# Quality Assurance Protection Plan *

**PROJECT TITLE:** Feather River Coordinated Resource Management Watershed Monitoring Pilot Project: Trend Analysis Approach Sierra, Plumas, and Lassen Counties, California

**RESPONSIBLE ORGANIZATION: Plumas Corporation**

| | |
|---|---|
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Feb.2001

*Based on the Field Sampling Plan and Quality Assurance Project Plan Guidelines For Region IX (dated Sep., 1998)

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## 1.0 Quality Assurance Protection Plan Introduction

Numerous watershed restoration activities have occurred in the Feather River watershed in recent years. The Feather River Coordinated Resource Management (FRCRM), which includes 21 public agencies, private interests, and local landowners has completed over 40 watershed projects in the Feather River watershed since 1985 including studies and assessments, resource management plans, stream restoration projects, community outreach and educational efforts.

This 319 grant establishes a regional monitoring a program in the upper Feather River basin to provide insight on overall trends resulting from restoration, land management changes and natural processes. The program targets the North Fork and Middle Fork Feather River watersheds. Smaller scale effectiveness monitoring to identify specific restoration benefits will be conducted in other proposed programs, and will be designed to compliment the regional program.

The data will be used to document trends in watershed condition resulting from restoration activities. The result will hopefully answer the question of whether restoration above the Central Valley's major foothill reservoirs can increase reliable water yield, and enhance flood protection above and within the Central Valley.

These data will provide critical input to the restoration program conducted by the Feather River CRM. Identification of conditions throughout the watershed will allow prioritization of restoration projects in terms of location and goals. Benefits of past restoration efforts will be quantified. Information on watershed condition will serve as a baseline data for future projects.

### 1.1 Project Goals and Objectives

The long-term goals of this project are to develop, implement and evaluate a monitoring program, which documents, at the watershed scale, long-term trends in watershed condition cumulatively resulting from restoration activities, land management changes and natural processes.

**Long-term Objectives**

- Continuously monitor changes in water temperature over time as a key parameter in assessing changes in watershed condition. A significant reduction in summer water temperatures over time is indicative of improving watershed condition.
- Continuously monitor changes in surface water flow over time as a key parameter in assessing changes in watershed condition. A significant increase in summer base flow and reduced peak flow are indicative of improving watershed condition.
- Continuously monitor changes in turbidity over time as a parameter in assessing watershed condition changes. An overall long-term decrease in turbidity is indicative of improving watershed condition.
- Monitor bedload and suspended sediment at various flows.
- Monitor, bi-annually, physical and biological changes in reference reaches:

  Channel morphology, including channel cross sections, channel entrenchment and gradient, channel bed material sampling, large woody debris, (LWD), and pool tail fines. Transect data includes bank stability, shade, width/depth ratio, stream shore water depth, and bank angle. Bankfull will be estimated based on known procedures and field indicators.

  Water chemistry, including water, air temperature and turbidity.

  Habitat, including spatial distribution of fast and slow water via longitudinal gradient (i.e. pool and riffle orientation), pools (size, depth and number), pool tail substrate (% fines), shading, and stream bank stability (i.e. vegetation cover).

  Macro-invertebrates, including analysis of population numbers and species diversity in comparison to Sierra Nevada reference sites. Not originally part of SCI protocol, but has been added on with the availability of reference site data.

  Aquatic fauna, includes ocular observations of fish, amphibians, reptiles, and bivalves.

  Aerial and ground photographs to provide visual documentation of in-stream and upland changes in vegetation and channel structure, and to support other monitoring results.

**Short-term Goals**

The short-term goals of this project are to evaluate the pilot monitoring strategy and determine whether it meets long-term project goals, is viable for long-term application, includes appropriate sampling intensity and parameters, and is reproducible. We will also solicit funding to continue the monitoring program beyond the two-year pilot.

**Short-term Objectives**

- Evaluate the effectiveness of the monitoring plan upon completion of the two-year pilot program. We will use the qualitative checklist in Table 1 to assess the success or failure of the program in meeting goals. Based on preliminary results of the pilot program, we will rate its effectiveness and provide recommended modifications.
- Develop a spatially referenced data management system to track, organize, and store monitoring data, facilitate analysis, and support production of reports needed to evaluate long-term trends. The system used should be compatible with other data sets managed by QLG, USFS etc.
- Coordinate with Plumas National Forest, DWR, UC Cooperative Extension, ICE, QLG, Feather River College, etc. on data collection and management approaches.

## 1.2 Work Scope Overview

The monitoring approach in this QAPP consists of two basic components as described below. The first two tasks vary in parameters measured, location and sampling. See Table 1., and Table 2.

Work products are to:

Conduct continuous monitoring of temperature and flow at eleven permanent sampling stations.
Conduct continuous turbidity monitoring at two locations.
Collect conductivity and pH data periodically at all stations.
Collect bedload and suspended sediment data in various flow regimes at two stations.
Conduct biannual monitoring of selected physical and biological parameters on 21 designated reference reaches. Measurements include stream morphology, water chemistry, habitat, macro-invertebrates, and fishery, and aerial and ground photography at pre-determined locations.

The 319 pilot monitoring program will be implemented over a two-year period. Monitoring equipment will be purchased and installed in the spring 1999. Other anticipated activities for 1999 include: 1) collection of flow and temperature measurements for rating the stations :2) collection of turbidity data: 3) completion of reference reach initial surveys, 3) developing a data storage and analysis approach: 4) securing cooperators' commitments and landowner agreements, and: 5) seeking new funding sources for continuing the monitoring program beyond the two year pilot.

The program will be integrated with other Feather River watershed monitoring activities underway or contemplated by the USDA Forest Service, DWR, UCCE, QLG and others. A technical advisory committee (TAC) composed of CRM Monitoring Committee members, agency specialists, and academic reviewers will provide technical guidance and oversight on the implementation of the project. The TAC members will be identified in spring 1999.

This project targets the watersheds of the North and Middle forks of the Feather River. The South Fork Feather is not included in the scope of this effort.

## 1.3 Expected Types of Data Analysis (needs work)

Permanent Station Data (Bridge sites): Continuous streamflow (stage) and temperature data is recorded and archived as baseline condition without analysis. Direct streamflow measurements (discharge) will be conducted at a variety of stages for the purpose of developing stage/discharge rating tables specific to each station. No analysis is intended because the rating table is an extension of the station operation.

Sediment monitoring will be conducted for three (classes) of sediment: turbidity, suspended sediment and bedload. The data will be used to establish baseline sediment/discharge (sedigraphs) tables for each class as well as baseline total sediment load values. Long-term data will likely be used only for comparability by site over time.

Stream Reference Reach Data: All data is entered in Excel spreadsheet format by **pass** and **reach.** Spreadsheets are formatted with a query system for retrieval and sorting by pass, reach and parameter. This data is intended to provide a baseline of condition without analysis. Once future data sets are collected, analysis will likely be only comparability by site over time.

## 1.4 Site Location

The Feather River watershed is located in California's northern Sierra Nevada, where the North and Middle Forks drain variable terrain from the Sierran crest westward into the Sacramento River. Project sites for permanent bridge stations and stream reference stations are located in the Upper Feather River Watershed, within Lassen, Plumas and Sierra counties, Northern California. The South Fork Feather River is not included in this study project.

## 1.5 Responsible Organization

Plumas Corporation is responsible for data collection, and instrument instantiation with technical input from members of the Feather River Coordinated Resource Management (CRM) group which includes 21 public agencies, private interests, and local landowners.

## 1.6 Project Organization

Project review, critique and oversight is provided by Feather River Coordinated Resource Management group via technical teams.

