Placer County Water Agency

Business Center: 144 Ferguson Rd. • Mail: P.O. Box 6570 • Auburn, California 95604-6570
(530) 823-4850 800-464-0030 www.pcwa.net

September 8, 2006
File No. 01030A

SUBJECT: Middle Fork American River Hydroelectric Project Relicensing
Final 2006 Geomorphology and Riparian Habitat Characterization Study Plan
and Final 2006 Aquatic Habitat Characterization Study Plan

Dear Resource Agency Representatives –

Enclosed are paper and electronic copies of the Final 2006 Geomorphology and Riparian Habitat Characterization Study Plan and the Final 2006 Aquatic Habitat Characterization Study Plan. Drafts of these documents were forwarded to you on May 5, 2006 and May 10, 2006, respectively for review and comment. The attached final plans address all comments received from the resource agencies to date, including those expressed during a meeting held on June 1, 2006 and during a site visit conducted on August 22, 2006. These documents (with the exception of Non-Internet Public Information) are also available on our MFP Relicensing Website at:

http://relicensing.pcwa.net/techdocs.htm

Please note the Federal Energy Regulatory Commission (FERC) considers some information Non-Internet Public (NIP). The FERC's regulations regarding NIP information are cited in Title 18 of the Code of Federal Regulations (18 CFR) Section 388.112. Pursuant to these regulations, any figures, maps and/or electronic files containing NIP information have been labeled accordingly. PCWA requests that you do not post any of the electronic files labeled NIP on the Internet.

If you have any questions regarding the attached plans or would like to discuss the relicensing project, please don't hesitate to call me at (530) 823-4889.

Sincerely,

Mal Toy

Mal Toy
Director of Resource Development

MT:bb

Attachments:
Final 2006 Geomorphology and Riparian Habitat Characterization Study Plan
Final 2006 Aquatic Habitat Characterization Study Plan
Distribution List

Final 2006 Geomorphology and Riparian Habitat Characterization Study Plan
Final 2006 Aquatic Habitat Characterization Study Plan
Distribution List

US Forest Service – Region 5 – Regional Hydropower Assistance Team (RHAT)

Bob Hawkins
US Forest Service
Regional Hydro Coordinator
650 Capitol Mall
Suite 8-200
Sacramento, CA 95814

Dennis Smith
RHAT Fisheries Biologist
US Forest Service
650 Capitol Mall, Suite 8-200
Sacramento, CA 95814-4706

US Forest Service – Eldorado National Forest

Beth Paulson
FERC Coordinator
Eldorado National Forest
100 Forni Road
Placerville, CA 95667

Jon Jue
Resource Officer
Georgetown Ranger District
Eldorado National Forest
7600 Wentworth Springs Road
Georgetown, CA 95634

Tim Dabney
Georgetown District Ranger
Eldorado National Forest
7600 Wentworth Springs Road
Georgetown, CA 95634

Jann Williams
Biologist
Eldorado National Forest
100 Forni Road
Placerville, CA 95667

US Forest Service – Tahoe National Forest

Dan Teator
American River Ranger District
Tahoe National Forest
22830 Foresthill Road
Foresthill, CA 95631

Mo Tebbe, Resource Officer
American River Ranger District
Tahoe National Forest
22830 Foresthill Road
Foresthill, CA 95631

Matt Triggs
Tahoe National Forest
American River Ranger District
22830 Foresthill Road
Foresthill, CA 95631

Rick Weaver, Hydrologist
Tahoe National Forest
631 Coyote Street
Nevada City, CA 95959-2250

US Fish and Wildlife Service

William E. Foster
Senior Fish and Wildlife Biologist
Energy and Instream Flow Branch
U.S. Fish and Wildlife Service
Habitat Conservation Division
2800 Cottage Way, Rm W-2605
Sacramento, CA 95825-1846

US Bureau of Land Management

Deane Swickard
Field Manager
US Bureau of Land Management
63 Natoma Street
Folsom, CA 95630

Final 2006 Geomorphology and Riparian Habitat Characterization Study Plan
Final 2006 Aquatic Habitat Characterization Study Plan
Distribution List

California State Water Resources Control Board

Jim Canaday
FERC Relicensing Team Leader
CA State Water Resources Control Board
Division of Water Rights
1001 I St 14th Floor
Sacramento, CA 95814

Beth Lawson
CA State Water Resources Control Board
Division of Water Rights
1001 I St, 14th Floor
Sacramento, CA 95814

Matt Myers
CA State Water Resources Control Board
State Water Resources Control Board
Division of Water Rights
1001 I St, 14th Floor
Sacramento, CA 95814

California Department of Fish and Game

John Hiscox
California Department of Fish & Game
Sacramento Valley Central Sierra Region
1701 Nimbus Road
Rancho Cordova, CA 95670

