a blocking net at the downstream end of the unit. Measure the gradient of the unit, depth of the water at the mid-point of the unit (measure at ¼, ½, and ¾ intervals across the channel and divide by 4 to get average depth), width at the beginning, mid-point and end of the unit and length of the unit (1.5-3m).

4. Remove all the substrate that can be moved by hand within the sample unit and collect any animals that may be incidentally seen during this process.

5. Do the first visual search of the unit using a viewing bucket and remove all tailed frogs seen. Place all of these animals in an appropriate container and repeat the visual search three additional times.

6. Check the blocking net after each pass and place any animals seen with the other animals collected during the search. If the number of frogs obtained in a removal pass is larger than the number of frogs obtained in a previous pass, perform an additional pass for a total of five.

7. Record the sex (adults only) and age class for each tailed frog captured. Following the final search, remove the blocking net, put the substrate back into the stream and release the animals back into the stream.

D.1.6.2.2 *Tentative Analysis*

The tailed frog monitoring protocol will yield the following data: 1) an estimate of the total number of tailed-frogs for each monitoring reach (using removal/depletion techniques), and 2) various physical measurements associated with each monitored reach (water temperature, flow, canopy cover and etc.). In addition, the distance and amount of disturbance (treatment sites) will be recorded.

D.1.6.2.3 *BACI Analysis*

For this analysis, the estimated number of tailed frogs in each stream will be analyzed using standard before-after-control-impact (BACI) analyses (Skalski and Robson 1992; McDonald et al. 2000). These analyses will make use of the paired nature of monitored streams and will adjust for nuisance variables that were used to form the pairs.

Following the philosophy of BACI analyses, the lack of parallelism in time trajectories of tailed-frog abundance on the control and treatment sites will be estimated from raw data. If the time trajectories of responses on the control sites are not parallel to those on the treatment sites, the treatment will be deemed associated with changes in the response. Parallelism will be estimated using the interaction effect in a univariate repeated measures analysis of variance (Little et al. 1996), where the pair and treatment-control factors are applied to "main plots" and the before-after disturbance factor forms the repeated measure. Using the systematic nature of sampled segment, a single tailed-frog abundance estimate will be computed for each monitored stream. Assuming p treatment-control stream pairs and t years of monitoring, the anticipated BACI analysis of variance table appears in Table D-3. Following McDonald et al. (2000), interest lies in components of the timeXtreatment interaction factor because they quantify the lack of parallelism in time trajectories. Significance of the interaction components will be assessed using standard likelihood ratio tests and will adjust for estimated overdispersion. Other environmental variables, such as flow and canopy cover, will be considered for inclusion in the repeated measures analysis of variance model to adjust estimated parallelism for these types of nuisance variables.

Table D-3. Anticipated analysis of variance table for the BACI analysis of tailed-frog monitoring data[1]

Source	Degrees of Freedom
Pair	p-1
Treatment	1
Pair X Treatment	p-1
Time	t-1
Time X Treatment	t-1
Residual	2(t-1)(p-1)
Total	2pt-1

Note
1 The BACI analysis is a repeated measures analysis and follows the philosophy of McDonald et al. (2000) where interest lies in the Time X Treatment factor.

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D.1.6.3 Southern Torrent Salamander Monitoring

D.1.6.3.1 Introduction

Torrent salamanders are generally found in springs, seeps and the uppermost headwater reaches of streams (Nussbaum et al. 1983; Stebbins 1985). They are a small salamander that appears to spend most of its time within the interstices of the stream's substrate, which make them difficult to locate and capture without disturbing their habitat. The larvae have gills and are restricted to flowing water while adults also appear to spend most of their time in the water, but are capable of movements out of the water. They are thought to have limited dispersal abilities and small home ranges so that recolonization of extirpated sites may take decades (Nussbaum and Tait 1977; Welsh and Lind 1992; Nijhuis and Kaplan 1998). Given the highly disjunct nature of their habitat, individuals at a given site (sub-population) are likely to be isolated from other adjacent sub-populations. The degree of isolation of these sub-populations probably varies depending on the distance and habitat that separates them so that torrent salamanders could be best described as existing as a meta-population.

Although there is some evidence for cumulative effects of sediment input in certain sites, torrent salamanders are primarily vulnerable to potential direct impacts from timber harvest (Diller and Wallace 1996). Direct impacts could include activities such as excessive canopy removal at the site leading to elevated water temperature, operating heavy equipment in the site, or destabilizing soil leading to excessive sediment deposits at the site. Past observations have indicated that these direct impacts can lead to extinction of the sub-population at the site. Due to the survey difficulties noted above, an attempt to get a statistically rigorous estimate of the number of individuals at monitored sites would be impractical. In spite of this, the project will provide an index of the number of individuals at each site and a record of the life history stage of each individual captured. However, given the unreliability of the index of sub-population size, the persistence of individual sub-populations will be used as the primary response variable for the torrent salamander monitoring.

Concerns could be raised that there are too few sub-populations in the meta-population of torrent salamanders to expect to see significant changes over time, or that any lose in sub-populations would threaten the long-term persistence of torrent salamanders within the Plan Area. However, Simpson has already located 598 torrent salamander sites (sub-populations) across the Plan Area and estimates that no more than 25-30% of the total potential habitat has been surveyed. In addition, without a formal monitoring protocol, Simpson has already documented both the apparent extinction and re-colonization of several torrent salamander sites. This would indicate that the meta-population concept does appear to apply to torrent salamanders in this region.

D.1.6.3.2 *Study Design*

The primary monitoring approach for southern torrent salamanders will employ the same paired sub-basin design that was described above for tailed frogs. Monitoring for tailed frogs and torrent salamanders will be geographically linked whenever possible by selecting monitoring sites for torrent salamanders in the same sub-basins where a tailed frog monitoring reach has already been selected. Therefore all the same criteria used to select sub-basins for monitoring described above will also apply to torrent salamander monitoring. However, instead of using larval populations as the primary response variable, Simpson will compare changes in the persistence of sub-populations of torrent salamanders in treatment and control sub-basins. In addition, within each sub-basin (treatment and control), two torrent salamander sites in the uppermost reaches of first order tributaries will be randomly sampled.

As noted above, all of the streams within the study area have been impacted from past land management activities. Many of these streams were heavily impacted from unregulated timber harvesting and other land management activities, which presumably adversely affected torrent salamanders. Since the inception of the California forest practice rules in the mid 1970s, protection of headwater streams has increased and it is our assumption, corroborated by review of past aerial photographs, that stream conditions have generally improved for torrent salamanders in recent years. Therefore, Simpson also assumes that populations of torrent salamanders that currently exist in streams either managed to survive the heavy impacts of the past or recolonized the stream some time after the initial impacts occurred. In either case, Simpson also assumes that lacking any new impacts, current populations of torrent salamanders will continue to persist into the future. Therefore, it is assumed that torrent salamander populations in control streams will persist at or above their current levels, and that statistically significant changes in torrent salamander persistence in treatment streams relative to control streams will be due to the treatment effect.

The sampling reaches in treatment sub-basins need to be located such that they will be located within a future treatment area (harvest unit). Control reaches should be located in a similar position in the sub-basin relative to the paired treatment reaches. Logistical constraints will be used to narrow the potential placement of a monitoring reach, but the specific starting point will be randomly chosen from some reasonable access point. The monitoring reaches within each sub-basin will be sampled at least one year prior to operations that could influence the treatment sites and every year thereafter. New sub-basins will be added across the ownership as the opportunities exist. (New sites cannot be created unless there is going to be harvesting in the area to create the treatment reach.) The goal is to have a minimum of 12-15 paired sites that are well distributed across the Plan Area to represent different physiographic regions. If there is little variance in the treatment effect among sites, this minimum number will be statistically adequate to reach a definitive conclusion on the impact of harvesting on torrent salamanders. However, if there is substantial variation in the treatment response, it will be necessary to add additional sites. The actual maximum number is a statistical question that cannot be answered until the data are collected and analyzed. The duration of the monitoring will be dependent on the inherent within and among stream variation in persistence of torrent salamander sites along with variation in abundance of salamanders (i.e. statistical power of the monitoring). The amount of harvesting in the treatment sub-basins may also influence the duration of the monitoring, since one cannot conclude that no treatment effect has occurred until the maximum treatment level has been achieved. All of these unknown variables make it impossible to set a minimum duration for this monitoring, but it will likely take at least 5 years before the minimum number of sites have been established, and it is anticipated that each monitoring site will be monitored for at least 10 years.

D.1.6.3.3 *Monitoring Protocol*

Chronology

Sampling should be done in the fall after enough rain to insure that the riparian habitat is cool and moist, but while stream flows are still low. The larger torrent salamander streams with higher flows should be surveyed first with other streams surveyed in order of decreasing flow. The goal is to insure that adult salamanders are active at the surface at a time when stream flows are low enough to make searching for larvae efficient. Stream temperature profiles will be obtained from mid-summer to early fall (July – October).

Physical Stream Characteristics

Water temperature data recorders will be placed near the lower end of each monitoring reach from mid-summer (July) until early fall (October) to determine temperature profiles during the warmest time of the year.

The total length and the amount of searchable habitat within the sample reach will be determined using a hip-chain or tape measure. The total amount of searchable habitat should be at least 10m with a maximum of 30m.

Measurements of active channel width will be made where obvious scouring can be seen somewhere near the beginning, middle, and end of the reach. Canopy closure will be measured with a spherical densiometer on the four cardinal directions at the same points (beginning, middle, and end) along the reach.

Discharge (flow) will be measured as the product of cross-sectional area and stream velocity over a known length (usually 1-2 m) of stream with relatively uniform depth and width. Stream depth will be estimated by measuring at ¼, ½, and ¾ intervals across the stream and dividing by four (Platts et al., 1983). Water velocity will be estimated by timing the surface speed of a small floating object for three trials over the pre-determined length of stream. This will be measured on all streams in late August during minimal flows to reduce the effects of seasonal variation.

Gradient of the reach will be measured using a clinometer. The gradient measurement can be broken up into more than one measurement depending on the length of the reach. Cascades are not included as part of the gradient measurement.

Where possible, changes in substrate composition will be estimated by assessing material deposited at the tail-out of pools in the same manner that was described for tailed frogs above. However, many torrent salamander reaches are sufficiently short and with such high gradient that no low gradient riffles are available at the tail-out of pools. As a result, it will be necessary to record a qualitative description of the habitat conditions associated with the reach. Include substrate composition, signs of recent sediment inputs, bank erosion or scour, inner gorge slides, and overall assessment of the quality of habitat for torrent salamanders. If it is feasible, the site will be photographed to document the general habitat conditions.

Animal Sampling

The entire length of the reach will be searched carefully for animals by moving upstream from the bottom of the reach turning the substrate by hand or with a rake when necessary. When flows are sufficiently high to allow animals to escape downstream without being detected, the search will be conducted while holding an aquarium net downstream of the area searched. Also search along the margins of the stream by turning rocks and moveable woody debris.

For each salamander found record: distance from the beginning of the reach to where the salamander was found, age class and sex of adults and habitat type where the salamander was found (e.g. low, medium, or high gradient riffle, pool, rock or log cascade and etc.).

D.1.6.3.4 Tentative Analysis

The torrent salamander monitoring protocol will yield the following data: 1) presence or absence of torrent salamanders at each monitoring site, 2) an index of salamander abundance (i.e., the raw count) associated with each monitored stream reach, and 3) various physical measurements associated with each monitored reach (water temperature, flow, canopy cover and etc.). In addition, the distance and amount of disturbance (treatment sites) will be recorded. Throughout the period of monitoring, the field sampling protocol applied at each monitored reach will not change. Among other things, this insures that the search effort expended at each monitored reach will be constant and that raw counts of torrent salamanders will be comparable through time. Two monitoring reaches are planned for each stream in each set of paired streams for a total of four monitoring reaches per steam pair.

Two analyses are proposed below. While both analyses will be useful for assessing impacts of timber harvest on torrent salamanders, it is unknown which analysis will be most statistically powerful prior to data collection.

Analysis 1: Regression

For this analysis, the paired nature of stream segments is ignored and the probability of torrent salamander extinction at a site is related to the distance and amount of disturbance (treatment). Let y_i = 0 if torrent salamanders were found on the i-th monitored reach before disturbance and *k* years after disturbance. Let y_i = 1 if salamanders were found prior to disturbance of the i-th monitored reach, but were not found during the field visit(s) that occurred *k* years after disturbance. Monitored reaches that did not contain salamanders prior to disturbance will be ignored in this analysis. Let x_i be either the distance from the i-th monitored reach to the nearest disturbance (treatment), or an index of the amount of disturbance incurred by the i-th monitored site.

A logistic regression equation (Hosmer and Lemeshow 2000), relating the expected value of y_i to x_i, will be estimated to assess the potential effects of disturbance on probability of extinction. The logistic regression equation will be of the form, logit (pi) = b0 + b1xi where pi = E[yi] is the probability of extinction at the i-th site, logit(pi) = log(

pi/(1-pi)), and b0 and b1 are parameters to be estimated. If β_1 is significantly different from 0, the probability of extinction will be declared significantly related to disturbance as quantified by x_i. The significance of β_1 will be assessed using standard likelihood ratio test and will adjust for any estimated overdispersion (Hosmer and Lemeshow 2000).

It is anticipated that the above logistic regression equation will be estimated for *k*=1, 2, 10 years post-disturbance. Other physical variables, such as flow and canopy cover, will be investigated in the logistic regression model to potentially adjust β_1 for these types of nuisance variables.

Analysis 2: BACI Analysis

For this analysis, the raw count of torrent salamanders, or count per unit effort (CPUE), will be analyzed using standard before-after-control-impact (BACI) analyses (Skalski and Robson 1992; McDonald et al. 2000). These analyses will make use of the paired nature of monitored streams and will adjust for nuisance variables that were used to form the pairs.