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### 1.7 Statement of Specific Problem
The quantity and quality of California's water supply is dependent upon the condition of source watersheds. Population growth, agricultural demand, land development and recreational use have placed heavy demands on a limited water supply, creating conflicts between water users and placing intense pressure on watershed resources. Water quality standards at both the State and Federal levels are being tightened to protect water quality and to enhance beneficial uses. As demand for high quality water increases, maintaining good condition watersheds in the northern Sierra is becoming increasingly important in meeting California's commercial, industrial, and residential water needs, and in protecting environmental values.

The Feather River watershed is located in California's northern Sierra Nevada, where the North, South and Middle Forks drain 3,222 square miles of variable terrain from the Sierran crest westward into the Sacramento River. Elevation ranges from 2,250 to over 10,000 feet, and annual precipitation varies broadly from more than 70 inches on the wet western slopes to less that 12 inches on the arid east side. Vegetation is diverse and ranges from productive mixed conifer and deciduous forests in the west to sparse sage/yellow pine plant communities in the east (Lindquist 1997). The Plumas National Forest manages most of the forested areas while alluvial valleys are predominantly privately owned and are grazed by livestock.

The Feather River watershed has long been recognized for its recreational and aesthetic value. An abundance of montane rivers, lakes and reservoirs dot the landscape, creating both summer and winter recreational opportunities. Water originating from this area represents a significant component of the State Water Project which provides high quality water to meet downstream urban and agricultural demand. In addition, a series of hydrolelectric dams, powerhouses and reservoirs produce over 4,000 MW of power, while the watershed produces significant forest and livestock outputs. Water is, therefore, a valuable commodity in this resource-dependent community, and maintaining stable watershed condition is a key element in promoting economic and environmental stability.

The Feather River watershed has been impacted by 140 years of intense human use. Mining, over-grazing, timber harvesting, wildfire, railroad and road construction have contributed to the degradation of over 60 percent of the watershed, resulting in accelerated erosion, degraded water quality, decreased vegetation and soil productivity, and degraded terrestrial and aquatic habitats. Annually, 1.1 million tons of sediment is delivered to Rock Creek Dam at the downstream end of the East Branch North Fork Feather River (EBNFFR) of which 80 percent is attributable to man's activities (Clifton 1994). Long-term vegetation disturbance and consequent gully erosion has led to a dramatic change in hydrology, leading to reduced summer flow, higher summer water temperature, lower water tables, reduced meadow storage capacity, and a trend from perennial to intermittent flow. Many downcut streams no longer sustain late-season flow, causing adverse consequences to riparian and upland vegetation, aquatic communities, and downstream water users (Ponce and Lindquist 1990).

In response to these trends, an alliance of 21 public agencies, private interests, and local landowners was formed in 1985 to collectively develop and implement a plan to restore the upper Feather River watershed. This collaborative group, later called the Feather River Coordinated Resources Management (FRCRM) group, has completed over 40 watershed projects since 1985 including studies and assessments, resource management plans, stream restoration projects, community outreach and educational efforts. Completed projects include meadow re-watering, biotechnical revegetation, abandoned mine restoration, grazing management, strategic planning, urban stream enhancement, and design and installation of fish ladders. At least 15.5 miles of stream and 4,000 riparian acres have been treated over the last decade, at a cost of over five million dollars contributed by CRM partners (reference).

The FRCRM recognized that restoring watershed function was a major priority for reversing erosional trends. Stable, well-vegetated streams with functioning meadows, aquifers and uplands are critical in maintaining good watershed condition. Achieving this stable state begins with reestablishing water and sediment retention and release functions in headwater meadows, which is the current focus of the FRCRM. Restoration activities play an important role in accelerating improvement in watershed function, the local economy, and downstream uses.

The goal of this 319 grant is to establish a regional monitoring a program in the upper Feather River basin to provide insight on overall trends resulting from restoration, land management changes and natural processes. The program targets the North Fork and Middle Fork Feather River watersheds. Smaller scale effectiveness monitoring to identify specific restoration benefits will be conducted in other proposed programs, and will be designed to compliment the regional program.

### 1.8 Data Uses
The data will be used to monitor long-term trends in the condition of the Upper Feather River watershed. It will also be used to document trends in watershed condition cumulatively resulting from restoration activities. This information will also hopefully inform the question of whether restoration above the Central Valley's major foothill reservoirs can increase reliable yield, create restoration opportunities, and enhance flood protection in the Central Valley. All of which are critical to the well being of the degraded Sacramento-San Joaquin Delta, and to California as a whole.

These data will provide critical input to the restoration program conducted by the Feather River CRM. Identification of conditions throughout the watershed will allow prioritization of restoration projects in terms of location and goals. Benefits of past restoration efforts will be quantified. Information on watershed condition will serve as a baseline data for future projects.

The data and analyses will be available to a wide resource management audience, including local land management agencies and private land-owners and public web users, via the Plumas Corporation web site. These data will hopefully inform land management decisions made by many which have the potential of affecting the Feather River watershed. In addition, this information will be useful to the public to gain insight on the overall condition of the Feather River watershed, and the connections between land use, restoration, and watershed condition.

## 2.0 Background
### 2.1 Project Location (General)
The Upper Feather River watershed collects waters from the northern Sierra Nevada, California, into the North Fork Feather River, East Branch North Fork Feather River and Middle Fork Feather River. These waters join with the South Fork Feather River at Lake Oroville in the Sierra Nevada foothills. The Feather River then flows into the Sacramento River in the Central Valley of California and out to the Pacific Ocean through San Francisco Bay. Monitoring projects are located on the main stem and tributaries of the North Fork, East Branch North Fork and Middle Fork Feather River, an area of approximately 3,220 square miles. The South Fork Feather River is not monitored at this time.

### 2.2 Geographic Location
The monitored portion of the Feather River Watershed encompasses a large geographic area extending from the Southern portion of Lassen County above Lake Almanor and Mountain Meadows Reservoir, across Plumas County to the northern portion of Sierra County at Sierra Valley and the headwaters of the Middle Fork Feather River. The watershed includes lands in the Plumas, Sierra, and Tahoe National Forests as well as many individual private landowners.

### 2.3 Specific (Site Name) Locations

**Bridge Stations**
Continuous stream flow and temperature stations will be installed at the following locations:

1. Last Chance Creek at Doyle Crossing

2. Red Clover Creek at Notson Bridge
3. Indian Creek at Taylorsville
4. Indian Creek at Flournoy Bridge
5. Middle Fork Feather River at Sloat
6. Indian Creek above confluence with Red Clover
7. Spanish Creek at Keddie
8. Spanish Creek at Gansner Bridge
9. Wolf Creek at Greenville Main Street Bridge
10. Lights Creek at Deadfall Bridge
11. Indian Creek at Crescent Mills

**Stream Reference Reaches**

Bi-annual reference reaches will be established at:

1. North Fork Feather River (NFFR) above Lake Almanor
2. Goodwin Creek above Mountain Meadows Resv.
3. NFFR below Lake Almanor
4. Butt Creek above Butt Valley Reservoir
5. NFFR above confluence with East Branch North Fork Feather River (EBNFFR)
6. EBNFFR above confluence with NFFR
7. Wolf Creek above confluence with Indian Creek
8. Lights Creek above confluence with Indian Creek
9. Last Chance Creek above confluence with Red Clover Creek
10. Red Clover Creek above confluence with Last Chance Creek
11. Indian Creek above confluence with Red Clover Creek
12. Indian Creek at Taylorsville
13. Indian Creek above confluence with Spanish Creek
14. Spanish Creek above confluence with Rock Creek
15. Greenhorn Creek above confluence with Spanish Creek
16. Spanish Creek above confluence with Greenhorn Creek
17. Spanish Creek above confluence with Indian Creek
18. Middle Fork Feather River (MFFR) at Beckwourth
19. Sulphur Creek above confluence with MFFR
20. Jamison Creek above confluence with MFFR
21. MFFR above confluence with Nelson Creek

**2.4 Geological Information**

In general terms the North and Middle Fork Feather River are composed of three different rock types: metamorphic, granitic, and sedimentary/volcanic. The oldest rock types are composed of metamorphosed sediment and volcanic rocks of the Nevadian geosyncline that has been highly deformed. Granitic intrusion has formed massive plutons that form much of the Sierra Nevada. The youngest rocks of the area are the sedimentary and Tertiary volcanic rocks that formed after the granitic intrusions. These younger rocks include glacial tills and sediment deposited in extinct lakes that once occupied most of the valleys in the Feather River Watershed. Volcanic rock covers large portions of the east side of the watershed and cap many peaks in the central watershed (Durrell,1987).