Following the philosophy of BACI analyses, the lack of parallelism in time trajectories of salamander count or CPUE on the control and treatment sites will be estimated from raw data. If the time trajectories of responses on the control sites are not parallel to those on the treatment sites, the treatment will be deemed associated with changes in the response. Parallelism will be estimated using the interaction effect in a univariate repeated measures analysis of variance (Little et al. 1996), where the pair and treatment-control factors are applied to "main plots" and the before-after disturbance factor forms the repeated measure. Using the systematic nature of sampled segment, a single torrent salamander abundance index will be computed for each monitored stream. Assuming p treatment-control stream pairs and t years of monitoring, the anticipated BACI analysis of variance table appears in Table D-4.

Table D-4. Anticipated analysis of variance table for the BACI analysis of southern torrent salamander monitoring data.[1]

Source	Degrees of Freedom
Pair	p-1
Treatment	1
Pair X Treatment	p-1
Time	t-1
Time X Treatment	t-1
Residual	2(t-1)(p-1)
Total	2pt-1

Note
1 The BACI analysis is a repeated measures analysis and follows the philosophy of McDonald et al. (2000) where interest lies in the Time X Treatment factor.

Following McDonald et al. (2000), interest lies in components of the timeXtreatment interaction factor because they quantify the lack of parallelism in time trajectories. Significance of the interaction components will be assessed using standard likelihood ratio tests and will adjust for estimated overdispersion. Other environmental variables, such as flow and canopy cover, will be considered for inclusion in the repeated measures analysis of variance model to adjust estimated parallelism for these types of nuisance variables.

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D.2 RESPONSE MONITORING

D.2.1 Introduction

Response Monitoring activities include:

- Class I channel monitoring
- Class III sediment monitoring

The Response Monitoring projects, like the Rapid Response projects described above, monitor the effectiveness of the conservation measures in achieving specific biological goals and objectives of the Plan. These monitoring projects are distinguished from the Rapid Response projects by the greater lag time required for feedback to the adaptive management process. The Response Monitoring projects are focused on the effects of cumulative sediment inputs on stream channels. Natural variation in stream channel dimensions, combined with the potential time lag between sediment inputs and changes in the response variables of these projects, make it difficult to determine appropriate thresholds for adaptive management at this time. When yellow and/or red light thresholds are determined, they are expected to require more than three years of results to be triggered in most cases.

D.2.2 Class I Channel Monitoring

D.2.2.1 Background and Objectives

The monitoring objectives of the Class I channel monitoring project are to track long term trends in the sediment budget of Class I watercourses as evidenced by changes in channel dimensions. The long term channel monitoring project is one of four monitoring projects designed to measure the effectiveness of the conservation measures in reducing management related sediment inputs to area streams. This technique is generally best suited for establishing long term trends due to the potential lag times between sediment inputs and the measured response in the monitoring reach. Nine monitoring reaches are currently established in eight streams across the Plan Area. Two additional reaches are established with a reduced protocol (thalweg profile only), because the sites do not meet the criteria necessary for doing the full protocol. An additional monitoring reach on Ah Pah Creek within the Klamath Basin will be established in the near future. These twelve reaches will be measured at least every other year for the duration of the Plan. The channel dimensions measured in each reach include cross-sectional and thalweg profiles, substrate size distributions (pebble counts), and bankfull and active channel widths.

D.2.2.2 Methods

Once a watershed has been selected for long-term cumulative effects monitoring, a sample reach, or reaches, should be located with respect to the channel's overall longitudinal profile. Generally, field inspection is necessary to properly identify desired low gradient (less than 1.5-% slope) stream reaches as potential sample sites; poor resolution of the longitudinal profile constructed from USGS topographic maps often obscures the true longitudinal profile of low gradient reaches.

The entire profile can be subdivided initially into transport, transitional, and aggradational/alluvial reaches. However, cutoff criteria (channel gradient changes) between these subdivisions are not always clear. Major tributary junctions and/or abrupt changes in channel type (e.g., a canyon segment within the low gradient, alluvial reach) may justify finer subdivision. A delta affected by flood backwaters of a larger channel may require an additional reach assignment, or not be selected for sampling.

Rather than sampling randomly or systematically throughout a channel's longitudinal profile, channel reaches most responsive to long-term cumulative effects should be selected. Low gradient channels (less than 1.5%) with alluvial, erodible banks probably are the most sensitive to changes in the watershed sediment budget.

A sample reach should be a minimum of three meander wavelengths long, but in many streams the entire low gradient, alluvial segment of the longitudinal profile probably should be included as one sample reach. A meander wavelength is approximately 7 to 9 bankfull widths long, therefore a monitored channel reach should be approximately 25 bankfull widths long. If the low gradient, alluvial-banked reach of the selected stream is extensive the selection of an appropriate monitoring reach should follow one of several methods. First, divide the entire lower reach into sample reaches of proper length (25 bankfull widths) and randomly select one for long-term monitoring. Second, monitor the uppermost section of the depositional reach. Third, select a monitoring reach for all parameters using one of the first two methods, but collect data for several of the parameters (such as thalweg profile, and pebble counts) for the entire depositional reach. Site selection may change as trend is analyzed from initial surveys to capture the section of the channel most responsive to change.

The following will be collected, analyzed, and reported:

- Determine drainage area at head of sample reach;
- Plot longitudinal profile from USGS topographic maps;
- Distinguish transport, transitional, aggradational segments on the longitudinal profile;
- Estimate average annual rainfall;
- Estimate average annual runoff;
- Estimate annual maximum flood duration curve;
- Inventory available aerial photographs, especially historical photos;
- Acquire personal photographs, verbal accounts; and
- Check CDFG for documented stream surveys.

The acquisition of historical information and photographs of the long-term monitoring watershed, especially historic photos of the actual monitoring reach are vital to evaluating the present channel condition with respect to recovery.

D.2.2.2.1 Plan Mapping

The plan map is a template for all additional measurements and can be produced either by hand or by various computer software packages. The following steps provide the data for plan map development and locations for all additional measurements within the monitoring reach.

Center Tape

After selection of the monitoring reach, place the beginning of the first 300 foot tape at a randomly selected starting point within the first ten feet of the beginning the monitoring reach. Because some measurements off the center tape occur at set 10-foot intervals, a random starting point creates a random, systematic sampling design. Methods to select random numbers include a random number chart, random # function on a calculator, or a roll of a pair of dice.

Two 300 foot centerline tapes are set up the channel, end to end, roughly between the bankfull channel edges, in straight segments. The ends of each tape are held in place with rebar stakes driven into the streambed.

Drive four-foot long rebar stakes into the streambed at any turning points along the tapes. Fix the position of the tapes by clamping them to the rebar turning points. Short pieces of hose (4-6 inches) are slipped over each rebar stake to protect the center tape from abrading on the rebar.

Record the length (nearest 1/10 of a foot) and azimuth (0^{o} to 360^{o}) of each leg or segment along the center tapes.

All measurements include a point location described in reference to the center tape. A point location includes a station number (feet upstream from the beginning of the tape) and the shortest distance between bankfulls for channel dimension measurements; or a perpendicular distance from the center tape for thalweg measurements. Measurements to the right of the center tape are recorded as a positive number. Measurements to the left of the center tape are recorded as a negative number. For example, (STA. 57.2', -14.3') is a point 57.2 feet upstream and 14.3 feet to the left of the center tape. Negative and positive numbers are used to reference spatial locations off of the center tape so that the plan map can be generated by the Microstation software program.

Temporary Benchmarks (TBMs)

The rebar stakes used for turning points are also used for TBMs. Assign an arbitrary elevation of 100' to the TBM furthest downstream.

Using a surveyor's level, survey elevations of all TMBs in reference to the arbitrary 100' TBM. "Close the loop" frequently (at least daily) to catch any surveying or note recording mistakes in a timely fashion.

In your field notebook record the point location of each TBM. A simple sketch of TBM locations can also be helpful for future reference.

D.2.2.2.2 *Channel Dimensions*

Working upstream, record the active channel width (Qa), and the bankfull channel width (Qbf) at the shortest distance between bankfulls on 10 foot intervals off of the center tape. For plan map purposes, take an azimuth at every channel dimension measurement. When the precise location of Qa or Qb is uncertain, use a surveyor's level to shoot the elevation of the nearest appropriate unambiguous channel dimension break. The elevation of the known channel break should be matched (allowing for the necessary change in stream gradient) to find the undecided point location.

Active channel (Qa) definition and indicators: Qa width is the wetted width during base winter flow. Some indicators of Qa along exposed cutbanks are fine exposed alder and willow roots and the lower extent of lichen and moss. "Bathtubs rings" and young (less than two years old) alder and willow growth are indicators along point bars. Combine these indicators with slight breaks in bank slope and slight changes in substrate particle size to locate the Qa margin.

Bankfull channel (Qbf) definition and indicators: Qbf is the wetted width during an elevated flow with a recurrence interval of approximately 1.5 to two years. This is the elevation at which bedload movement initiates and when elevated flows begin to spill onto flood terraces and dissipate scouring forces. Some indicators of Qbf include the edge of perennial vegetation such as mature alders and occasionally conifers. On the outside of meander bends look for the tops of exposed point bars. Combine these indicators with significant breaks in bank slope and changes in substrate particle size to locate Qbf.

D.2.2.2.3 *Thalweg Profile*

Working upstream, survey the thalweg depth (elevation) and location in reference to the center tape. The thalweg is the deepest point of the flowing channel, excluding any detached or "dead end" scours and/or side channels. These features are important and could be surveyed later and added to the plan map, however do not include these deep points in the thalweg profile or analyses of thalweg residuals.

At 10 foot intervals, measure the perpendicular distance (left or right) from the center tape and shoot the thalweg elevation.

Use the nearest TMB to determine the elevation of the surveyor's level. Record each thalweg elevation to the nearest 1/100 of a foot.

Record the point location of each elevation measurement using the numerical referencing described in Section D.2.2.2.1.

Always record the thalweg elevation at the maximum depth and the crest of the tailout of all pools so that pool depth variation (thalweg elevation residuals) can be calculated.

D.2.2.2.4 *Pebble Counts*

Straight channel reaches, exceeding three to four bankfull widths long, are the best sites for pebble counts. These sites usually coincide with thalweg crossovers (where the thalweg switches from one bank to another). These areas are generally uniform in cross-sectional dimensions and are resistant to adjustments in channel width. With relatively less change in water surface slope over a wide range of discharges, deposition is less likely to include secondary deposits overlaying primary deposits (each having its own particle size distribution). This substantially reduces surface particle size variation.

Each pebble site location includes the area from the top to the bottom of the riffle and the width of the Qa channel. Most riffles are diagonal to the flowing channel - be sure to sample only the riffle area. This may necessitate truncating either or both ends of the riffle in order to sample a roughly rectangular area. Measure the area of, and then exclude any LWD or localized sand deposits, which are larger than 10% of the sample area.

Divide the rough length of the sample area by ten to determine the location of ten approximately equally-spaced transects across the riffle. Randomly select a starting point for the first transect (between zero and the determined spacing) then systematically locate the remaining nine transects to be sampled. For example, if the riffle was 100 meters long - first divided the riffle into ten, 10 meter sections. Then using a random number chart you pick a number between 0 and 10 - lets say “4”. The first transect to conduct a pebble count would be at 4 meters, the second transect at 14 meters, the third at 24 meters, etc.

Along each transect, randomly select fifteen pebbles at approximately equal intervals and measure the secondary axis to the nearest millimeter. To randomly select a rock, walk along the transect without looking at your feet or the channel bottom. After the appropriate number of steps required to achieve equal spacing along the transect, stop and place your finger at the tip of your right foot and touch to the ground. The first pebble you touch is the one you pick up and measure to the nearest millimeter. Repeat this procedure until 150 pebbles have been sampled across the entire riffle. The secondary axis is the diameter that would allow the pebble to pass through a sieve.

In the field notes record the surveyor and transect number, along with the appropriate measurements. Sketch each pebble count sample site in the field notebook including area measurements of the site and any LWD and/or local sand deposits.

D.2.2.2.5 *Repeat*

Continue to measure the channel dimensions, thalweg profile, and conduct pebble counts along each 600-foot reach of center tape until the end of the monitoring reach.

D.2.2.2.6 *Measurement Error Calibration*

Due to the subjective nature of several of the proposed monitoring variables it is necessary to quantify the measurement error between crews. Once the monitoring reach is selected, determine the number of 300-foot tapes required for the survey. Then, randomly select two numbers between zero and total number of tapes (again - use a random number chart, random # function on a calculator, or roll a pair of dice). These two reaches will then be surveyed twice for channel dimensions and the thalweg profile following the appropriate protocols. Because this exercise is testing for measurement error, it is necessary for each crew to use the same randomly selected starting points. Two crews, of two members each, will independently survey each channel reach. The difference between the two surveys is considered the measurement error.

D.2.2.2.7 Permanent Bench Marks

Two permanent benchmarks will be installed, one at each end of the monitoring reach. These benchmarks should be located well above the bankfull channel margin near an established, easily recognized feature (bridge, old-growth stumps, and boulder). Include a sketch of the bench mark location in the field notebook. Permanent benchmarks are constructed using one to two bags of redimix concrete and a carriage bolt. Dig a hole about one foot in diameter and two feet deep. Fill the hole with redimix and mix in water to from concrete. Sink the carriage bolt upright into the middle of the concrete pad, leaving about 1" of the bolt exposed. Survey the elevation of the permanent benchmarks using the nearest TBM as a reference. The datum and associated elevations should reference mean sea level, otherwise (or until surveyed) an arbitrary elevation can be assigned to the downstream benchmark. Recent state legislative activity may soon require licensed land surveyor approval. Record locations of both permanent benchmarks in reference to the center tape. If a GPS unit is available, enter the positions of both benchmarks.

D.2.2.2.8 Video and Still Photography

Videotaping the entire monitoring reach in an upstream direction will be conducted. This will capture important features within the reach including: location of permanent bench marks, location of cross sections, instream structures, side channel habitat, terraces, and riparian composition. Accurate descriptions of all these features will be made verbally while filming and include the date that the filming occurred. Still photos of the important features described above will also be obtained. While photographing, notes documenting what frame corresponds to which feature will be made so that the developed slide can be labeled with an accurate title.