Most soils within the watershed are well drained, gravelly loam or clay loam. The productivity and manageability of these major soil types does not vary greatly through the watershed. Exceptions to this are generally associated with rock outcrops, serpentine areas, breakland areas, and flood plains. Generally, the western slope of the watershed contain more productive soils. North-facing slopes are known for moister, deeper, and more productive soils than south-facing slopes. Erosion hazards are higher on granitic soils than other soil types within the watershed (Durrell,1987).

**2.5 Environmental and/or Human Impact**

Human population in the watershed is low compared to other areas of the state of California, primarily because of federal ownership of much of the land base, and a sparse economy. A natural appearance is maintained throughout most of the watershed compared to heavily settled areas elsewhere.

However, human impacts have been profound throughout the watershed since the advent of the gold rush in the 1850's. Most watershed streams have been mined for gold, some of which were completely transformed by hydraulic mining. The area was subject to over-grazing during the early years of exploitation by cattle and sheep ranchers.

The majority of the landscape at low to middle elevations has been harvested for timber both by private timber companies and on federal forests. Large wildfires in the last decade have included the Cottonwood fire in 1995 (100,000 acres), the Buck's fire in 1999 (40,000), and the Storrie fire in 2000 (40,000) acres. Railroad lines and roads traverse most of the watershed. A series of hydro-electric dams occupy the lower sections of the North Fork of the Feather River.

The North Fork of the Feather River has borne the majority of the impacts. These impacts have contributed to the degradation of over 60 percent of the watershed, resulting in accelerated erosion, degraded water quality, decreased vegetation and soil productivity, and degraded terrestrial and aquatic habitats. Annually, 1.1 million tons of sediment is delivered to Rock Creek Dam at the downstream end of the East Branch North Fork Feather River (EBNFFR) of which 80 percent is attributable to man's activities (Clifton 1994).

Although portions of the Middle Fork of the Feather River are designated as Wild and Scenic, the headwaters area bears impacts from its heavy use for agricultural production and livestock grazing.

Long-term vegetation disturbance and consequent gully erosion has led to a dramatic change in hydrology in many areas including reduced summer flow, higher summer water temperature, lower water tables, reduced meadow storage capacity, and a trend from perennial to intermittent flow. Many downcut streams no longer sustain late-season flow, causing adverse consequences to riparian and upland vegetation, aquatic communities, and downstream water users (Ponce and Lindquist 1990).

**2.6 Previous Investigations**

There have been a large number of past studies and projects within the watershed . Several of these have been significant and published in professional journals. The Feather River Coordinated Resource Management (Group) can provide a list of all published data regarding project and studies. Several other monitoring efforts are on-going in the Feather River watershed. The USDA Forest Service, Plumas National Forest is conducting its own Stream Condition Inventory at selected sites throughout the watershed. Several USGS monitoring stations are installed and still operative within the Feather River Watershed. However, none of these efforts have attempted to integrate an overall monitoring of watershed trends.

### 2.7 Regulatory Involvement

This project consists of non-intrusive monitoring activities requiring no regulatory permitting action. As needed, Special Use Permits and Letters of Permission were obtained from landowners, public agencies and rights-of-way holders.

## 3.0 Project Data Quality Objectives

### 3.1 Data Uses

The data collected in response to the long-term monitoring objective will be used to document long-term trends in existing watershed condition, restoration activities, land management changes, and natural processes. The data is collected in a manner that allows for consistency and quality control over time, a variety of channel conditions and multiple observers.

These data, along with recommendations from contractors, CRM staff and the CRM Monitoring Committee, will then be used to evaluate the effectiveness of the pilot monitoring project and to recommend modifications to the protocols.

### 3.2 Project Tasks

The following table shows the array of measurements that will be made at each of the continuous stream flow and temperature stations.

TABLE 1 **– Measurements taken at permanent bridge stations**

| Station # | Location | Stream Flow & Temp. | Staff Gage | Weat-her Station* | Sedi-ment & Turbidity | Existing USGS Gage |
|---|---|---|---|---|---|---|
| 1. | Last Chance Creek at Doyle Crossing | X | | X | | |
| 2. | Red Clover Creek at Notson Bridge | X | X | X | | |
| 3. | Indian Creek at Taylorsville | X | X | | X | |
| 4. | Indian Creek at Flournoy Bridge | X | X | | X | |
| 5. | Middle Fork Feather River at Sloat | | X | | | |
| 6. | Indian Creek above confluence with Red Clover | X | X | | | |
| 7. | Spanish Creek at Keddie | | | | | X |
| 8. | Spanish Creek at Gansner Bridge | X | | | | |
| 9. | Wolf Creek at Greenville Main Street Bridge | X | X | | X | |
| 10. | Lights Creek at Deadfall Bridge | X | X | | | |
| 11. | Indian Creek at Crescent Mills | X | X | | | |
| | | | | | | |

**TABLE 2** - Bi-annual reference stream reach data. This table shows types of data taken at each of the 21 stream reference reaches.

| Reach # | Location | Channel Morphology | Biological/habitat |
|---|---|---|---|
| | | S*, X-section, sieve analysis, shade, width/depth, shore water depth, bank angle | Channel gradient, pool/riffle, pool tail substrate, macro-invertebrate, fisheries |
| 1. | NFFR above Lake Almanor | X | X |
| 2. | Goodrich Creek above Mountain Meadows Rsv. | X | X |
| 3. | NFFR below Lake Almanor | X | X |
| 4. | Butt Creek above Butt Valley Reservoir | X | X |
| 5. | NFFR acw** EBNFFR | X | X |
| 6. | EBNFFR acw NFFR | X | X |
| 7. | Wolf Creek acw Indian Creek | X | X |
| 8. | Lights Creek acw Indian Creek | X | X |
| 9. | Last Chance Creek acw Red Clover Creek | X | X |
| 10. | Red Clover Creek acw Last Chance Creek | X | X |

| | | | |
|---|---|---|---|
| 11. | Indian Creek acw Red Clover Creek | X | X |
| 12. | Indian Creek at Taylorsville | X | X |
| 13. | Indian Creek acw Spanish Creek | X | X |
| 14. | Spanish Creek acw Rock Creek | X | X |
| 15. | Greenhorn Creek acw Spanish Creek | X | X |
| 16. | Spanish Creek acw Greenhorn Creek | X | X |
| 17. | Spanish Creek acw Indian Creek | X | X |
| 18. | Middle Fork Feather River (MFFR) at Beckwourth | X | X |
| 19. | Sulphur Creek acw MFFR | X | X |
| 20. | Jamison Creek acw MFFR | X | X |
| 21. | MFFR acw Nelson Creek | X | X |

****acw = above confluence with**

**3.3 Expected Data Quality**

**3.4 Data Quality Indicators**

Accuracy and Precision of Instrumentation and Maps: USGS 7.5 Quad maps, GIS-generated maps, reach specific transit mapping and GPS location sensing provide more than adequate mapping accuracy for the purpose of this program. All instrumentation is of high quality and field-calibrated as recommended by manufacturers. Field data and notes are checked for errors by the team leader or supervising scientist prior to leaving measurement site.