D.2.2.2.9 Sampling Frequency

The variables will be re-measured every other year. The re-measurement will be conducted to capture changes in channel features resulting from relatively small, yet important, channel-forming flows, such as:

- A coarsening of riffle-bed surfaces by mobilizing fines previously deposited by a major storm event.

Re-measurement will include:

- Taking pebble counts along uniform straight reaches;
- Estimating the peak discharge of the previous winter's high flow to include an update for the flood frequency curve used to determine the occurrence of a 5-year or greater storm event;
- Measuring thalweg profile and calculating thalweg depth residuals; and
- Measuring Qa and Qbf channel widths; and

- In addition, all established monitoring locations in fish-bearing watercourses will be re-mapped as well as re-measured the summer following a storm event with at least a five-year recurrence interval.

D.2.2.3 Data Analysis

Data analyses are performed using the methods of McDonald (1998). This analysis focuses on assessing changes in bank width, thalweg elevation, and shifts in substrate (pebble) size distributions. A section of each creek will be monitored using the methods and at the frequency outlined above. Monitored sections are chosen from the highest (closest to headwaters) depositional reach in each creek. Depositional reaches are chosen because if changes in sediment load or other stream morphology parameters occur anywhere in the watershed, such changes are likely to be reflected in the first depositional reach downstream. During each channel monitoring interval thalweg elevation (defined as the height of the deepest part of the channel), bank full width, active channel width, and substrate (pebble) sizes will be recorded on the monitoring reaches. Thalweg elevation will be analyzed for change in mean elevation. Thalweg elevation residuals (variability in pool depths) will be analyzed for changes in variance. Bank full and active channel widths will be analyzed for changes in average width. Substrate sizes will be analyzed for changes in distribution.

Thalweg elevation will be analyzed for change in mean elevation and thalweg depths will be analyzed for change in variance. These analyses both use statistical models appropriate for correlated data. The basic data are pairs of points, (d_i, y_i), where y_i is thalweg elevation and d_i is the distance from the upper terminus of the reach to the point where y_i is measured. Because thalweg elevations are measured relatively close together (approximately every 10 feet) the measurements (i.e., the y_i) are potentially spatially correlated and do not represent independent observations. Therefore, the analysis accounts for this lack of independence by adjusting model coefficients and significance levels using a one dimensional spatial regression model (Cressie 1991; Venables and Ripley 1994). The spatial regression model estimates a one dimensional correlation function among residuals then adjusts estimates and p-values via generalized least squares regression techniques. The spatial regression techniques and the adjustment for auto-correlation are described in more detail in Appendix A of McDonald (1998).

For the analysis of thalweg elevation, a regression model relating elevation of the thalweg to a cubic polynomial in distance is estimated. Included in this model is a year factor so that the interaction between year and the cubic polynomial in distance can also be estimated. In equation form and provided the reach is monitored for three or more years, the regression relationship is:

$$E[y_i] = \beta_0 + \beta_1 x_{1,i} + \beta_2 x_{2,i}$$
$$+ \beta_3 d_i + \beta_4 d_i^2 + \beta_5 d_i^3$$
$$+ \beta_6 d_i x_{1,i} + \beta_7 d_i^2 x_{1,i} + \beta_8 d_i^3 x_{1,i}$$
$$+ \beta_9 d_i x_{2,i} + \beta_{10} d_i^2 x_{2,i} + \beta_{11} d_i^3 x_{2,i}$$

where y_i is the thalweg elevation measured at a distance of d_i meters from the top of the reach, $x1_{,i}$ is an indicator variable for year 1 (i.e., 1 if observation $_i$ was taken in year 1, 0 otherwise), and $x2_{,i}$ is an indicator variable for year 2 (i.e., 1 if observation $_i$ was taken in year 2, 0 otherwise). These models effectively fit separate cubic polynomials in d_i each year.

The analysis for change in thalweg residual variance is a statistical test designed to detect increased (or decreased) variance in residuals which is indicative of increased (or decreased) pool depths and complexity of the reach habitat. Thalweg residuals are defined as the residuals of thalweg elevation in the above regression model; $ry_i = yy_i - y\^y_i$, where yy_i is observed elevation at distance d_i in year y and $y\^y_i$ is the predicted elevation at distance d_i in year y. The test for change in thalweg residual variance is carried out using a modified version of Levene's test (Neter et al 1991). Absolute deviations of the residuals from their median are calculated as $d_{yi} = |r_{yi} - m_y|$, where d_{yi} is the absolute deviation associated with the i-th observation in the y-th year and m_y is the median of residuals in the y-th year. Levene's test entailed carrying out a one-way analysis of variance on the d_{yi}, with year defining the groups. Because the r_{yi} are potentially (spatially) correlated, the d_{yi} are also potentially correlated and the one-way analysis of variance is adjusted using the spatial regression techniques outlined in Appendix A of McDonald (1998). Variance of the original residuals is deemed significantly different across years if the (spatially adjusted) one-way analysis of variance rejected the hypothesis of equal average deviations. The distribution of thalweg residuals can be also plotted as a visual interpretation aid.

Both bank full and active channel widths are analyzed for changes across years. To conduct this analysis, a systematic sample of widths is computed from available data after field sampling is completed each year. Such a systematic sample of widths is necessary because the field sampling protocol dictated that each bank of the creek is measured separately. Consequently, width measurements are not taken completely across the creek, but rather from each bank to a center tape. Furthermore, measurements from one bank to the center tape are not necessarily in the same place as measurements to the opposite bank. Therefore width cannot be computed directly from the raw data and consequently a systematic sample of widths is computed and analyzed by the following methods. The systematic sample of widths is computed by first connecting left and right bank width measurements with straight lines to form an approximate stream channel. A random starting point along the center tape is then chosen and widths (across the whole channel) are computed at regular intervals along the center tape. The number of systematic points in the sample is equal to the smaller of the two sample sizes taken on each bank. For example, if 50 measurements were taken on the left bank and 75 measurements were taken on the right bank, 50 systematic measurements of width were taken to analyze. An example of the systematic sample of widths computed at Cañon Creek in 1996 is presented as Figure D-3 below.

The above described systematic sample of widths will be computed each year for each creek. Average width is analyzed using one-way analysis of variance (anova) techniques analogous to the modified Levene's test (Neter et. al. 1991) described for analysis of thalweg residual. A one-way analysis of variance (two sample t-test if only two years) is computed, with year as the grouping factor, to test for changes in mean stream width. Because measurements in the field are taken relatively close together and because spacing of the systematic sample of widths are relatively tight, computed widths are potentially correlated and consequently the analysis of variance can be modified to adjust for spatial correlations using the techniques outlined in Appendix A of McDonald (1998). This analysis of variance was parallel to the modified Levene's test described for analysis of thalweg residual variance.

Substrate size, or pebble size, is measured at approximately 10 sites within each monitored reach. Each site is approximately 50 feet by 50 feet in size and consisted of riffle bed areas within the stream. At each site, field personnel measure the secondary axis of rocks (pebbles) which are collected by selecting one near the toe of their right foot as transects were walked around the site. Collection and measurement continues until 150 rocks are measured. All measurements are reported in millimeters and the smallest measurement is one millimeter.

The distribution of pebble size is plotted and analyzed for changes across years assuming independence of the measurements. Due to the large distances (relative to average pebble size) at which rocks are measured and the fact that several independent systematic samples are taken at each site, spatial correlations among observations are highly unlikely and consequently no adjustments for such correlation are made.

The hypothesis of no change in distribution is tested using two sample Wilcoxon rank sum tests (Wilcoxon 1945; Hollander and Wolf 1973) or three sample Kruskal-Wallis tests (Lehmann 1975; Hollander and Wolf 1973) depending on the number of years data are collected from a stream. Substrate size measurements from all sites within a year are combined for testing because site to site differences in substrate size are not of interest and, if such differences existed, would tend to inflate the distributions variance and provide a conservative analysis. Treating the systematic measurements as if they were purely random (i.e., by assuming independence) also inflates the distributions variance and further contributes to a conservative analysis.

Three quantiles from each substrate distribution are estimated. The 16-th, 50-th, and 84-th quantiles are estimated from each distribution to facilitate comparison with sediment movement models previously developed (USEPA 2000). The 16-th quantile is defined as that point in the distribution which was greater than 16% of the observations and less than 84% of the observations. By symmetry, the 84-th quantile is defined as that point in the distribution which was greater than 84% of the observations and less than 16% of the observations. The 50-th quantile is defined similarly and corresponded to the median. The standard error of each quantile is estimated using standard bootstrap methods (Manly 1997).

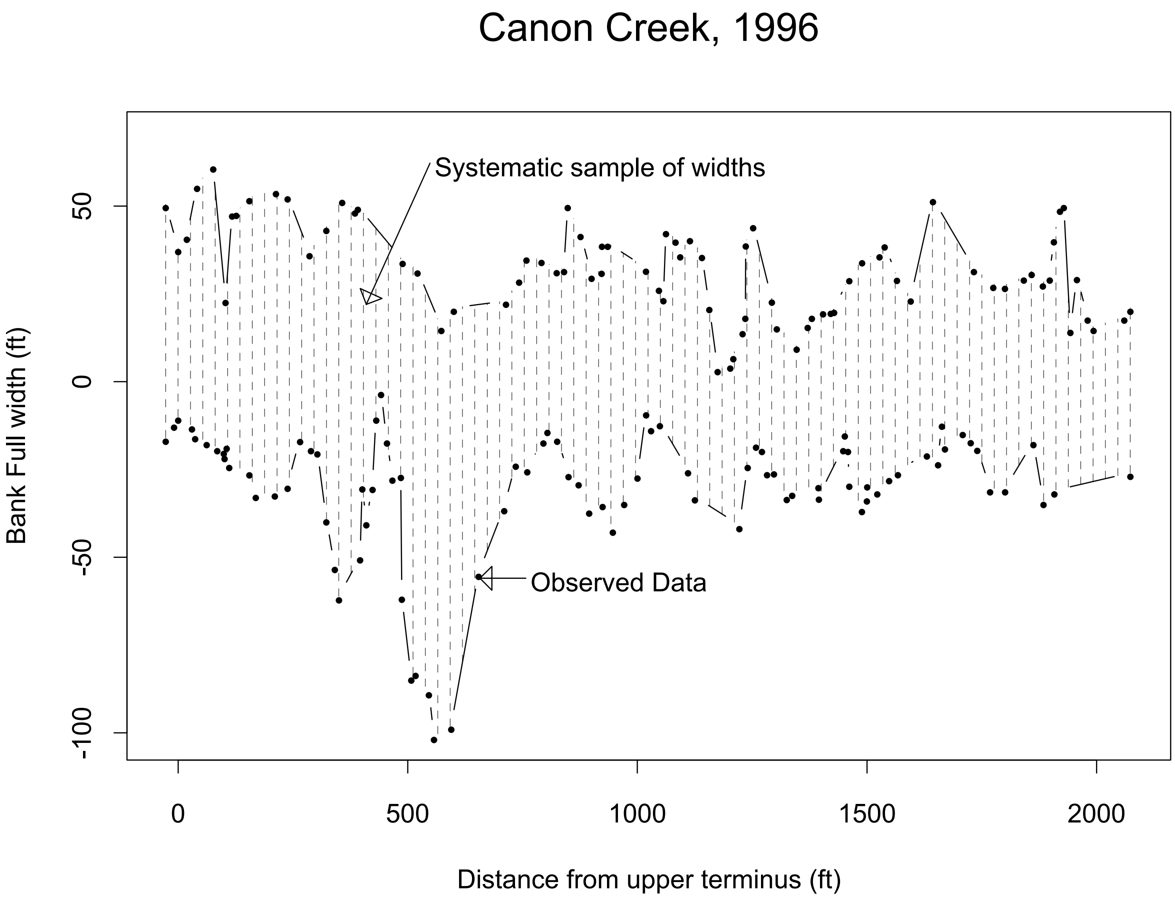

Figure D-3. Diagram of the systematic sample of widths taken for the investigation of width. This example shows bank full width at Cañon Creek in 1996. The zero in vertical dimension represents the center tape while negative numbers represent the left bank and positive numbers represent the right. Dots are observed bank full measurements with linear interpolation between each. Dashed lines show the systematic sample of widths.

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D.2.3 Class III Sediment Monitoring

D.2.3.1 Background and Objectives

Concerns have been raised that complete removal of trees from Class IIIs will result in destabilizing these headwater areas resulting in an upslope extension of the channel and increased risk of shallow rapid landslides. The mechanisms that could trigger these potential effects may not be fully mitigated by the existing forest practice regulations: loss of root strength in the soil column that could increase mass wasting, and increased incident precipitation and storm runoff that could increase mass wasting and fluvial erosion processes in Class III watercourses. There is some evidence suggesting the latter from Caspar Creek (Lewis 1998). The net effect is that there could be significant increases in sediment production from watercourses even though Class I and II watercourses may have ample buffer retention. Because the majority of a channel network is made up of the first order channels, the overall impact of destabilized Class IIIs may be quite large even though increased sediment delivery in any given Class III is small. There is also the concern that if a debris torrent is triggered from one of these Class III areas, there will be no opportunity for delivering LWD into the channel below if no trees are retained in the uppermost reaches of these watercourses. The role of LWD in erosion and sedimentation processes in Class III channels is also potentially significant. LWD provides sediment storage sites, controls channel grade by preventing channel bed erosion, and deflects and concentrates stream flow thereby both protecting banks from erosion and magnifying fluvial bank erosion processes.

There are few empirical data available to assess the magnitude of these potential problems in northern California forestlands. Based on the protocols used in the retrospective study the results from across Simpson's ownership between 1992 and 1998 of 100 Class III watercourses indicated that changes in Class III channels following timber harvest were subtle and indistinguishable from natural channel changes over time (see Appendix C3: *Assessment of Sediment Delivery from Class III Water Courses: A Retrospective Study*). There was no evidence of substantial changes in channel morphology (e.g. increased width, depth or "head cutting"), few slides or bank erosion and no evidence for debris torrents. However, inferences related to more subtle changes in Class III watercourses following timber harvest were not possible given the retrospective study design. A more detailed examination of the channel, pre-harvest, with subsequent multiple surveys post-harvest would be required to detect these subtle changes. As a result, Simpson initiated a prospective study of sediment delivery from Class III watercourses scheduled for harvest utilizing a BACI (before, after, control, impact) experimental design. The objectives are to monitor Class III watercourses to quantify the amount of sediment delivered from treatment channels following timber harvest relative to control channels. Quantification of sediment delivery will be estimated utilizing four basic approaches: 1) documentation of changes in channel morphology (e.g. channel width, depth, bank scour, head cutting along with landslides, debris flows and areas of bank scour); 2) monitoring of turbidity (suspended sediments) during storm events; 3) sediment traps placed on the stream bank at selected high potential sediment delivery sites, and 4) silt fences placed at the lower extent of watercourse below the harvest unit. Each of these techniques will quantify sediment delivery in different ways, and tend to be measuring a different component of the total sediment budget in Class III watercourses, but collecting the different protocols should provide a comprehensive evaluation of sediment delivery from these streams. This monitoring program will only be employed in the four basins that make up the Experimental Watersheds Program.

Appropriate biological objectives and threshold values for Class III sediment delivery cannot be determined at this time. Approximately five years of initial trend monitoring are expected to be necessary to set the appropriate biological objectives and threshold values. At the end of 5 years a review and evaluation of trend monitoring results will be conducted. In addition, at other times agreed upon with the consensus of the Services, periodic reviews will be conducted to evaluate progress in determining turbidity thresholds.

D.2.3.2 Channel Morphology (In-channel Survey)

This protocol is designed to estimate sediment delivery from Class III channels by quantifying changes in channel morphology. Even using a BACI experimental design, Simpson does not expect to be able to quantify subtle changes that might result from small of amounts of fine sediment inputs. However, this technique should provide good estimates of more significant sediment inputs and it will also allow one to assess the mechanism of the sediment delivery.

Before going into the field, delineate the Class III channel on the proposed THP map to determine the drainage area. A minimum survey length will be 200 feet. In the field, assess the watercourse beginning at the lowest point on the channel within the THP unit. This point may be at the culvert inlet on a road crossing or at a Class II/Class III break. Take channel measurements systematically up the channel at 10-foot intervals based on a random start within the first 10-foot interval. At each 10-foot sampling interval, if an active channel is evident, measure its width, maximum depth, and determine if there is evidence of recent scour (sediment erosion by fluvial processes). Also measure the linear length of exposed bank within 15 feet of the channel on both banks. If the exposed bank is part of an earth flow or slide, measure the entire limits of the exposed ground. Game trails and animal burrows are not included in measurements of exposed banks, but their occurrences should be noted. In order to facilitate subsequent re-surveys of the channel following timber harvest, install benchmarks along the channel at 25-50 foot intervals. Scribe the in-channel distance and benchmark number onto the tag.

At every 50-foot interval, measure the bank angle perpendicular to the channel on the left and right banks. At every 100-foot interval, measure the mean understory vegetation height and percent overstory canopy closure using a densiometer. Measure the channel gradient with a clinometer at the beginning of the layout and at all major breaks in slope throughout the remaining channel length. Measure the diameter and length all large woody debris (LWD) greater than 6-inch diameter wherever it occurs throughout the channel. (There is no minimum LWD length requirement.) Record if the LWD is hardwood or conifer. The LWD classification is intended to give an indication of its expected longevity within the channel. If the classification cannot be determined, default to the hardwood classification under the assumption that the piece of wood is rapidly decaying. Also note if the LWD is acting as a control point. A control point is any in-channel feature that retains sediment and/or prevents headcutting with a minimum of a 6-inch drop. Record the location and type of all other control points (roots, boulders, bedrock, etc.). Include the dimensions of the control point, vertical drop, scour below the control point and note the predominant channel substrate. Measure the area of all significant channel scour holes (hole in the channel > one foot in depth where, when there is flow, the flow would go subsurface) or other major in channel areas of scour. Benchmark all major control points (>1 foot drop), scour holes or other major in channel areas of scour. The benchmark needs to be designated in such a way that it will allow for an accurate assessment of changes in both the area and depth of these features. In addition, benchmark and construct a cross-section for any areas of significant entrenchment (>l foot depth). Cross-sections are constructed by first setting two fixed points that establish a line perpendicular to the desired site. The fixed points (benchmarks) must remain in place without any movement throughout the entire monitoring period so aluminum tags are typically attached by nails to large stumps or stable large woody debris with nails. A line is affixed between the two points and leveled using a line level. Depth measurements are taken at intervals along the fixed line using a stadia rod. Accompanying the depth measurement is a distance measurement taken from one of the designated fixed point (primary benchmark) to the various depth measurement points on the fixed line. If only one fixed point can be established due to a lack of suitable stable structures, then a different method is used. A primary fixed point is placed on one stable object (e.g. stump or LWD) “distal” to the cross-section. A secondary fixed point is then placed “medially” on the same stable object such that the line passing through the two points forms the desired cross-section. The line is leveled as above and depth measurements are taken at fixed intervals as described above.

Photo document the channel both upstream and downstream at the beginning, middle and top of the channel. In addition, photo document at major gradient breaks in the channel that precludes visibility, major control points, channel scour holes, significant mass wasting, or other major features that affect the channel. Note the presence and flow of water, changes in predominant vegetation and the occurrence of any aquatic vertebrates.

Continue the in-channel survey until the Class III channel ends at a headwall or spring, or at the harvest unit boundary, if the channel is a “run-through”. Survey the associated road system within the sub-basin and sketch the drainage area onto a topographic map. Record any stream piracy or diversions associated with the road system and include it in the drainage area. On the topographic map, record road failures, inner gorge slides or other larger scale sediment delivery features within the sub-basin.

D.2.3.3 Sediment Traps

This technique is designed to estimate delivery of sediment from stream banks by direct overland movement. The traps are set to capture a portion of the sediment being delivered directly to the channel through bank erosion (raveling or colluvial inputs). The technique does not allow for an estimate of the total sediment being delivered to the stream by this process, because it not possible to adequately estimate the total “input zone” for each trap. Rather, this technique is designed to estimate changes in the delivery rates between treatment and control streams, before and after harvest.

To maximize the potential to gather samples of sufficient size to allow for quantification and statistical analysis, the watercourse is first assessed prior to the placement of any of the sediment traps. All of the sites with highest potential to deliver sediment (with the exception that active slides need to be avoided) are flagged, and beginning with a random start, the sediment traps are distributed systematically at sites such that the entire length of the watercourse is sampled. During placement of the sediment trap, consider micro-topographic features to maximize collection of bank material that is mobilized, and to allow for an assessment of the micro-drainage area for each trap.

Set up the trap above the high water level but as close to the channel as possible. Sediment collected in the trap is assumed “delivered” to the Class III watercourse. This assumption may be violated if the trap is placed too far from the edge of the channel, because there is a possibility that the collected sediment actually would not have reached the channel. At the selected trap site remove the small organic debris so a tight seal is achieved between the ground surface and the edge of the trap. Next, push the leading edge of the traps into the hill slope. Position the slope of the trap so that it is sufficiently steep to insure that sediment will be carried into the collection bucket. Measure and record the slope of each sediment trap to insure that they are all placed at a similar slope. Drive rebar through the retaining rings on the trap and into the ground to stabilize the trap. Place a collection bucket at the outfall of the trap to collect the sediment generated by surface erosion. Place a plywood cover over the trap and collection bucket, to avoid collecting rainfall. At each sample site measure and record the following information: micro-drainage area above the trap, bank slope, distance of exposed soil above trap and canopy closure.

Check the sediment traps after every storm event that exceeds 1 inch of rainfall. Discard the first sample following the initial trap setup to “clear” material that was mobilized by the installation. Pour the collected sample through a number 230 testing sieve and transfer the sediment into a sample bag. In the field, measure the total volume of water that was collected. Bring the sample bags back to the lab for analysis. Record precipitation from the rain gage that was placed in the vicinity of the monitoring site. Sediment bags are dried and weighed prior to taking samples. After sampling, the bags are dried and reweighed in the laboratory. To obtain sediment weight, subtract the empty bag weight from the total weight of the bag with the sediment.

D.2.3.4 Turbidity and Suspended Sediment Sampling

Class III channels only flow in response to storm events, and by definition, are capable of transporting sediment to receiving Class I and II watercourses, but do not support "aquatic life". Sediment sampling will take place during storm events, since turbidity and suspended sediment are highly dependent on discharge and the vast majority of sediment transport occurs during high flows. The turbidity and suspended sediment sampling element of the Class III monitoring program was designed to determine the validity or accuracy of the sediment traps in quantifying the sediment contributions from timber harvesting activities. In addition, it will measure suspended sediment and turbidity generated from in-channel scour and remobilization of stored sediments. The latter sediment contributions should correspond to changes detected from the in-channel survey.

Grab samples will be taken at the downstream end of the Class III channel (but above the silt fences) within the BACI unit. Automated samplers and depth-integrated samplers will not be used, since these watercourses are generally very shallow and only flow during storms. Water samples are taken from a well-mixed area of the watercourse using a 0.5 L plastic bottle and stream discharge is measured at the same location. It also will be noted if the inboard ditches are contributing flow. The grab samples are analyzed for turbidity and suspended sediment in the laboratory.

A storm event that is expected to deliver 1 inch of rain will trigger the crews to collect turbidity and suspended sediment samples. Repeat measures are taken during the rising limb, peak, and falling limb of the hydrograph. Following the sampling period, record the rainfall amounts from the rain gages located in the vicinity of the BACI unit.

Turbidity is measured making sure the sample is well mixed. Filter papers (Whatman glass microfibre filters) are labeled, dried and weighed. Volume of sample is measured before sample is poured through the vacuum filtration system. Filter papers are removed, dried and reweighed. Sediment weight is post filtration weight minus original filter paper weight.

D.2.3.5 Silt Fences

The final portion of the Class III sediment monitoring includes estimating fine sediment production using silt fence check-dams. The relatively small size and low ephemeral discharge of Class III channels makes it possible to attempt to construct relatively low cost, low maintenance sedimentation basins using silt fence material. The principle behind this approach is that the silt fence check-dams act as a velocity break to the flow in the channel, which allows suspended sediments greater than some particle size to be deposited above the fence. The actual particle size that is deposited depends on the size of the silt fence and the degree to which it impounds the flow. These data will be used primarily to correlate with the turbidity (suspended sediment) sampling to determine consistency between the two methodologies. If the turbidity sampling correlates well with the silt fence results, it may be possible to eliminate the more labor-intensive turbidity sampling.

The proposed design will include three successive sedimentation basins created by silt fences in close proximity to accommodate potential overflow as the silt fence pores become clogged with sediment (Britton et al. 2001). Successive basins will provide for additional capture of sediment in the flow. In addition, if the upstream basins fail, downstream basins will be in position to capture flow and sediment.

The design of sedimentation basins will include steel rebar and sections of chain link fence to support the silt fence. Silt fence will be fastened to the bed and banks to prevent flow under and around the structure. It is expected that there will be some leakage around the edges, adding another design purpose in setting up three successive basins. The data to be collected seasonally is the dry weight of sediment accumulated in the sedimentation basins. Colloidal material will not be collected, but most silt, sand and gravel should be captured. Data on soil particle size distribution will be collected to estimate the efficiency of the sedimentation basins.

D.2.3.6 Literature Cited

Britton, S.L. Robinson, K.M., and Barfield, B.J. 2001. Modeling the effectiveness of silt fence. Proceedings of the Seventh Federal Interagency Sedimentation Conference, March 25 to 29, Reno, Nevada. Volume 2, Part V, pp75-82.

Lewis, J. 1998. Evaluating the impacts of logging activities on erosion and sediment transport in the Caspar Creek watersheds. In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 6 May 1998; Ukiah, California. General Tech. Rep. PSW GTR-168. Albany, California: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 55-69.

D.3 LONG-TERM TREND MONITORING/RESEARCH

D.3.1 Introduction

Long-term trend monitoring includes:

- Road-related mass wasting monitoring,
- Steep streamside slope delineation study,
- Steep streamside slope assessment,
- Mass wasting assessment,
- Long term habitat assessments,
- Large woody debris (LWD) monitoring,
- Summer juvenile salmonid population estimates, and
- Out-migrant trapping.

The long term trend monitoring projects are those monitoring projects for which no thresholds for adaptive management are set. For some projects, this reflects the multitude of factors which affect the response variables, in others, the long time scales required to distinguish the ‘noise’ from the underlying relationships. Research projects designed to reveal relationships between habitat conditions and long-term persistence of the covered species are also included in this section. Each of these projects has the potential to provide feedback for adaptive management, but in some circumstances, decades may be required before that can occur.

D.3.2 Road-related Mass Wasting Monitoring

D.3.2.1 Background and Objectives

Roads can lead to increases in the frequency and severity of all types of mass soil movement. Increased sediment inputs to streams can in turn negatively impact all six of the Covered Species. The road upgrading and decommissioning process described in Section 6.3.3 is expected to significantly reduce the frequency and/or severity of road related mass wasting sediment inputs. As such, it is an integral component of the suite of conservation measures designed to achieve the biological goal of reducing management-related sediment inputs to Plan Area streams.

The road-related mass wasting monitoring project will monitor the effectiveness of the road upgrading and decommissioning measures in reducing the frequency and severity of road related mass wasting inputs. This will involve before and after monitoring of particular road segments, comparisons within basins or sub-basins of treated and non-treated roads, and Plan Area wide comparisons of treated and non-treated roads. If no significant effect (i.e. reduced frequency and severity of road-related mass wasting inputs) can be attributed to the road upgrading and decommissioning measures, the monitoring results will be used to adjust and revise the road upgrading and decommissioning measures to improve their effectiveness.