Completeness: Field data and notes are checked for errors by the team leader or supervising scientist prior to leaving measurement site. Minor variations in site conditions that affect sampling are evaluated and accounted for by team leader or supervising scientist prior to sampling and any rectifications made prior to leaving measurement site.

Representativeness: The protocols used throughout this program have been thoroughly field tested by the referenced authorities (e.g. USFS, USGS, etc.) to provide a qualitative representation of the sampled parameters.

Comparability: The data is collected in a manner that allows for consistency and quality control over time, a variety of channel conditions and multiple observers.

**3.5 Data Management Checklist**

The following checklist of data management steps pertains to any and all of the parameters included in the bi-annual reference reaches surveyed for this project.

1. Collect field data for the most downstream or first reach.
2. Assemble Supervising Field Scientist, QA and Project Manager, and Field Personnel Coordinator to review and adjust data collection methods.
3. If methods adjustments are substantial, seek authorization from the EPA.
4. Deliver first reach results to data management team for production of graphics and GIS links to base map.
5. Assemble Supervising Field Scientist, Project and QA Manager, and Field Personnel Coordinator to assess graphics output format and to conduct initial interpretation of first reach data, and adjust graphics format as required.
6. Proceed with next two reaches.
7. Deliver results from next two reaches to data management team for production of graphics and GIS links to base map.
8. Assemble Supervising Field Scientist, Project and QA Manager, and Field Personnel Coordinator to assess graphics output format and to conduct initial interpretation of data for the next two reaches and test GIS links.
9. Assemble Supervising Field Scientist, Project and QA Manager, and Field Personnel Coordinator to review field methods, field notebooks, personnel assignments, data management requirements and adjust as required.
10. If methods adjustments are substantial, seek authorization from the EPA.
11. Hold a public workshop to present work to date and solicit input.
12. Proceed with remaining reaches.
13. Assemble Supervising Field Scientist, Project and QA Manager, and Field Personnel Coordinator to review field methods, field notebooks, personnel assignments, data management requirements and adjust as required.
14. Assemble Supervising Field Scientist, Project and QA Manager, and Field Personnel Coordinator to conduct final analysis and to assign reporting responsibilities
15. Transfer all graphic and GIS data between….
16. Write draft report and provide to project sponsors for internal review.
17. Write final report, deliver to sponsoring agencies, and make available through web site….
18. Hold a public workshop to present project results.

**3.6 Assessment Oversight**

The Supervising Field Scientist, Project and QA Manager, and Field Personnel Coordinator will have monthly meetings to solve any problems with field procedures, data management, GIS, or information exchange. The Supervising Field Scientist and Field Personnel Coordinator will work closely together in the field and between field trips to assess and solve any problems with personnel. The Project Manager and QA Managers will maintain quarterly accounts of project funds spent and remaining.

**4.0 Sampling Protocols and Design**

**4.1 Requests For Information and Analysis**

The USDA Forest Service, Plumas, Lassen, and Tahoe National Forests provided USGS Quadrangle (7.5) maps, well as the most recent aerial photographs (1997) of both bridge and stream reference sites for scanning by Chico State University.

The California Department of Water Resources provided global positioning system data on all reference reaches and cross section locations to be used in the Geographical Information System data base for the project. In addition they also provided an experienced crew menber to gather data on reference reaches.

Meadowbrook Conservation Associates in conjunction with Feather River College, and Chico State University provided the analytical software to analyze data collected from both the bridge and reference sites.

Chico State University provided Geographical and Web Site information and expertise to enable the Feather River Coordinated Resource Management (Group) to expand there existing web site to included data, maps and graphics.

Utah State University, Department of Fisheries and Wildlife, National Aquatic Monitoring Center, Buglab, provided analysis of macro-invertebrate samples collected at stream reference reaches.

**4.2 Environmental measurements**

1. Stream Temperature
2. Air Temperature
3. Channel Gradient, Water Surface Longitudinal Profile
4. Habitat Type, Pool/Non-pool relationship
5. Maximum Pool Depth and Maximum Pool Tail Crest Depth
6. Pool Tail Substrate: Percent surface fines
7. Channel Cross-Sections
8. Channel Entrenchment
9. Channel Width-to-Depth Ratio
10. Stream-bank Stability
11. Stream Shading
12. Channel Substrate: Sieve Analysis
13. S* Measurements (depth of sediment in pools)
14. Stream Shore Water Depth
15. Bank Angle
16. Macro-invertebrate, species and abundance
17. Aquatic Fauna, ocular observations
18. Stream Flow
19. Suspended Sediment
20. Turbidity

**5.0 Methods and Procedure**

This project will involve continuous detailed measurements of stream flow, sediment, and temperature at 11 permanent stations, as well as bi-annual measurements of channel morphology, biological, and habitat characteristics at 21 reference reaches.

The field work will be conducted by a team of people that includes a professional geomorphologist, wildlife biologist, and graduating, natural resource students from Feather River College. To the extent possible, the fieldwork will follow scientific procedures and protocols that are well established in the primary literature or common practices in Federal or State resource agencies.

**6.0 Field Health and Safety Procedures**

Each Sierra Nevada stream presents a suite of hazards that must be addressed by any field investigator. During the wet season, stream flows can be too height to enter. In the dry season, when most of the field work will be conducted, there are localized hazards due to unsure footing, abundant and unstable large debris, exhausting work, poison oak and poisonous snakes.

To counter these hazards, the Coyote Creek Riparian Station (CCRS) and San Francisco Estuary Institute (SFEI) developed a “Safety Sheet” for volunteer field work in streams. The CCRS manages volunteers for field work in Bay Area wetlands and watersheds. The Safety Sheet was developed as part of a set of volunteer monitoring protocols for California rivers, streams, and watersheds (SFEI 1996), under contract to the US EPA and California State Water Resource Control Agency. The Safety Sheet has been reviewed by the EPA. It presents general guidelines for health and safety in the field that will be followed during this project. In addition to the above guidelines additional safety information was developed by the project supervising field scientist, and used specifically for stream and river conditions encountered during project field work within the Feather River Watershed.

**Safety**

Field work in wildland riparian and aquatic environments presents a variable set of possible health and safety hazards to crew members and crew leaders alike. Monitoring personnel may be expected to traverse rough terrain, spend long hours in cold water, carry heavy or bulky equipment, and work in a variety of weather conditions. Each carries its own set of possible hazards.

**Objective:** to foster an awareness of safety equipment, commonly encountered safety hazards, and crew procedures designed to minimize accidents or injuries incurred while conducting environmental measurements in the field.

**Safety Equipment List**

Comprehensive First-aid Kit

Cellular Phone

Chest Waders
Wadding Boots with Felt Soles
Personal Flotation Vest
Rescue Rope

**General Safety Protocols to be Followed at Each Monitoring Site**

Before leaving the office be sure each crew member has all personal equipment, and that equipment is in working condition. Personal equipment includes; chest waders, felt soled wading boots, lunch, at least one gallon of drinking water for each person, and an extra set of warm, dry clothes.

Check to ascertain that all group safety equipment is in the monitoring truck and in working condition. This includes; first aid kit, personal flotation vests, rescue rope, and cell phone with emergency phone numbers.

On arrival at the monitoring reach be sure that all crew members know their location in relation to the nearest medical assistance, phone numbers, and how to get there.

Prior to conducting any monitoring measurements within the survey reach the crew walks the entire reach identifying and discussing potential safety hazards.

Crew members always work in teams of two and three. No one ever works alone.

The two most important safety concepts are; pay attention ( be aware of your environment) and use common sense. Crew safety comes first, equipment safety is second, and completion of the task is third.

**Commonly Encountered Safety Hazards**
Potential safety hazards vary with each stream or river to be monitored. No two monitoring sites contain the same potential hazards. Generally, smaller streams classified as "wading" stream are much safer than a "non-wading" river. The difference between these two types deals with water depth and velocity. Wading streams are generally not any deeper than three feet (in pool areas) where rivers can exceed the depth of chest waders. Other differences concern water velocity, volume, temperature, and channel gradient. Larger channels, higher velocity, cold water temperature, and deeper water, all equate to increased potential safety hazards.

**Deep Water Hazards**
In larger streams and rivers pool habitat can exceed chest wader height. When measuring maximum pool depth in these reached use a flotation vest, rescue rope, and a large truck tire inner-tube, or other flotation device. Have two crew members on shore, one to record data and one to act as a safety person. Never use waders where overtopping is a potential hazard.

**Fast Water Hazards**

Even shallow, fast moving water can present a hazard to monitoring personal. If long runs of fast water are present in the proposed monitoring reach it may be best to relocate the reach up-stream or down-stream to avoid the potential hazard. If fast water can't be avoided use a wading staff, flotation vest and rescue rope. Keep safety personal on shore. If you loose your footing and are swept down stream, assume a sitting position with your feet pointed down-stream and your arms out to the sides. Use your feet to avoid crashing into large rocks or other debris and your arms to maneuver into slower water where you can exit the stream.

**Cold Water Hazards**
When working in water that is less then 60 degrees F. always wear waders and warm clothes. Stay as dry as possible. Avoid getting chilled to the point of shivering. If you begin to get chilled, leave the water and don't reenter until you have warmed up. Keep an additional set of dry, warm clothes nearby.

**Entanglement Hazards**
Entanglement hazards can take many different forms; logs, tree roots, fence wire, logging cables, fence posts, automobile bodies, and logging debris accumulations. When encountered, point them out to the entire crew. Avoid working near these objects.

**Water Quality Hazards**
Always carry plenty of fresh drinking water. Never drink untreated stream water.

**Substrate Hazards**
Channels with sand and gravel beds generally offer good footing and easy walking. Channels with cobble and boulder beds can present slick and treacherous footing. Felt soled wading boots will offer increased traction in this type of substrate. Crew members should walk slowly, pick your footing carefully, and use a wading staff to maintain balance.

**Other Hazards**
**Poison oak:** learn to identify poison oak before going into the field. If encountered, point it out to the rest of the crew and avoid coming into contact with it.

**Rattlesnakes:** stay alert and aware of your environment. Watch where you put hands and feet. Avoid thick brush and rocky outcrops. Walk slowly while watching the ground in front of you, pick your footing with care.

**Ticks:** avoid walking through, or resting in thick brush or tall grass. Ticks often inhabit these areas and wait for a passing host. At the end of the day, check yourself carefully for ticks. If a tick should bite you, remove the tick by pulling it straight out, enclose it in a Ziplock bag or other container labeled with your name and date you were bitten, it can then be tested for Lyme's disease.

## 7.0 Field Procedures

### 7.1 Equipment
The field monitoring equipment used to conduct field measurements is listed below. All equipment needed for the project is available at this time. Although there is not a complete back-up set of field equipment, none of the equipment is especially expensive and most items can be replaced at a small cost to the project. If necessary, back-up equipment can be borrowed from local partners.

The necessary computer hardware and software is currently being developed in conjunction with Chico State University.

300' fiberglass measuring tape
150' fiberglass measuring tape
0.5" steel pipe for benchmarks
Large claw hammer
Pocket knife
Clinometers
Compass
Pencils of varying hardness
Fine-point waterproof ink markers
Surveyor's flagging
Surveyor's wire flags
Surveyor's pins
Hip chain

- Aqua scope
- Hobo temp. data loggers
- First aid kit
- Pool tail fines grid
- Pocket tape measures
- Hand-held calculators
- 35mm camera and print film
- Waterproof field notebooks
- Waterproof data sheets and clip boards
- Self leveling optical level or laser level
- Tripod with telescoping legs
- Fiberglass telescoping survey rod
- USGS quad maps
- Field vests
- Chest waders
- Personal flotation vests
- ATM sieves
- Hand trowels for macro-invertebrate sampling and mixing concrete
- Ready mix concrete for benchmarks
- 0.5mm mesh D-net for macro-invertebrates
- Sample bottles, plastic for macro-invertebrates
- 5 gallon buckets
- Safety rope
- Sample bags for sieve analysis samples
- Pool tail fines grid
- S* calibrated probe for measuring depth of sediment in pools
- 4”x4” aluminum tags for benchmarks
- Galvanized nails for aluminum tags
- Orange marking paint for benchmarks

### 7.2 Equipment Calibration and Maintenance

Very little of the equipment required for the monitoring project requires calibration and maintenance. The optical and/or laser level are subject to routine professional inspection and maintenance as recommended by the manufacturer. Fiberglass measuring tapes are routinely checked for stretching or tearing. Survey rods are cleaned and stored in cloth sheaths. Clinometers are compared on a given angle to determine if readings are the same. The hip chain (string machine) is checked against the fiberglass tape each time a spool of string is changed.

### 7.3 Field Sampling Procedure

Field sampling procedures are based on the “Stream Condition Inventory Guidebook” version 4.0, United Stated Department of Agriculture, Forest Service, Pacific Southwest Region, 1998. The Stream Condition Inventory (SCI) procedures and protocols were developed over a five year period (1993-98) by fisheries biologists and hydrologists in the US Forest Service Region 5, with support for sampling design and statistical analysis from the USFS Pacific Southwest Research Station.

The goal is provide protocols that can be consistently applied in assessing and monitoring stream conditions in the Pacific Southwest Region. Attributes were tested that have been demonstrated through research to be indicative of stream condition, could be sampled by seasonal field crews, and yet had low enough measurement error to be useful in describing difference with a moderate to high level of confidence. The intensity of data collection meets the objective of comparing data over time, or from other streams with a reasonable level of statistical confidence.

For the purpose of the Watershed Monitoring Program, two of the original SCI protocols have been dropped or replaced by other protocols and three additional protocols have been added. Large Woody Debris counts and Pebble Counts have been dropped from the protocol. Pebble counts have been replaced by sieve analysis of channel bottom material.

Water surface longitudinal channel profile survey and macro-invertebrate sampling have been added to the monitoring protocols for this project.

### 7.4 Personnel

Conducting a Stream Channel Inventory (SCI) requires a team of at least four people. For the purpose of this project, which is a modified SCI, a team of five will conduct monitoring on each identified channel reach. This team of five will divide into two teams to collect separate sets of data on the same reach.

### 7.5 Personnel Qualifications

All field crew members possess some college level hydrology and watershed management knowledge and experience. The field crew leader has over nine years field experience in watershed management, hydrology, and fisheries, including conducting SCI, and will be responsible for training crew members.

### 7.6 Getting Started

Prior to any fieldwork the Feather River Coordinated Resource Management Monitoring Committee choose 21 channel reaches to be monitored. All chosen reaches are at the lower end of their watersheds. All monitoring reaches are within Feather River Watershed, including the North Fork, East Branch North Fork, and Middle Fork Feather River Watersheds (the South Fork Feather River is not included in the scope of this project).

All USGS Quadrangle maps covering the selected reference reaches and bridge sites were gathered, and permission to use the most up to date USFS Plumas, Tahoe and Lassen National Forest aerial photography covering selected sites was granted. Access to currently available information will provide or may include the following. Watershed size, watershed name, geomorphic province, ownership, elevation range, mean annual precipitation, watershed lithology, geomorphic influence, channel type or classification, miles of dirt road, square miles of forest and riparian area, meadow conditions, gross yield of sediment, square miles of burnt over land, vegetation condition index, and range condition inventories.