D.3.2.2 Site Selection

The road-related mass wasting monitoring project will be employed in the four basins that make up the Experimental Watershed Program. Various road segments representing different categories of road use and road condition will be selected for monitoring. The categories will be seasonal versus rocked, low (or moderate) versus high-use, upgraded versus scheduled for upgrades (not yet upgraded) and decommissioned versus scheduled for decommissioning (not yet decommissioned. The goal will be to have a minimum of 12-15 crossings in each road category selected for monitoring. Within a given experimental watershed, watercourse crossings or road related landslide features to be sampled will be selected from all of the combinations of road use and condition categories using a stratified random sampling approach. Within a given selected road segment, the individual crossings or road related landslide feature to be monitored will be selected using a systematic sample with a random start. For example, assume that a 20% sample achieves the desired sample size for a given road use and condition category. Then all of the sites that have or will be upgraded along a selected road segment will be identified. A random starting point will be selected from the first 5 sites with every fifth site systematically selected for sampling beyond that point.

D.3.2.3 Field Measurements

Road related mass wasting sediment inputs to streams are episodic in nature and typically triggered by intense rainfall events. As such the sample sites will be resurveyed the summer following a flow event with a 5 year return interval. The volume of sediment delivery that occurred from each sample site will be determined. The time scale required to collect enough data and accurately assess the effectiveness of road upgrading and decommissioning may be on the order of decades.

D.3.3 Steep Streamside Slope Delineation Study

The goal of the Steep Streamside Slope (SSS) Delineation Study is to determine the minimum slope gradient and maximum slope distance of SSSs for each HPA. The initial default minimum slope gradients and maximum slope distances for the HPA Groups will be adjusted for each HPA based on the results of this study.

The quantitative criteria for determining SSS minimum slope gradients and maximum slope distances will be the same as described Section 6.3.2.3. The minimum slope gradient will be based on an 80% cumulative sediment delivery volume from streamside slopes in the all HPAs. The maximum slope distance will be based on a 80% cumulative sediment delivery volume from streamside slopes in the Blue Creek and Coastal Klamath HPAs, and 60% cumulative sediment delivery volume from streamside slopes in all other HPAs.

Initially, the procedure will be based on the assumptions described in Section 6.3.2.3 and it will utilize similar methods as were employed in the three pilot watershed areas to determine the initial default SSS slope gradients and distances. This will include conducting an office-based Steep Streamside Slope and landslide inventory using aerial photographs and published geologic maps, designing a statistically valid field-based data collection program based on the SSS and landslide inventory, field verifying the office-based SSS and landslide inventory, collecting geologic data (e.g. landslide-related information or lithologic data during on-site review), data analysis, reporting results and implementation of adaptive SSS slope gradients and distances.

In order to collect data that will allow statistical inferences to be made that will apply to the entire HPA, it will be necessary to sample study sites across the HPA using a probability based sampling design that is spatially distributed. The specific sampling design has not been determined yet, because the sampling frame or acceptable levels of variance in the estimates has not been set. Once this has been done, there are a variety of possible sampling schemes that will achieve the objective of obtaining a statistically valid sample from which to draw inferences to the entire HPA, and the specific sampling scheme selected will be based on minimizing variance and while maximizing efficiency of data collection. Data collection will emphasize landslide type, landslide crown distance to watercourse, natural pre-existing slope gradient, geologic and geomorphic setting, and land-use or management history. Causal mechanisms for individual landslides may also be assessed.

The SSS Delineation Study for each HPA will be completed with priority given to completing the HPAs that are anticipated to have substantial timber harvesting operations in the near future.

The SSS Delineation Studies for all 11 HPAs will be completed within 7-years following the effective date of the Permits. The modified slope and distance criteria for each HPA may be applied starting on the 30th day after a letter of notice with a summary map that summarizes the data and describes the findings of the data analysis for each HPA is sent to The Services. Subsequent updates to the SSS Delineation Study for each of the HPAs will be conducted depending on climatic cycles and landscape response.

The adaptive management account will not be credited or debited based on the results of the first SSS Delineation Study for each HPA following Plan approval. Instead, the baseline for credits or debits to the adaptive management account will be reset according to these results. The subsequent modifications to SSS maximum slope distances and minimum slope gradients will be handled through the adaptive management account.

D.3.4 Steep Streamside Slope Assessment

The goal of the SSS Assessment is to determine the effectiveness of SSS prescriptions and to recommend appropriate changes to the SSS conservation measures, if any such change is necessary, that will more closely achieve the effectiveness goal of the SSS conservation measures. The SSS conservation measures are designed to be at least 70% effective at preventing management -related sediment delivery from landslides compared to that from appropriate historical clear-cut reference areas. A maximum of a 30% relative increase in landslide-related sediment delivery compared to merchantable-sized, advanced second-growth uncut SSS areas may be used as another comparative standard to determine the effectiveness of the conservation measures. The objectives of the SSS Assessment are to collect data relevant to landslides in SSSs and to determine the effectiveness of the SSS conservation measures by comparative analysis of cumulative sediment delivery volumes and associated data. The procedure will utilize similar methods as were employed in the three pilot watershed areas to determine the initial default SSS slope gradients and distances. For each HPA, this will include conducting an office-based Steep Streamside Slope inventory and a landslide inventory using aerial photographs and field surveys, designing a statistically valid field-based data collection program (as described for the SSS Delineation Study), field verifying the office-based SSS and landslide inventory, collecting field data, data analysis, reporting and implementation of adaptive SSS slope gradients and distances.

A California Registered Geologist (R.G.) will oversee data collection. Data collection is expected to focus on landslide location and type, geologic composition and setting, distance of landslide crown from watercourse, pre-existing natural slope gradient, landslide dimensions, volume of sediment delivery, land-use or management history, and causal mechanisms. Other data parameters may also be collected based on the professional discretion of the supervising R.G. All data will be stored in a database and appropriately represented on maps in order to facilitate data analysis.

Data analysis to determine the effectiveness of the prescriptions will be performed by a scientific review panel, which will consist of independent experts on the subject at hand. The panel will have three members, one appointed by the Services, one appointed by Simpson, and a third selected by the first two panel members. The analysis will be performed after the 15th winter following the effective date of the Permits.

The role of the scientific review panel will be to provide technical analysis of the data and to attempt to reach conclusions on the effectiveness of the SMZ prescriptions relative to the goal of the SMZ conservation measures. The criteria for determining appropriate modifications to the SMZ conservation measures, if any modification is necessary, will be based on the comparison of the cumulative sediment delivery volumes from harvested SSS, unharvested SSS, and historically clearcut SSS. Modifications to the initial default prescriptions can range from clear-cut to no harvest and may vary from HPA to HPA and possibly within individual HPAs. Modifications will not be made to the default SSS prescriptions unless the analysis is conclusive in the opinion of a majority of the scientific review panel.

If the results are not conclusive, the monitoring protocol will be evaluated to ensure that appropriate methodologies are being applied and the monitoring will be extended for another 5 years. Any adjustments to the conservation measures will be in keeping with the Adaptive Management Reserve Account and changed circumstances. For comparative purposes, harvested SSS may be subdivided into those areas harvested using the default prescription and those areas harvested using alternative prescriptions developed through onsite geologic review. Historical clearcuts may be used as a comparative standard to determine the effectiveness of the conservation measures. Unharvested or advanced second growth stands may be used to represent background landslide-related sediment delivery rates as a comparative standard to determine the effectiveness of the conservation measures. Both harvested and unharvested SSSs may also be subdivided for comparison according to geologic conditions, forest stand type, management zone (RSMZ and SMZ) land-use, and other sub-groupings as may be appropriate, in order to ascertain the most meaningful results in each HPA or subunit thereof. If modifications are made to the initial default SSS prescriptions, the Services will be notified prior to the implementation of the modified prescriptions.

D.3.5 Mass Wasting Assessment

Simpson will conduct a property-wide Mass Wasting Assessment (MWA) within 20 years. The Goal of the MWA is to examine relationships between mass wasting processes and timber management practices. The objectives of the Mass Wasting Assessment are to collect a thorough data set that represents a wide range of mass wasting processes and management practices, to analyze the data, and to present the results in a report or in several reports. The results of the MWA will not be subject to the adaptive management mechanisms provided by the plan.

A preliminary MWA will be completed within 7 years of the effective date of the Permits. The preliminary MWA will primarily include a landslide inventory and some statistical reporting with limited comments and discussion. The landslide inventory and analysis will generally follow the procedures outlined in the Washington State Department of Natural Resources (WDNR) methodology for mass wasting analysis, with some modifications. Modifications to the WDNR method may be implemented based on data or at the professional discretion of the supervising geologist.

The final MWA will be complete in 20 years of the effective date of the Permits. The final MWA will include updating the preliminary data and it will attempt to identify patterns or trends in mass wasting processes as they relate to management practices. The final MWA will be presented in a report or in several reports.

Simpson and the Services will jointly review the final MWA results to determine if the MWA Assessment should continue. If The Services and Simpson cannot reach agreement on the finality of the MWA, a scientific panel shall be convened to determine if continued slope stability monitoring is necessary. If the scientific panel is required, the panel shall be convened in the same manner and generally follow the same procedure as the panel for the SSS Assessment.

D.3.6 Long-term Habitat Assessments

D.3.6.1 Background and Objectives

Channel and habitat typing assessments were previously conducted by Simpson personnel during 1994 and 1995 following CDFG methods (Flosi and Reynolds 1994; and Hopelain 1994). Sixteen streams within the Plan Area were assessed identifying 75 reaches by channel type, for a total of nearly 104 miles of stream channel. Additional channel and habitat typing assessments on Plan Area streams have also been conducted by the Yurok Tribal Fisheries Program (YTFP), the California Conservation Corp (CCC), the Louisiana Pacific Corp., and CDFG. Those parties have conducted assessments on 40 streams, covering 140 reaches for a total of 131.0 miles of channel being assessed. All streams assessed were selected based on their biological significance as producers of salmonids, and the size of Simpson's ownership in the watershed's anadromous reaches.

Future channel and habitat assessments will be conducted to provide information about the health of these streams, especially with respect to salmonid habitat. Channel and habitat variables including the following will be collected:

- Percent canopy cover
- Percent LWD as structural shelter
- Habitat types as a percent of length
- Dominant substrate composition
- Pool embeddedness
- Pool depths
- Shelter rating in pools

The trends observed through this long term, comprehensive assessment will be valuable for comparison with the results of the other more specific monitoring projects. The habitat assessment monitoring project will ensure that the individual biological objectives (i.e. permeability, channel dimensions, water temperature monitoring projects), are accurately depicting overall aquatic habitat health and function.

The channel and habitat assessment process will be repeated on the original 56 surveyed streams every 10 years for the life of the Plan. As the first assessments were completed in 1994 and 1995, the next assessment will be conducted in 2004 and 2005. Detection of significant trends will probably require at least a third assessment beginning in 2014 and 2015. The channel and habitat typing reaches are distributed throughout Simpson's entire ownership except for properties in Trinity County. Each assessment will identify the channel types and habitat features in the particular stream assessed. The objective of the Habitat Assessment Monitoring Project is to document long term trends in habitat quality and quantity across the ownership.

D.3.6.2 Methods

To evaluate salmonid stream habitat value and quality, channel and habitat assessments for streams that are known to have historically contained coho salmon will be conducted. Brief inspections (spot checks) for fish presence will also be conducted at the same time at the lower, middle, and upper reaches of the streams assessed. These assessments will be utilized to assess channel conditions in anadromous reaches of

Plan Area streams. This protocol is based on the CDFG Habitat Inventory Methodology as described in the California Salmonid Stream Habitat Restoration Manual, (Flosi et al. 1998) and the FFFC Channel and Habitat Typing protocols (FFFC 1997). The assessment of anadromous streams will consist of the following primary components: 1) channel classification, 2) habitat typing, and 3) riparian vegetation assessment

D.3.6.3 Channel Classification

The channel classification data will be utilized to describe specific stream reaches by channel type and sequence within a watershed. This will help predict a stream's behavior from its appearance (e.g. predicting a channel's response to upstream sediment inputs). The method will assist in stratifying streams by channel types for conducting subsequent habitat typing surveys.

Streams will be classified using the system developed by Rosgen (1994) and will use the following eight morphological characteristics to describe the stream channels:

- Channel width
- Depth
- Velocity
- Discharge
- Channel slope
- Roughness of channel materials
- Sediment load
- Sediment size

The stream channel delineation criterion includes general description, width/depth ratio, water surface slope/gradient, dominate particle size, entrenchment, and sinuosity. Descriptions and definitions of these classification criteria are found in the CDFG Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998). Field data will be entered on standardized worksheets using the instructions and methods for completing the stream channel type worksheets provided in (Flosi et al. 1998). The results of this classification will result in the categorization of the target stream reaches into 1 of 34 single thread channel stream types or 1 of 7 multiple thread channel types (Rosgen 1994).

D.3.6.4 Habitat Typing

The stream-level habitat typing data yields the most detailed information of the assessment methods. Habitat typing of a watershed's anadromous reaches provides information that physically describes the anadromous habitat within the wetted channel. Habitat typing reveals factors that may limit production of salmonid smolts. These assessments also facilitate planning, prioritizing, and implementing fisheries restoration projects. Finally, habitat typing evaluates habitat responses to restoration efforts.