As with most all County, State and Federal agencies, existing budgets, priorities, and personnel, may restrict the availability of existing information to the Feather River Coordinated Resource Management Group and this project prior to field monitoring of individual reaches.

Each of the identified monitoring reaches will be visited prior to the start of fieldwork. A reconnaissance visit is necessary to determine the location of a sensitive reach along the identified channel. Each selected monitoring reach is likely to show change relative to the questions being asked, and is uniform in terms of channel characteristics, such as gradient, sediment and flow conditions that best match the requirements of the protocols.

**8.0 Stream Reach Attributes to be monitored**

**.1 Air and Water Temperature**

Water and riparian air temperature strongly influence the function of biological systems, as well as individual organisms and species. Stream temperature has impacts on health, behavior and survival of aquatic species.

OBJECTIVE:

- Monitor air and water temperature using HOBO Temp data loggers (Range -20 degrees C to +70 degrees C. error/resolution: 0.5 degrees C to 2.0 degrees C).

These thermographs collect and record stream and air temperatures during low flow, long day length periods, when maximum temperatures are likely. Air and water temperature will be recorded to determine mean maximum temperature for the period July 1- August 31. The full temperature range for this time period will also be monitored. Individual recording units will be installed to record a minimum of 1468 measurements (hourly for 62 days or longer).

METHOD: Thermographs are installed at the lower end of each reach at the start of field season and collected at the end of the field season.

**8.2 Channel Longitudinal Profile (Water Surface Profile)**

The longitudinal profile measurement is a modification of the original Stream Condition Inventory (SCI) protocols containing one additional measurement. The SCI protocol calls for a measurement of channel gradient at channel cross-sections. The modified measurement measures gradient (water surface elevation) along the entire length of the sensitive reach.

Nested within the longitudinal profile measurement are several other SCI measurements.

1. Habitat - Pool/ Non-pool
2. Maximum depth Pools
3. Maximum depth Pool-tail Crest

OBJECTIVE:

- Describe the water surface slope and spatial distribution of pools and riffles (pools/non-pools) within the survey segment.
- Quantify the number pools and determine the range of residual pool depths within the survey segment.

METHOD: Measurements will be taken using standard surveying methods for differential leveling (Harrelson et al., 1994). Equipment used will include an optical survey level or laser level, tripod legs, telescoping fiberglass survey rod, and hip chain

(string machine for distance). Elevation changes will be read to the nearest 0.01 feet, distance measurements (by hip chain) will be read to the nearest foot (hip chain accuracy to 0.2%).

A description of the Longitudinal Profile Measurement can be found in Appendix B, Longitudinal Profile Measurement Protocol.

**8.3 Pool Tail Substrate (Percent Surface Fines)**

Watershed and streambank disturbance often results in increased erosion and sediment input to streams. Increased fine particles in stream substrate have been shown to impair aquatic food production and decrease survival of young trout.

OBJECTIVE:

- Quantify the percentage of fine sediments on pool tail substrate within the survey segment.

METHOD: The pool tail "unit" to be sampled is defined as the downstream 10% of the total pool length. A fines grid; a 12 inch square frame with 49 string intersections and one identified corner (50 points total) is used to make 3 random tosses within the defined pool tail area. The first measurement is taken in the thalweg. The second measurement is taken between thalweg and left waters edge, third measurement is taken between the thalweg and right waters edge. Counts are made of percent fines 2mm or less at the intersections of the strings and the identified corner. Total fines per toss are multiplied by 2 and recorded. The grid is read with the use of an Aqua Scope.

The procedure and method for measuring pool tail fines can be found in Appendix A, page 29.

**8.4 Channel Cross-sections**

Channel cross-section measurements express the physical dimensions of the stream perpendicular to flow. They provide fundamental understanding of the relationship of width and depth, streambed and streambank shape, bankfull and floodprone area. Each are important attributes of channel condition and indicators of health of the aquatic and riparian ecosystem. Cross-sections also provide essential criteria for stream classification. Monumented cross-sections are used to determine channel condition and trend over time since they can be monitored repeatedly.

OBJECTIVE:

- Establish permanent monitoring sites to determine changes in channel condition over time. Measure channel cross-sections, including width/depth ratio, bank angle, channel shape, and floodprone area.

METHOD: A cross-section survey can be constructed with or without an optical level. If a level is not available, then a level line cross-section can be constructed using surveyor's string, string levels, and a measuring tape.

A complete description of cross-section methods and procedures can be found in Appendix A, pages 19-21.

**8.5 Identification of Bankfull**

There is considerable uncertainty associated with the identification of bankfull in the field. For gauged streams, bankfull is determined as the discharge recurring about every 1.5 years. For streams that are not gauged, bankfull is estimated as the apparent floodplain. This type of estimate requires considerable field experience and training. If the floodplain is not obvious, bankfull can be estimated based on Regional Curves developed in Dunne and Leopold, 1978. These curves will give the investigator an idea or estimate as to what elevation to look for bankfull indicators. Other various field indicators related to the effects of bankfull flow on bank relief and vegetation characteristics can be found in Harrelson et al., 1994.

OBJECTIVE: identification and location of the bankfull elevation for each study reach is a necessary bench mark on which other measurements are founded.

METHOD: use Harrelson et al, 1994 and Dunne and Leopold, 1978. Many other publications exist to help in bankfull identification on western streams, however personal experience within the watershed in conjunction with training is the best of both worlds.

**8.6 Channel Entrenchment**

The distribution of streamflow above bankfull stage is a primary influence on the character of the channel. These flood flows play a major role in sediment transport and storage, streambank stability and channel morphology.

Entrenchment is defined as the ratio of floodplain width-to-bankfull width measured at twice maximum bankfull depth. The measure is intended to quantify the confinement of the channel in its valley.

OBJECTIVE:

- Classify the channel and to understand stream processes and conditions for comparison with similar channel types.

METHOD: Eight measurements of entrenchment are taken for each survey reach. Measurements are taken at each of the three cross-sections and five additional measurements between cross-sections are taken. Each of the additional measurements are randomly selected from available candidate sites within the survey segment.

At selected sites maximum bankfull depth and bankfull width are measured. The floodplain width is measured at an elevation equal to double the maximum bankfull depth using an optical hand level and tape. The floodplain width is divided by bankfull width to obtain the entrenchment ratio

**8.7 Channel Width-to-Depth Ratio**

Width-to-depth ratio is a key indicator of channel condition. A low ratio results in deeper water, higher water tables, and is considered optimum conditions for aquatic and riparian flora and fauna.

OBJECTIVE:

- To characterize the channel and understand stream processes and condition for comparison with similar stream types.

METHOD: From five to eight measurements are taken on each survey segment. Measurements are taken at the same locations as are channel entrenchment measurements. Bankfull level is identified and flagged for both banks at each location where the measurement is to be taken. A measuring tape is stretched between bankfull flags. Starting at bankfull on the left bank, a minimum of 10 depth measurements are taken before reaching bankfull on the right bank. The thalweg, water's edge and any slope changes are included in the channel cross-section. Bankfull width is recorded and the mean bankfull depth is calculated. Bankfull width is divided by mean bankfull depth; yielding the width-to-depth ratio.

**8.8 Streambank Stability**

Streambank stability is a key indicator of channel condition. Streambank stability is a measure of cover, which protects the area immediately adjacent to the edge of the streambed and is susceptible to the erosive force of water during high flows. Cover consists of perennial vegetation, rocks, down wood debris or similar erosion resistant material.

OBJECTIVES:

- To assess condition of slopes immediately adjacent to streams.
- To calculate streambank stability representative of the survey segment.

METHOD: Streambank stability is measured by observing (ocular estimate) cover within a plot on the surface of the streambank. One hundred plots are defined for each survey segment (50 per bank). Each survey segment (reach) is a minimum of 20 bankfull widths long. Each reach is divided by 50 to determine distance between streambank stability plots; measurements are taken on both banks. Each stability plot is 30cm wide, perpendicular to the flow and extends from where cover is first encountered above the streambed or at bankfull, which ever occurs first, to the crest of the first convex slope above bankfull or twice maximum bankfull depth, whichever occurs first.

Measures:

- Stable - a stable streambank plot has 75% or more cover of living plants and/or other stability components which are not easily eroded, and has no indicator of instability.
- Vulnerable - a vulnerable streambank plot has 75% or more cover and may have instability indicators, such as fracturing, blocking or slumping.
- Unstable - an unstable streambank plot has less than 75% cover and may have instability indicators. Unstable streambanks are often bare or have nearly bare banks composed of particle sizes too small or uncohesive to resist erosion at high flows.

**8.9 Stream Shading**

Stream temperature has impacts on the health, behavior and survival of aquatic organisms and is strongly influenced by streamside shading.

OBJECTIVE:

To determine the average canopy cover for the channel reach.

METHOD: The amount of shade the channel receives is measured using a Solar Pathfinder and reading from the August sun path. The Solar Pathfinder is held above the mid-channel area, approximately 30-cm above the water surface at each of the 50 channel plots within the survey segment. The pathfinder is leveled facing south, and the reflection of objects providing shade on the instrument's dome is measured. The numbers shaded along the August sun path are totaled. The total is the percent shade for that plot.

**8.10 Macro-invertebrate Sampling**

Collecting and identifying macro-invertebrates present in the survey segment can provide valuable information on the general health of the aquatic system. The occurrence of specific species acts as an indicator of channel condition.

OBJECTIVE:

- To quantify the diversity of aquatic macro-invertebrates by survey segment as an indicator of channel health, and determine channel condition over time.

METHOD: Three riffles suitable for sampling are identified, beginning at the downstream extent of the survey segment. Identified riffles are composed of large gravel to cobble size substrate where the water surface is turbulant. Care is taken to not disturb the sample sites prior to sampling. This is the first measurement taken at each survey segment.

Once the three riffles are identified, measurements are taken from bottom to top (downstream to upstream) beginning at the farthest downstream riffle. A tape is placed parallel to the longest upstream-downstream axis and the length of the riffle is measured. The riffle is divided into equal segments of length. Three segments are randomly selected for sampling using a random numbers sheet. One of three lateral sampling locations (1/4, 1/2, 2/3 width from the right edge of suitable habitat) is randomly select at each of the three selected segments.

Once the sampling locations have been selected, a D-net with a one-foot wide opening and a mesh size of 0.5mm is placed perpendicular to the flow, and adjusted as necessary to prevent flow under the net frame. An area upstream of the net that is one foot wide by two feet long is chosen for sampling.

Macro-invertebrates captured in the net are placed in a sample container. The net is picked clean using tweezers. Once all macro-invertebrate have been removed from the net and placed in the sample container 100% alcohol is added to the sample container, which has been labeled with; date, reach name and cross section number. Samples are sent to: The Buglab, Dept. Fish and Wildlife, Utah State University, Logan,UT 84322-5210.

**8.11 Channel Substrate Sampling, Sieve Analysis**

Substrate sampling provides a measurement of both surface and sub-surface channel bottom material. These measurements, when divided into standard material size classes will provide an indication of bedload movement and stream power over time.

METHOD: a minimum of three samples are collected on each monitoring reach. Each sample is divided into a "surface sample" and a "sub-surface sample". At each full cross section within the reach an open bottom, five gallon bucked is placed on the riffle. Channel bottom surface material within this bucket is removed to a depth of about 2-3 inches depending on the size of the surface material (generally about 1/3 the total depth of the surface and sub-surface combined sample). The surface sample is then placed in the smallest mesh standard soil sieve and allowed to drain before being place into a sample bag which is labeled with reach name, date, cross section number and sample type. Sub-surface samples are then collected to the depth of about 6-8 inches, from the same location where the surface sample was just collect. The sub-surface sample is allowed to drain and then bagged and labeled in the same fashion as the surface sample.

In addition to collecting samples at each of the three cross sections within the monitoring reach, samples are also collected on bars associated with the riffles sampled. Bar samples are only collected if the bar that was formed during normal (bankfull or slightly greater) flow events, and occurs in conjunction with the cross section/riffle just sampled. Bar samples are not divided into surface and sub-surface samples, but are collected and bagged as one sample. Bar samples are generally collected at the midpoint of the lower 1/3 of the total bar length (from upstream to downstream), and taken .5' below the bankfull elevation on the bar. Bar samples are drained, bagged and labeled.

Bed material analysis is conducted by wet-sieving each bagged sample through a series of standard soil sieves. Standard Soil Sieves #4- 4 mm, #10- .5 mm, #35- .250 mm, #60- .125 mm, and #120- .067 mm. The samples are then bone-dried in situ. When the sample is bone dry, each sieve starting with the largest size first are shaken for a minimum of one (1) minute, or, till minimal particles are observed on clean, white paper placed under the sieve.

All particles larger than 4 mm. are hand measured with a millimetric ruler and sorted into geomorphic size classes (Rosgen, 1996). All sample size classes are then bagged and weighed in grams. Several bags are placed in a freezer for 30 minutes to detect the presence of moisture. If moisture is present, samples will be un-bagged and re-dried until moisture is not present. Size classes are determined in geometrically increasing units as follows:

| 4 units | 8 units | 16 units | 32 units | 64 units |
|---|---|---|---|---|
| 4- 8 mm | 16- 24 mm | 32- 48 mm | 64- 96 mm | 128- 192 mm |
| 8- 12 mm | 24- 32 mm | 48-64 mm | 96- 128 mm | 192- 256 mm |
| 12- 16 mm | | | | |

The results are then graphed according to weight and size class for each sample. Samples are processed and analyzed by the Feather River CRM.

OBJECTIVE: to quantify the size class and distribution (quantity) of both the surface and sub-surface, and where present, the bar material in each channel reach. This information provides a baseline of particle size distribution that with subsequent sampling would indicate change in watershed condition.

**8.12 Stream Shore Water Depth**

This measurement is an important indicator of channel morphology in low gradient alluvial channels (channels with a gradient of <2%) with fine textured banks. Stream shore water depth is closely related to other indicators of channel condition, which provide cover and resting areas for fish in these types of streams.

OBJECTIVE:

- To quantify the average stream shore depth in the survey segment of alluvial channels only.

METHOD: One hundred measurements are taken, one on each bank within the 50 transects per survey segment, but only on alluvial channels. The depth of the water at shoreline is measured. If the bank angle is greater than 90 degrees, then the water depth at water edge will generally be zero. If the bank angle is 90 degrees or less the water depth will be greater than zero. A survey rod will be used to measure water depth to the nearest 0.01 feet.

**8.13 Bank Angle**

Bank angle is an important factor in aquatic habitat on low gradient alluvial channel reaches. It influences shading, vegetation potential and bank stability. Stream banks that are vertical or undercut provide more habitat value than banks that slope away from the streambed. Undercut banks provide excellent cover for fish, and are recognized as a component of healthy meadow streams.

OBJECTIVE:

- To quantify bank angle and the frequency of vertical and undercut banks in the survey segment.

METHOD: One hundred measurements are taken on alluvial channels. Measurements are taken on both banks at each of the 50 transects. Bank angle is the measurement of the dominant angle of the streambank between the base of the bank and the bankfull elevation.

To measure bank angle, a depth rod is placed perpendicular to the flow on the dominant angle of the bank between the base of the bank (streambed) and bankfull. A clinometer is placed on the top of the rod and the angle is recorded to the nearest 5 degrees. If the bank slopes away from streambed, the angle is greater then 90 degrees, if the bank is vertical or undercut the angle is 90 degrees or less.