Habitat typing will be conducted on the entire target stream from mouth to the upper extent of anadromy using CDFG methods as specified in Flosi et al. (1998). These methods are a variation of a system originally developed by Bisson et al. (1982) and modified by others. Level II habitat typing will be conducted to describe the specific pool, flatwater, and riffle habitats within each target stream. Each habitat unit type is determined based on riffle or pool type and location. The following variables are measured for each habitat unit:

- length, width, depth of pools and riffles
- shelter rating based on shelter complexity
- substrate composition including percent exposed
- percent canopy cover
- percent coniferous and deciduous trees
- pool tail
- bank attributes

The level II habitat typing will describe each habitat unit and categorize into the following habitat types:

- Riffle:
  - Low-gradient riffle
  - High-gradient riffle
  - Cascade
  - Bedrock sheet

- Flatwater:
  - Pocket water
  - Run
  - Step run
  - Glide
  - Edgewater

- Pool:
  - Plunge pool
  - Mid-channel pool
  - Dammed pool
  - Step pool
  - Channel confluence pool
  - Trench pool
  - Lateral scour pool
  - Root wad enhanced
  - Boulder formed
  - Bedrock formed
  - Log enhanced
  - Corner pool
  - Secondary channel pool
  - Backwater pool-boulder formed
  - Root wad formed
  - Log formed

Habitat inventory data will be collected and recorded onto standardized data sheets following the instructions provided by the CDFG Salmonid Stream Restoration Manual

(Flosi et al. 1998). Data will be entered into a data management system (Access) for subsequent analysis using the CDFG developed program HABITAT©.

D.3.6.5 Riparian Vegetation Assessment

A riparian vegetation assessment will be conducted for each target stream. This consists of a large organic debris (LOD) survey. This survey will be conducted in 200 foot sections to cover a minimum of 20% of each channel type in each target stream. Variables measured will include:

- all LOD within 50 ft. of each bank tallied
- percent bank slope
- dominant vegetation/LOD percent and type
- large debris accumulation (noting those that retain gravel upstream)

D.3.6.6 Field Survey

Surveys are conducted by two person teams and are begun at the downstream end of the stream reach. The surveys continue by walking upstream and measuring the variables throughout the length of the entire survey reach. All data are collected on standardized data forms while in the field. For each habitat unit, its length is measured and recorded. When conducting the habitat typing inventory all variables are measured and recorded for each first-time encounter of each habitat type in a channel type, starting with the units above the hydraulic influence of its receiving stream. All variables for all randomly selected habitat units are measured and recorded. These include depths, widths, and embeddedness in all pool habitats.

D.3.6.7 Literature Cited

Flosi, G. and F.L. Reynolds. 1994. California salmonid stream habitat restoration manual. Second Edition. IFD, CDFG, Sacramento, CA.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California salmonid stream habitat restoration manual. Third Edition. IFD, CDFG, Sacramento, CA.

Hopelain, J. 1995. California salmonid stream habitat restoration manual. IFD, CDFG, Sacramento, CA.

D.3.7 LWD Monitoring

D.3.7.1 Objectives and Background

The objectives of the LWD monitoring are to document long term trends in the abundance and size class of inchannel and potential LWD under this Plan.

The development of potential LWD in riparian areas throughout the Plan Area is relatively predictable. Simpson has projected future stand composition in riparian zones through the life of the plan. In contrast, the recruitment of potential LWD into the stream (inchannel LWD) is a highly stochastic process that occurs over long time scales. For this reason, the LWD assessment project does not lend itself to be used as measurable thresholds for adaptive management. The conservation measures as a whole are expected to increase potential LWD, and may increase inchannel LWD, over the life of the Plan, and this monitoring project will document whether this expectation is met.

LWD inventories have been conducted previously on fifteen streams distributed throughout the Plan Area. Information regarding the distribution of LWD was also obtained in the channel and habitat typing assessment process, but the importance of LWD to biological and physical processes in the stream channel justified the need for a more thorough assessment of this critical habitat component. The LWD inventory covers two distinct zones:

- LWD within the bankfull discharge area of the stream channel; and
- LWD and live trees within the "recruitment zone," defined as the area encompassing the floodplain and 50 feet of the hillslope beyond the bankfull channel margin.

The objectives of the LWD inventory include:

- Accurately documenting the current abundance, distribution, and characteristics of instream LWD.
- Providing a repeatable methodology for monitoring long-term changes in the abundance, distribution, and characteristics of instream LWD.
- Accurately identifying the source of instream LWD (naturally recruited or restoration structure) and the species composition of instream LWD (hardwood or conifer).

The LWD inventory will be conducted using the CDFG methods (Flosi et al. 1998). This methodology was designed with the objective of quickly identifying stream reaches lacking in LWD for prioritizing restoration projects. After analyzing previously collected data on Simpson properties, it became clear that the following modifications to the in-channel CDFG methodologies were necessary to meet Simpson's objectives:

- A 100% inventory of LWD instead of a 20% sub-sample;
- A more precise breakdown of LWD size classes;
- Identification of LWD as either deciduous, conifer, or redwood; and
- Designation of LWD as naturally recruited or as stream enhancement structures.

D.3.7.2 Methods

Personnel conducting the LWD inventories will be familiar with channel typing methods of Rosgen (1996) and the equipment needed to conduct LWD inventories. Training and daily sight calibration will be conducted as needed to assist in categorization and recording of field data. Equipment required for LWD inventories includes:

- Clinometer

- Hip chain
- 50' diameter tape
- Waders
- Clipboard and data forms

Inventory teams consisting of 2 people will walk upstream within the stream channel recording LWD information as they proceed upstream. One team member inventories the defined right bank and the stream channel while the other member inventories the left bank. LWD inventories will be conducted after stream habitat typing surveys have been conducted and channel habitat types and lengths have been determined. LWD inventories will be conducted throughout the entire length of the anadromous reach of all streams inventoried.

Standardized LWD data forms will be used to capture inventory data. Inventory data collected are that described by Flosi et al. (1998). The LWD data will include tallies of diameter and length categories, and the condition (e.g. live, dead, perched), and wood type (e.g. conifer, deciduous, redwood).

D.3.7.3 Literature Cited

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California salmonid stream habitat restoration manual. Third Edition. IFD, CDFG, Sacramento, CA.

Rosgen, D.L. 1996. Applied River Morphology. Printed Media Companies, Minneapolis, Minnesota.

D.3.8 Summer Juvenile Salmonid Population Estimates

D.3.8.1 Background and Objectives

The objectives of the summer population estimates are to estimate summer populations of young-of-the-year coho and age 1+ and older steelhead and cutthroat trout, and to track trends in these populations over time. This protocol has been modified from previous methodologies to provide more consistency between individual crews and from year to year. The definition distinguishing deep or shallow pools has been modified so that determination is made solely on depth. A pool less than 1.3 meters is considered a shallow pool regardless of cover. This provides better consistency between crews, allowing comparisons of population estimates between different streams, crews, and property owners.

The sampling and process variance associated with the population estimates and the uncertainty related to the possible causes of observed long-term trends preclude the use of summer population estimates as measurable thresholds for adaptive management purposes. While changes (positive or negative) in summer population estimates will clearly be a source of interest, it remains unclear what, if any, changes can be related to management. The summer population data, in combination with other monitoring efforts, may provide valuable information about the relationships between coho populations in different streams throughout the Plan Area, and the climactic and/or habitat conditions which affect summer population size. In addition, trends in summer population estimates will be valuable in determining the recovery status of the coho populations within the Plan Area.

The protocol for estimating summer populations of young-of-the-year coho salmon and yearling or older steelhead was developed by Dr. W. Scott Overton (Oregon State University, retired) and Dr. David G. Hankin (Humboldt State University) and is that of the Fish, Farm and Forest Communities (FFFC). The methodology is an extension of earlier sampling designs developed, in part, by Dr. Hankin (Dolloff et al. 1993) that utilized a combination of direct observation counts and electrofishing. This protocol relies less on electrofishing to calibrate dive counts, instead employing multiple-pass dives for calibration. Electrofishing is still utilized to calibrate a proportion of the dive units (in habitat units with 20 or more fish of each species counted on the initial dive pass).

D.3.8.2 Methods

The methods were modified from Hankin and Reeves (1988) single stream fish population estimate. The summer population estimation method allows for increased use of diver counts for estimating the abundance of juvenile salmonids in streams. This approach reduces the need for electrofishing and related possible mortality of special status species (e.g. coho salmon).

The first phase of the sampling design:

- classifies habitat units into riffles, runs, pools, and deep pools,
- measures dimensions of each unit,
- randomly selects a fraction of units in each habitat class for Phase 1 sampling (employing the adaptive sequential independent sampling [ASIS] method [Hankin, in press]).

Phase 1 sampling consists of diving each selected unit to obtain an initial count of fish within that unit. Riffle segments are electrofished as diving cannot be conducted in riffles. A subset of the sampled units is then randomly selected for calibration using the ASIS method. The mode of calibration (2nd phase sampling) is determined by the following procedure. If the initial dive counts of the target species is less than 20 individuals then calibration is conducted by a bounded count methodology (Robson and Whitlock, 1964) using 3 additional independent diver counts. If the initial dive count of the target species exceeds 20 fish, then calibration is made by four-pass removal electrofishing method. Calibration within deep-pool stratums is made only by diver counts, as electrofishing is inefficient in this stratum. In riffles selected for calibration, a 2 to 3 pass-removal electrofishing method is the mode of calibration.

If the method of bounded counts is the mode of calibration, the 3 additional dive counts are made immediately following the Phase 1 dive counts. If the Phase 2 sampling is conducted by the 4 pass-removal electrofishing method the electrofishing is conducted within no more than 2 days following Phase 1 sampling. The methods employed for sample selection and estimation, the ASIS methodology, and Phase 2 calibration methods are those of Hankin (in press). Additional discussion of the applicability and assumptions of the population estimation methodology employed by Simpson are found in (Hankin, in press).

D.3.8.3 Fish Survey: Phase I

The initial fish counts are obtained by snorkeling each of the flagged shallow pools, deep pools, and runs while progressing upstream to each successive unit. The diver(s) will enter the unit to be surveyed from the lower end without disturbing the fish and progress through the length of the unit counting the fish as they go. A "clicker" will be carried to record fish numbers for abundant species. Fish counts will include 0+ coho, 1+ coho, "trout" and other species in the survey. The presence of 0+ trout may be noted, but not counted. The length of time that it takes to complete the snorkel count is recorded in case the unit is selected for calibration. Following completion of a snorkel count of the fish in a designated unit, the appropriate Phase II ASIS number is drawn to determine if the surveyed unit will be selected for calibration. It is critical that the diver(s) doing the initial pass in the unit do not know if the unit is to be calibrated prior to doing the dive.

D.3.8.3.1 Phase I Snorkel Survey

The snorkelers will record the following data:

- Unit Number-The unit number assigned by the habitat crew. This number is found on the flags that bound the habitat unit.

- Diver-Initials of the diver for that unit. If divers on the same team share the same initials, follow the initials with a number and indicate in comments which diver uses the numbers.

- Species Code-Code indicating species:

CODE	SPECIES
CO	Coho
CH	Chinook
SH	Steelhead
CT	Cutthroat
UT	Unknown Trout
Oi	Other species #I

(Other species is for use if surveyor is interested in species not on the list. The surveyor assigns number I and notes in comments the species names with the corresponding number.)

- Age class-age class of the group counted for that row of data entry (0+, 1+)

D.3.8.3.2 Dive 1

- Count-the number of fish counted in the dive of that species within the age class for the row.

- Duration-the duration of the dive. Note the start and stop times in the diver notebook

- Vis-visibility for the initial dive. If visibility becomes worse in later repeat dives, make detailed notes in a comment page, noting the habitat unit. If visibility for repeat dives becomes too clouded, the calibration must be electrofishing, or, if electrofishing is not possible, the unit reclassified as other. Visibility codes:

Code	Visibility
E	**Excellent** - no problems seeing anything in unit
G	**Good** - Approximate minimum of 10 feet of visibility. (Visibility from bank to bank with minimal movement, or, for two divers, from midline to bank.)
P	**Poor** - Visibility not good enough for reliable counts
Z	**Fails** - Visibility near zero, counting impossible

D.3.8.3.3 ASIS

- Phase II Number- ASIS strip number including the yes or no. Each ASIS selection strip provided by FSP will have:

- the selection probability for that strip,

- the sequence number for the strip, and

- a 'YES' or 'NO'. Record both the sequence number and the response. If the third run entry has a 'YES', then record as 3YES.

- E fish-record a 'Y' or 'N'. If the unit was selected by phase II ASIS as a calibration unit, and if the unit is a Run or Shallow Pool with a 0+ coho count greater than 20, then record a 'Y' and the unit is flagged as an electrofishing unit. Otherwise, record a 'N' for no phase II electrofishing.

D.3.8.4 Fish Survey: Phase II (Calibration)

If the ASIS number indicates that the unit needs to be calibrated, a decision will be made based on the number of 0+ coho seen. If the count for coho 0+ exceeds 20, then the unit is flagged for later 4-pass electrofishing calibration. If the fish count is less than or equal to 20 fish and there is not excessive complexity in the pool that would preclude seeing all the fish without risk of double counting, then the calibration will be done by the bounded count method. This involves three additional passes through the same unit following a brief (5 minutes) wait with approximately equal effort in each pass. The wait between dives must be long enough to insure that the water has cleared and the fish have had time to settle down. If other species of interest exceeded 20-fish threshold while 0+ coho did not, the unit may be flagged for electrofishing of the other species that exceeded the threshold. However, three additional dives are required.

The sampling of riffles, which is only done by electrofishing and the calibration of phase I units by electrofishing should be done within two days of the initial snorkel surveys. Block nets must be placed at the top and bottom of the units to be electrofished, and three depletion passes are made through the unit. The effort (time spent electrofishing) on each pass should be approximately equal.

D.3.8.4.1 <u>Phase II Snorkel Survey</u>

Phase II snorkel dive data are recorded onto the same data sheets as the Phase I snorkel dive. The Phase I data was recorded in the Dive 1 column while the Phase II data will go into the appropriate Dive 2, Dive 3, or Dive 4 column for the appropriate dive pass. These dives will be immediately following the dive 1 pass and determining the Phase II status.

D.3.8.4.2 <u>Phase II Electrofishing Survey</u>

Each electrofishing data sheet is for one habitat unit. Each phase II electrofishing unit will be subjected to four depletion passes.