**8.14 Aquatic Fauna (Vertebrates)**

Aquatic and semi-aquatic vertebrates are key indicators of aquatic condition. The presence and distribution of this biota is useful for management considerations

OBJECTIVE:

- To collect information on the presence and distribution of aquatic vertebrates in the survey segment.

METHOD: An ocular survey of the entire survey segment is conducted as crew members proceed upstream gathering hydrological data.

**9.0 Permanent Station Data Collection**

**9.1 Streamflow Measurements**

Method: Streamflow measurements will be conducted in accordance with protocols developed by the USGS and published in *Water Supply Paper 2175,* 1983, p. 95- 182. A brief summary description of equipment and methods is discussed below.

All direct measurements will be conducted with pygmy or Price AA velocity meters. These are vertical-axis, mechanical meters with high field reliability. Pygmy meters are used for very shallow water and low velocities. The Price AA meter is the standard for most measurements including floods. Price AA is configured to be used with either a wading rod, or suspended by cable from bridges using collapsible 3-wheel bridge cranes, a bridge board or a truck mounted boom. All above referenced equipment will be used as conditions dictate in this monitoring program.

Three vertical sampling protocols will be used depending upon conditions. The .6 depth method will be used for all measurements where water depth is <2.5 feet. When depths exceed 2.5 feet the .2/.8 depth averaging method will be used. In major flood events where equipment is incapable of providing accurate direct measurement, or, when inaccessible at peak stage, the Slope/Area method will be utilized to calculate peak discharge. All measurements are recorded relative to the water level height on the permanently install staff gages in hundredths of a foot.

All horizontal measurements will be referenced to a common datum point at the measurement site. A 300' fiberglass tape will be used for wading measurements. Bridge measurements will be referenced to pre-established, permanent, 1-foot increments on the bridge railing.

Objective: To provide highly accurate streamflow measurements, particularly at bankfull and lower stages. This is to provide stage/discharge rating tables that will accurately reflect changes in duration and volume of summer baseflows. Rating tables will also be combined with sediment measurements for the development of sediment/discharge (sedigraphs) relationships.

**9.2 Turbidity Sampling**

Method: Direct turbidity measurements are taken on a daily basis during elevated streamflow events at the Wolf Creek, Lights Creek and Indian Creek-Taylorsville stations. These are gathered by grab sample in accordance with protocols developed by the USGS and published in *USGS Open-File Report 76-153,* Pickering, 1976. A brief summary description of equipment and methods is discussed below.

Turbidity will be sampled using grab samples at the aforementioned sites. This entails completely submersing a 500 ml/ one-quart clean, rinsed sample bottle into the flowing water. Sample bottle is filled until all air bubbles have been evacuated, then capped beneath the water.

All samples are labeled with station name, date, time, gage height and technician name. At the end of the sample day all samples are transported to Contractors Office for measurement by turbidimeter. This measurement will produce a value expressed in Nephelometric Turbidity Units (n.t.u) which indicates the degree of opacity in the water sample.

Objective: To provide accurate turbidity values which, when related to discharge values will provide a baseline of information for the specific station. N.t.u's will be combined with discharge measurements for the development of turbidity/discharge (sedigraphs) relationships.

**9.3 Suspended Sediment Sampling**

Method: Suspended sediment sampling will be conducted in accordance with protocols developed by the USGS and published in *Federal Inter Agency Sedimentation Paper,*1963, p.41. A brief summary description of equipment and methods is discussed below.

Sampling will be performed using the equal-transit-rate (ETR) method. The ETR method provides a fully depth-integrated sample of the entire water column at multiple verticals in the cross-section. This method entails lowering and raising the sampler (DH- 48) at a uniform vertical rate from surface to bottom and back to surface. Transit rate is calibrated as necessary to account for depth and velocity change. Transit time is determined by the fill rate of the sampler (1 quart/500ml capacity). Further calibration is achieved by changing nozzle size.

Cross-section sampling points are determined by river size as well as flow depths and velocity. The number of sample points may vary from 3- 25. The most common protocol will involve 3 sample points equidistant across the cross-section. All samples are labeled with station name, date, time, gage height and technician name.

Initially, all samples will be measured wet via the Imhoff cone method, then transferred to a water lab for dry weight measurement. The intent is to develop an Imhoff/dry weight correlation, obviating the need for expensive lab analysis. All data is measured in ml/L concentrations.

Objective: To provide highly accurate suspended sediment volumes which, when combined with bedload measurements will provide total load weights. Total load weights will be combined with discharge measurements for the development of sediment/discharge (sedigraphs) relationships.

**9.4 Bedload Sampling**

Method: Bedload sampling will be conducted in accordance with protocols developed by the USGS and published in *USGS- Open File Report,* Helley & Smith, 1971. A brief summary description of equipment and methods is discussed below.

Bedload is that component of the river sediment supply that typically is transported within .5' of the stream bed. It is typically composed of the coarser particles, which in mountain alluvial streams ranges in size from 8mm (very small gravel) to 256 mm (large cobbles). This material is generally not mobilized until stream flows are near or above "bankfull". Helley-Smith bedload samplers are the most common method of collecting bedload data. The Helley-Smith sampler is operated with the same cable equipment used for streamflow measurements.

Bedload transport is non-uniform both temporally and spatially, therefore, sampling technique emphasis is on fewer sampling points and more samples per point. Typically, a bedload sample will be conducted in 5- 10 sampling cells equidistant through the cross-section, with three (3) equal time measurements per cell. Calibration is performed by selecting that cell which appears to have the highest concentration of load and conducting several timed test drops. The intent is to provide a standard sample time for the cross-section that will fill the sampler bag to no more than 2/3 full.

Collected samples are bagged separately for later sieve analysis. Bags are labeled by station name, date, time, sample cell number, cell drop number and technician name. Sample bags are sorted by station number and transported to storage by Supervising Scientist. Sieve analysis procedures are as described in section ? .

Objective: To provide accurate bedload volumes which, when combined with bedload measurements will provide total load weights. Total load weights will be combined with discharge measurements for the development of sediment/discharge (sedigraphs) relationships. Subsequent sieve analyses provide particle size distributions necessary for channel design and streampower calculations.

**References**

Clifton, Clay, C., 1994. "East Branch North Fork Feather River Erosion Control Strategy". USDA Forest Service, Plumas National Forest. Region 5, California, 159 Lawrence St. Quincy Calif. 95971.

Dunne, T. and L. Leopold, 1978. Water in Environmental Planning. W. H. Freeman, New York, 818 pp.

Durrell, Cordell, 1987. "Geologic History of the Feather River Country Calif. ". Univ. Calif. Press, Berkeley, Calif.

Harrelson et al., 1994. "Stream Channel Reference Sites: An illustrated guide to field technique". USDA Forest Service, Rocky Mountain Forest and Range Experement Station, Fort Collins, Co 80526. Gen Tech. Report RM-245.

Linquist, D.S., 1997. " Red Clover Creek Erosion Control Demonstration Project. Ten-year Research Summary, 1985-1995". PG&E Co. Research and Development. 2303 Camino Ramon, Suite 200, San Ramon, Calif. 94583.

Leopold, L. B. 1970. "An Improved Method for Size Distribution of Stream-bed Gravel". Water Resources Research. 6(5):1357-1366.

Ponce D. M., and Linquist, D. S., 1990. "Management of Baseflow Augmentation: A Review". Water Resources Bulletin, Vol. 26, No2. April 1990.

(SFEI) San Francisco Estuary Institute, 1996. "Volunteer Monitoring Protocols: A reference guide for monitoring California's rivers, streams and watersheds". 180 Richmond Field Station, 1325 South 46th Street, Richmond, CA 94804.

USDA, 1998. " Stream Condition Inventory Guidebook" (Version 4.0) USDA, Forest Service, Pacific Southwest Region.