- On the top table record the following:

  a) E-fish time-the start and stop time for the electrofishing

  b) Duration-the duration, in seconds, of time the electrofishing unit was on for each pass

  c) Processing time-only if desired for those taking lengths and weights

  d) Water temp (°C)-the water temperature at the beginning of the pass

  e) Conductivity-measured conductivity, if means available

- On the bottom table record the following:

  a) Pass number

  b) Species Code-the following code indicating species:

CODE	SPECIES
CO	Coho
CH	Chinook
SH	Steelhead
CT	Cutthroat
UT	Unknown Trout
Oi	Other species #i

  (Other species code is for use if surveyor is interested in species not on the list. The surveyor assigns number i, and notes in comments the species names with the corresponding number.)

  c) Age Class-age class of the group counted for that row of data entry (0+, 1+)

d) Fish Count-the number of fish captured for that species and age class on the given pass number. Note, if taking scale samples, weights, and/or lengths, treat fish count as fish id number and one row will be one fish.

e) Mortality Count-the number of mortalities for that species and age class on the given pass number. Note, when taking scale samples, weights, and/or lengths record a zero if the individual fish was alive or 1 if that fish was dead.

f) Length-fork length (mm) of an individual fish. If fork length not appropriate for the particular species, make a note in comments about which length measurement was taken.

g) Weight-weight of an individual fish in grams.

h) Scales-denote with a 'Y' if scale samples were taken.

i) Comments-note any difficulties encountered that may affect the reliability of the results.

D.3.8.5 Literature Cited

Dolloff, C.A., D.G. Hankin, G.H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. USDA Forest Service, General Technical Report SE-83.

Hankin, D.G, 1999. Unpublished MS, a modification of the "Hankin and Reeves" (1988) survey designs, as summarized in detail by Dolloff et al. (1993).

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45: 834-844.

Robson, D.S. and J.H. Whitlock. 1964. Estimation of truncation point. Biometrika 51: 33-39.

D.3.9 Out-migrant Trapping

D.3.9.1 Background and Objectives

The out-migrant trapping monitoring project is designed to monitor the abundance, size, and timing of emigrating salmonid smolts. Furthermore it is conducted to look for long term trends in any or all of these variables. The results of the out-migrant trapping are used in conjunction with the summer population monitoring to estimate overwinter survival in the Little River HPA. Eventually this information will be further analyzed to correlate specific habitat conditions with overwinter survival of coho salmon.

The objectives of monitoring out-migrant salmonid smolts are threefold: to estimate overwinter survival of juvenile coho by comparing out-migrant abundance to the summer population estimates; monitor the abundance, size, and timing of out-migrating smolts; and look for long term trends in any or all of these variables. Juvenile smolt out-migration is monitored to:

- Determine the diversity of salmonid species.
- Identify physical and age-specific characteristics of each species.
- Determine species specific out-migration timing.
- Establish baseline data to ascertain the viability and abundance of salmonids.
- Monitor long-term trends in smolting populations.

D.3.9.2 Methods

This monitoring method uses a combination of a weir, pipe, and live-box to capture juvenile salmonids (Figure D-4). Smolting populations of coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha*), steelhead trout *(O. mykiss iridens*) and coastal cutthroat trout (*O. clarki clarki*) are the species targeted. The data are used to estimate the relative population sizes of those species. The equipment and methods utilized allow for variation in fish sizes being trapped, maximize the number of out migrants entering the trap, and minimize the stress and mortality of fish.

D.3.9.2.1 Establishing the Survey Area

Selecting an area to sample juvenile salmonids can be a difficult task, and the location must be based on several criteria. There are four very important factors to consider during a field visit to select the trap site. Items considered are: access, stream flow, stream gradient, and substrate composition.

Access is extremely important, since juvenile out-migration trapping is a time consuming methodology that requires daily visits, 7 days a week, potentially 150 days of the year (February to July). Having a nearby road or well-established trail is very important, for both delivery of equipment and daily trap maintenance. Flows ranging from 150 to 200 cubic feet per second are the maximum volume of water that has been dammed with this technique. Flows of greater volume may require the use of a screw trap or alternative method (if flow regularly exceeds 150 cfs). Weir strength limits water volume being trapped and may be exceeded during early February and March peak flows, resulting in a loss of trap efficiency.

Stream gradient is important to create the vacuum needed to draw fish towards the mouth of the pipe (positioned at the v-notch in the weir). A minimum of one to three percent drop in stream gradient is sufficient and can be best located in a pool to riffle transition area. By placing the weir on the tail-out of a pool or run, the pipe can be placed in the riffle, capturing the drop in stream gradient that will create the suction necessary to attract fish towards the mouth of the pipe. Substrate composition determines what material will be used in weir construction. Depending on whether there is a sandy bottom with loose gravels or a large cobble/boulder dominant reach, the weir can be fashioned from fence posts and pallets or boulders taking advantage of on site material. This is important, because if planning to use fence posts as anchoring points, it is impossible to drive them through a large cobble/boulder dominated substrate.

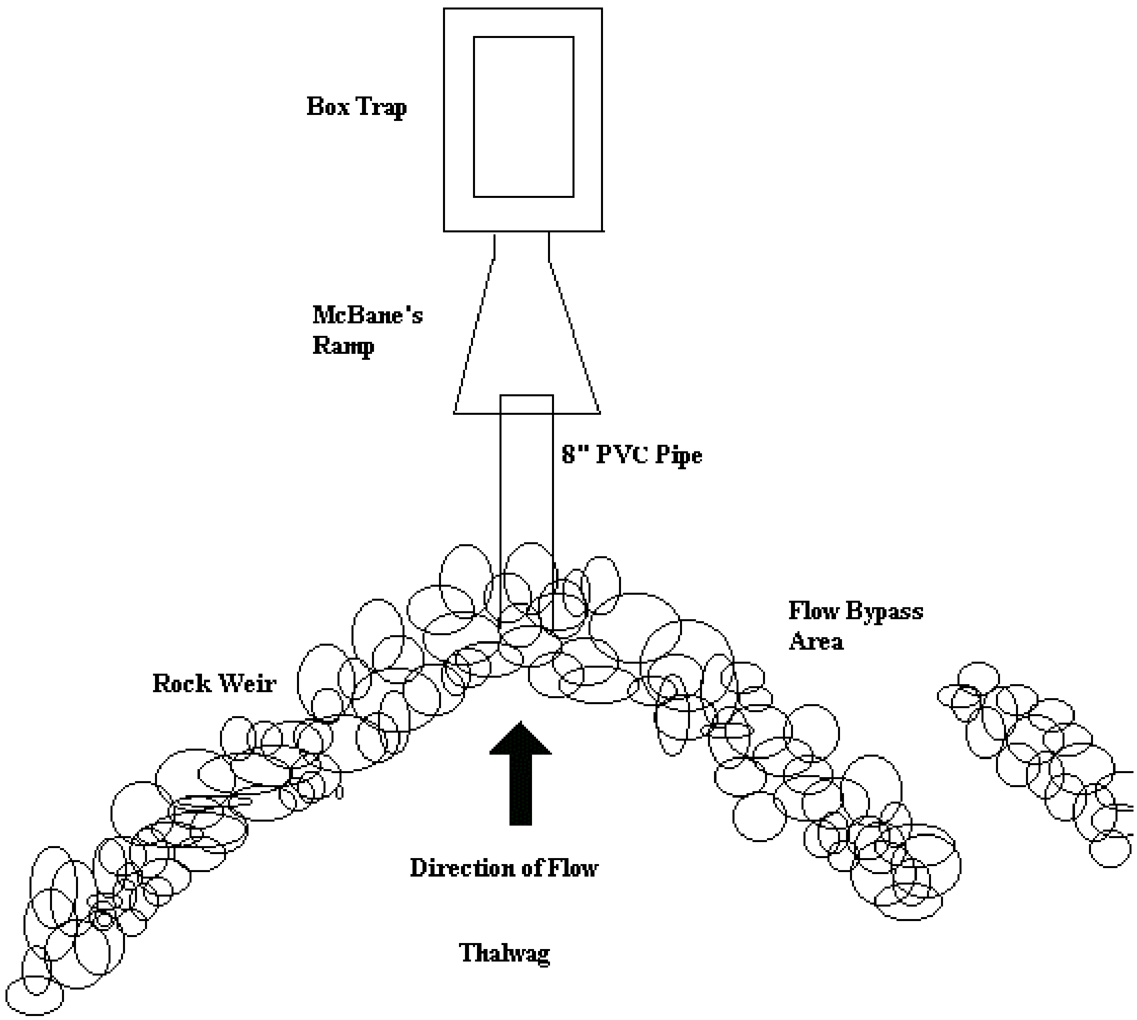

Figure D-4. **Out Migrant Fish Trapping System. The weir is constructed out of boulder and cobble from the streambed. Four to five sections of 20 foot, 8 inch diameter PVC connect the weir to the McBane's ramp downstream. The McBane's ramp diffuses the water velocity before entering the box trap. Diagram not shown to scale. Note: A wooden pallet weir can take the place of the rock weir.**

D.3.9.2.2 *Duration of Surveys*

Juvenile out-migration trapping can run from early February to late July, and may start earlier and run later depending on the out-migration timing of the species being studied. Out-migration timing can vary widely in parts of northern California, and can be triggered by environmental conditions, competition, or egg deposition time. To ascertain site specific out-migration timing for each species during the first year of trapping, allowance for up to 150 days of continuous trapping (February through July) should be made.

Smolt abundance, size, and timing will be monitored annually. The time required to correlate these results with habitat information and summer population estimates is truly unknown, but will probably require a minimum of ten years due to the high variability observed in both summer population estimates and smolt abundance.

D.3.9.2.3 *Equipment List*

The following equipment is needed for each trap site established:

- One to two wood or plastic box(es) (for retaining fish)
- McBane ramp (dissipate water velocity)
- 6’ Steel fence posts (optional)
- Wooden Pallets (optional)
- 60 to 100 feet of 4’ T Galvanized Hardware Screen (optional)
- Galvanized bailing wire (optional)
- 5-6 20’L x 8”D PVC pipes
- Car jacks (scissors variety)
- Nylon rope

The list of equipment that will be needed to maintain and check each trap daily is listed below:

- Three black 5-gallon buckets
- Large meshed fishing net
- Large dip net
- Small dip net
- Ventilated holding cage
- Measuring board

- Viewing chamber
- Data Sheets
- Scissors
- Clear plastic cup
- Alka-Seltzer® (or other anesthetic)
- Long handled scrub brush

D.3.9.3 Weir Construction and Trap Installation

Weir construction is the most time consuming yet important part of trap installation. Once the substrate composition of the streambed is determined, the appropriate material for weir construction will be selected. If large cobble and boulder dominate the substrate of the surrounding stream reach, constructing the weir from streambed material (boulders and large cobble) maybe more appropriate. If the streambed material is small cobble, gravel, or sand, fence posts will be used in weir construction, in combination with either wooden pallets or wire mesh to retain the water.

D.3.9.3.1 Weir Construction

First, locate the thalweg of the run or pool. This will be where the mouth of the pipe is placed and the weir converges to form a V-shape. Clear a location for a 20' section of PVC pipe by removing streambed obstructions (i.e., large rocks and boulders). Take a section of PVC (20'L x 8"D) pipe and place it in the thalweg of the downstream riffle running parallel with stream flow. Submerge the PVC pipe in the unobstructed area of the pool thalweg and quickly place large boulders or several fence posts along the pipe to secure it in place. This location will serve as a convergence point to start constructing both sides of the weir. The rock wall or fence post wall should be shaped as a V, with the mouth of the PVC pipe being at the V-notched end of the weir. Before weir construction is complete, create a small, shallow channel at the edge of the weir, which will serve as a bypass area for escaping steelhead adults. Make sure the bypass area is just shallow enough to pass fish moving upstream. Too much flow may draw out-migrants to this section of the weir. Construction materials and procedures for building the weir depends on the weir type required:

- If building a rock weir, form a large base to the wall like a pyramid (4'-5' thick). Around the mouth of the pipe should be the strongest, thickest portion of the weir. This is the location that needs the most protection, because if this section blows out, it will be very difficult to reconstruct under strong flows. Begin construction by building out from the converging points towards the stream bank, keeping the same thickness of wall. Start adding height to the wall until the majority of flow is trapped and funneled towards the mouth of the pipe. This style of weir is very effective in swift flowing, higher gradient (3-4%) streams.

- If building a fence post/pallet weir, use wood pallets as a marker for fence post placement. Construct the weir by moving from the convergence of the weir out towards the stream banks forming a classic or slightly altered V– shape (depending on thalweg location). Using a fence post driver, place one post deep into the substrate of the streambed. Place one end of the wooden pallet over the fence post and sink it until you reach the streambed. Take another fence post and secure the pallet in place making sure the angle and direction form the V-shape necessary to corral the fish. Continue this procedure until the stream banks are reached and the majority of stream flow is dammed behind the weir. Scrape streambed gravel and cobble around the foundation to cover gaps at the foot of the weir. Be sure to cut wooden pallets in half sections and fill in gaps between the wood with redwood slats or other material to effectively block flow. Half pallets can be stacked to form the weir and will make for a very effective system to manage flow during peak events. This style of weir capable of damming large flows in swift flowing streams, and may be the most efficient method for long-term trapping (if substrate allows).

- If building a fence post/screen weir, placement of the fence posts with use of the fence post driver can be done before the screen is attached to the posts. Place the fence posts by moving from the convergence of the weir out towards the stream banks forming a classic V– shape (depending on thalweg location). The fence posts can be 2 – 4 feet apart, spaced closer together if trapping late in the winter during higher flows. Using bailing wire, attach the screen to the fence posts. Scrape streambed gravel and cobble around the foundation of the screen to cover gaps at the foot of the weir. The majority of flow will be filtered through the wire mesh creating very little incentive for fish to move towards the mouth of the pipe. Sometimes, young fish can become impinged on the surface of the screen during higher flows. To avoid this, angle the V of the weir as much as possible, to avoid perpendicular angles to the direction of stream flow. This system works well for low gradient streams that will not experience large flow events, and may be best suited for late season trapping in flows 1 – 50 cfs (if algae blooms are common, strongly consider the use of pallets or boulders).

D.3.9.3.2 Pipe Installation

The section of pipe that has already been laid parallel with stream flow and sits at the notch of the weir is connected together with the remaining sections of pipe. This string of pipe is run down the full length of the riffle to take advantage of the change in stream gradient (three to six sections of PVC pipe may be needed to run the full length of the riffle). This will help to create the suction at the mouth of the pipe and draw fish in. An attempt is made to empty the pipe into the next habitat unit, preferably a run or pool with slack water, near the stream bank. Place large boulders or use fence posts to keep the pipe stationary during large flows.

D.3.9.3.3 Ramp Installation

If using a rock walled weir, the system is working well when the majority of trapped water is being funneled through the pipe, with the lot of head pressure coming out the far end of the pipe. This will not occur with a fence post/screen weir. In order to reduce the potential for fish mortality, do not place the downstream end of the pipe directly into the box. Alternatively, using a scissors jack, raise the downstream end of the pipe off the ground, and place the mouth of the McBane ramp under the pipe. The McBane ramp is a graduated ramp made out of perforated sheet metal, which will dissipate large volumes of water. Adjust the flow over the McBane ramp by moving it forward or backward. The majority of flow will dissipate through the McBane ramp leaving a smooth sheet of water to carry fish into the box trap. Be sure there is just enough water to gently glide the fish into the live box. There should be 10 – 12 inches of clearance between the surface of the water and the mouth of the McBane ramp, and five to six inches of clearance between the surface water and the portion of the ramp entering the box. The ramp at this point should be at a downward angle when entering the box trap, leaving enough room under the ramp for increased water levels. If there is not enough water flowing over the McBane ramp to create a constant flow, place plastic on the ramp to cover the holes and achieve more flow. This may be necessary when using a fence post/screen weir.

D.3.9.3.4 Box Trap Installation

Attach the box trap to the McBane ramp. Slide the McBane ramp into the pre-formed board created to support the ramps' exit point. The box trap can be submerged or remain out of the water depending on the box trap type being used. Preferably, the box trap should be submerged five to eight inches in the water, which will leave room for increased water levels. Placing rocks or other material along the base of the trap should slow flow against the box trap screen. Installation of a second box trap is optional, but highly recommended to reduce in-trap predation from sculpin, cutthroat and/or steelhead. If a second box trap is used attach the second box trap behind the first box with a connector. The second box trap will hold the young-of-the-year fish. Slide two different gauge screens into the series of box traps, one at the rear of the first box trap and the other at the mouth of the second box trap. This will serve as a barrier to separate large salmonids from smaller salmonids, which will naturally segregate themselves into the two boxes.

D.3.9.3.5 Fine Tuning the Trap Systems

During the first few weeks of trapping, trap and weir maintenance are required daily, especially if higher flows are present. Use this period to fine tune both the weir and the trap to increase trap efficiency and eliminate potential mortality associated with higher flows.

D.3.9.4 Daily Monitoring Procedure

There are three basic steps to the daily monitoring procedure; remove fish from box, identify and measure, and release. All fish entering the box and the number observed are recorded including incidental catches of non-target species such as lamprey, suckers, and sculpins. To initiate the monitoring procedure, the following steps are completed:

D.3.9.4.1 Organization

Data sheets are prepared to measure the day's catch. The organization of the data sheets is important, and species are arranged systematically. Before opening the traps, boards are slid into the screening area and screens are removed. This will stop young-of-the-year from moving back and forth between boxes. The first box trap is opened and any steelhead trout down-runners are removed first. These adult fish are measured and any hatchery marks are noted. After removal of adult steelhead, preparations to measure, mark (if necessary) and release the day's catch are made.

D.3.9.4.2 *Preparation of Holding Containers*

A 5-gallon bucket is prepared by filling it with three to four inches of water. One Alka Seltzer® tablet is dissolved into the water in the bucket. This bucket will be used to anesthetize the first batch of fish (CO_2 and MS-222 may be substituted for Alka-Seltzer®. If Alka-Seltzer® is being used, the tablet must be fully dissolved. A second 5-gallon bucket is filled 2/3 full with water and placed next to the trap. This is used as a recovery bucket for processed fish. A sheet-metal live box or other holding cage is placed in three inches of flowing water next to the trap to serve as a temporary holding cage for clipped fish.

D.3.9.4.3 *Capture Fish*

The day's catch is then sampled by sweeping the large dip net through the trap. A group of twenty to twenty-five fish are selected and place into a bucket for identification, measurement and for potential clip (marking). Until fish-handling proficiency is perfected during the first few weeks of trapping, fewer fish will be selected. Later in the season when water temperatures increase, additional handling stress may occur to fish and therefore will be checked at one time. Fish are placed into the bucket to be anesthetized. Smolting steelhead trout, cutthroat trout, and coho salmon are the only species that will be used to test trap efficiency.

D.3.9.4.4 *Check Fish*

After the selected fish are fully anesthetized they are identified and measured. All measured parr, pre-smolt and adult fish are placed into the release bucket, and data for: species, length and age class are recorded on the data sheet. If a smolt is being measured, an appropriate caudal clip is made to mark fish and the fish is placed into the holding trap. Recaptured smolts are noted at the bottom of the data sheet but are not included in the day's total count. The procedure for marking smolts is found below. Checking fish should take no longer than ten minutes per group, and less time if water temperatures increase or fish are anesthetized quickly. Water in the anesthetizing bucket and recovery buckets are changed every time a new group of fish is selected for data collection.

D.3.9.4.5 *Marking Smolts*

Coho salmon smolts, steelhead trout smolts and cutthroat trout smolts will be marked with fin clips. A total of four different clips will be used throughout the trapping season. Clips will be used for a period of seven-days. The easiest clips to see are caudal fin clips. A horizontal upper caudal, vertical upper caudal, vertical lower caudal and horizontal lower caudal clip will be used for each seven-day period, in any sequence seen fit. After the first 28 days, the same sequence of clips is repeated. Having at least a 28-day period before repeating a sequence of clips is absolutely necessary. Up to 16 smolts of each species will be marked. It may be necessary to increase this number if the number of recaptured fish remains extremely low.

D.3.9.4.6 Release Recovered Fish

After the first bucket of fish are measured and recorded, they are checked to see if the unmarked fish in the recovery bucket are ready to be released. If these fish have recovered from the anesthetic, these fish are released to a portion of slack water near the trap site. Procedures are repeated until the first box trap is empty.

D.3.9.4.7 Check Young-of-the-Year

The majority of young-of-the-year chinook salmon, coho salmon and trout will have already separated themselves into the second box trap and there will be no need to anesthetize these young-of-the-year fish. A 5-gallon bucket is filled with water and the young-of-the-year fish are removed from the second box using additional caution on hot days. Twenty measurements from a sample of each species are obtained and recorded. Once the twenty measurements are recorded, tallies of the remaining young-of-the-year are made until all fish are observed.

D.3.9.4.8 Release Marked Fish

Fish clipped for trap efficiency tests will be fully recovered from the anesthetic and placed into a 5-gallon bucket for transport above the weir. Clipped fish are then placed into the pool a few yards above the weir (but not at the mouth of the pipe). Trap efficiency is designed to test how well the weir is working not predation or any other factor. If these fish are recaptured, they are not used again for efficiency testing. In some cases the fish may be held until dusk before releasing. This accomplishes several things; testing to see if there is some handling mortality; release of the fish to coincide with peak diurnal movements; and allows fish to fully recover from handling prior to re-approaching the weir. This is an optional procedure step in this protocol.

D.3.9.4.9 Record Mortality

Very little trap-related mortality will be generated with this method. Under federal and state salmonid trapping permits, some mortalities are retained for genetic studies. Appropriate handling and preservation techniques will be implemented if permit requires that mortalities be archived.

D.3.9.5 Daily Trap Maintenance

All accumulations of debris will be cleaned and removed daily from the McBane ramp, interior of both boxes, behind the weir and screens that segregate the fish. The majority of mortality is caused by debris accumulations on the ramp or inside the live boxes. The weirs will be checked for leaks or debris accumulations that may have piled up.

D.3.9.5.1 Calculating Trap Efficiency

A “mark-recapture” method is used to estimate trap efficiency. Accurate population estimates depend on this portion of the protocol.

A 28-day period will be used to test trap efficiency, utilizing coho salmon smolts, cutthroat trout smolts, and steelhead trout smolts, as described above. Trap efficiency will be calculated by using only species that are actively leaving the drainage on their seaward migration ("smolts"). These tests will be run to determine what percentage of the population is missed by inefficiencies in the weir. Marks (fin clips) will be changed every 7-days to account for variations in environmental attributes. Trap efficiency will be calculated using a software package (DARR: Darroch Analysis with Rank-Reduction) that analyzes stratified mark-recapture data (Bjorkstedt 2000).

D.3.9.5.2 Population Estimation

Population estimates will be made for smolt year classes of coho salmon, steelhead and coastal cutthroat trout. Population size will not be estimated for chinook salmon due to their size and abundance during out-migration. Chinook are too small when first entering the traps to mark with a caudal fin clip. Population estimates are not made for young-of-the-year, parr, or pre-smolts of the same species because these life stages are only redistributing themselves within the watershed, and not actively emigrating to the ocean. The out-migrant smolt population estimates will be calculated using a software package (DARR: Darroch Analysis with Rank-Reduction) for analysis of stratified mark-recapture data (Bjorkstedt 2000).

D.3.9.6 Literature Cited

Bjorkstedt, E.P. 2000. DARR (Darroch Analysis with Rank-Reduction): A method for analysis of stratified mark-recapture data from small populations, with application to estimating abundance of smolts from outmigrant trap data. U.S. Department of Commerce, NOAA, NMFS, SWFSC, Admin. Rep., Santa Cruz, SC-00-02. 261 Kb, 28 p.

D.4 EXPERIMENTAL WATERSHEDS PROGRAM

While the majority of the Plan's monitoring projects will be conducted throughout the Plan Area, four experimental watersheds judged to be representative of the different geologic and physiographic provinces across the Plan Area have been designated for additional monitoring and research on the interactions between forestry management and riparian and aquatic ecosystems. Those watersheds are the Little River HPA, the South Fork Winchuck River in the Smith River HPA, Ryan Creek in the Humboldt Bay HPA, and Ah Pah Creek in the Coastal Klamath HPA (see Figure 6-9 in Section 6.3).

In general, the program will entail:

- Effectiveness monitoring projects and programs that due to their complexity and expense of implementation can only be applied in limited regions (these include turbidity monitoring, Class III sediment monitoring, and road-related catastrophic sediment input monitoring;

- BACI studies of harvest and non-harvest areas, allowing for more effective evaluation of conservation measures and increased understanding of the effects of forest management on the habitats and populations of the Covered Species.

- BACI studies of conservation and management measures, allowing for a refinement of measures and an assessment of the relative benefits of different measures under the Plan; and

- Development and implementation of new or refined monitoring and research protocols.

In addition, Simpson may expand Out-migrant Trapping in the Little River HPA to one or more of the other experimental watersheds.

In the program, management will be implemented as a large scale experiment where possible, allowing for more effective evaluation of conservation measures and increased understanding of the effects of forest management on the habitats and populations of the Covered Species. Where possible, harvest with a variety of different conservation measures will be the “treatments” in a BACI experimental design, with an adjacent unharvested area as the control. Specific effectiveness monitoring projects will compare the treatment and control before and after harvest to determine the effectiveness of the conservation measures.

The turbidity monitoring and catastrophic sediment input monitoring are designed in part to measure the effectiveness of the road management plan’s upgrading and decommissioning measures in reducing road-related sediment inputs. For these road-related monitoring projects, the experimental design occurs as monitoring is implemented both spatially and temporally to allow comparisons of road-related sediment inputs before and after road upgrading and decommissioning.

Upgrading and decommissioning the roads as effectively and efficiently as possible is the first priority, therefore monitoring will essentially be conducted “around” the road work schedule. The prioritization process (see Section 6.3.3.) used to schedule the road work will provide the information needed to design an effective monitoring program without slowing the implementation of the road upgrading and decommissioning process. For example, the prioritization table may dictate that, within a specific sub-basin, one road work unit will be upgraded before another. Monitoring could begin in both units before any work is done, and continues while first one, and then the other work unit is upgraded. This experiment would not be conducted in a true BACI design, because Simpson will not leave any sub-basins as “controls” in the untreated condition. However, over time it will be possible to make a cumulative comparison of treated versus untreated roads and sub-basins to determine if the road management plan is effective in reducing road related catastrophic sediment inputs or road-related increases in turbidity.

Simpson and CDFG are already implementing an experimental management program in the Little River HPA to assess the relative benefits of two different mitigation measures to protect aquatic resources following timber harvest. A randomized BACI experiment will be conducted in blocks of three streams, wherein the two sets of mitigation measures are viewed as two different treatments with the third stream as a control. During the course of the experiment, both mitigation measures will be applied to an approximately equal number and linear distance of streams. The primary objectives of the study will be to:

- determine if there are any detectable changes in environmental and biological variables measured on watercourses following timber harvest, and if there are,

- which mitigation strategy is more effective in reducing negative impacts.

The response variables will be monitored pre and post harvest and will include water temperature, shallow landslide activity, Class III sediment delivery, and potential LWD. Air temperature, relative humidity, wind speed, turbidity, and stream amphibian populations will also be monitored in selected sites.

The development and implementation of new research and monitoring protocol will provide an opportunity for Simpson to refine existing conservation measure to make them more effective and efficient. This will include state-of-the-art existing study designs along with original research approaches that will require the input from academic, agency and private scientists.

No experiment which involves the application of conservation measures other than those prescribed in the Plan will occur without the concurrence of the Services.