Robert Hughes
California Department of Fish & Game
NAFWB
830 S Street
Sacramento, CA 95814

Stafford Lehr, Associate Fisheries Biologist
California Department of Fish & Game
Sacramento Valley Central Sierra Region
1701 Nimbus Road
Rancho Cordova, CA 95670

MaryLisa Lynch
California Department of Fish & Game
Staff Environmental Scientist
1701 Nimbus Road
Rancho Cordova, CA 95670

California State Parks

Bill Deitchman
California State Parks
Boating Program Manager
Auburn State Recreation Area
501 El Dorado Street
Auburn, CA 95603

Jay Galloway
California State Parks
Sector Superintendent
Auburn State Recreation Area
501 El Dorado Street
Auburn, CA 95603

Jim Michaels
California State Parks
Folsom State Recreation Area
7806 Folsom Auburn Road
Folsom, CA 95630

Julie Leimbach
Foothills Water Network
P.O. Box 713
Lotus, CA 95651

Placer County Water Agency
Middle Fork American River Hydroelectric Project
(FERC No. 2079)

FINAL

2006 GEOMORPHOLOGY AND RIPARIAN HABITAT CHARACTERIZATION STUDY PLAN

Prepared for:

Placer County Water Agency
144 Ferguson Road
Auburn, CA 95604

September 8, 2006

TABLE OF CONTENTS

Page

1.0 Introduction 1
2.0 Study Objectives 1
3.0 General Approach 1
4.0 Study Methodology 2
4.1 Selection of Study Reaches and Quantitative Study Sites 3
4.1.1 Step 1 - Identify Potential Study Reaches 3
4.1.2 Step 2 - Inspect Candidate Study Reaches and Select and Flag Potential Quantitative Study Sites 4
4.1.3 Step 3 - Final Selection 4
4.2 Data Collection at Quantitative Study Sites 4
4.2.1 Geomorphology Studies 4
4.2.1.1 Rosgen Level II Analysis 4
4.2.1.2 Calibration of Bankfull Stage to Known Streamflows 5
4.2.1.3 Rosgen Level III Analysis 6
4.2.1.4 Data Reduction and Work Products 7
4.2.2 Riparian Studies 8
4.2.2.1 Photo Documentation 8
4.2.2.2 Vegetation Transect Composition and Structure 9
4.2.2.3 Stream Bank Composition 11
4.2.2.4 Age Class Structure 11
4.2.2.5 Data Reduction and Work Products 12
4.3 Watershed and Land Use Activities 12
4.4 Sediment Recruitment Downstream from Ralston Afterbay 12
4.5 Potential Comparison Streams 13
5.0 Reporting 13
6.0 Agency Consultation and Next Steps 14
7.0 Schedule Milestones 15
8.0 References 16

LIST OF TABLES

Table 1. Phase 2 Study Site Locations

Table 2. Additional Pebble Count Sites for Rosgen Level II Classification

Table 3. Level II Bankfull Calibration Sites at USGS Gaging Stations

LIST OF FIGURES

Figure 1. 2006 Geomorphology, Riparian, and Aquatic Study Reaches (Sheets 1- 3)

LIST OF APPENDICES

Appendix A. Rosgen (1996) Classification Key for Natural Rivers

Appendix B. Bank Erosion Potential Rating

Appendix C. Channel Stability Rating

Appendix D. Phase 2 Riparian Study Data Sheets

1.0 INTRODUCTION

This study plan describes Placer County Water Agency's (PCWA's) proposed approaches for conducting Phase 2 of a two-part Geomorphology and Riparian Habitat Characterization Study (Study) associated with the relicensing of the Middle Fork American River Project (MFP or Project). Phase 1 of the Geomorphology and Riparian Habitat Characterization Study was completed during 2005, in accordance with the approaches and methods presented in PCWA's 2005-2006 Existing Environment Study Plan Package dated June 17, 2005 (PCWA 2005). The technical approaches included in this study plan represent a refinement of the methods originally presented in PCWA's 2005-2006 Existing Environment Study Plan Package. The Phase 2 studies will be conducted during the summer of 2006 and will augment the work completed in 2005. The 2005 study methods and results are documented in a report titled Draft 2005 Physical Habitat Characterization Report dated January 30, 2006.

PCWA circulated a draft version of the Proposed 2006 Geomorphology and Riparian Habitat Characterization Study Plan (Draft Study Plan) to the resource agencies for review and comment on May 5, 2006. All comments received from the resource agencies, including those expressed during a meeting held on June 1, 2006 and during a field trip conducted on August 22, 2006, have been addressed in this final study plan. PCWA intends to continue to consult with the resource agencies and other interested stakeholders as the work described in this plan is completed and to address any outstanding questions or issues.

2.0 STUDY OBJECTIVES

The purpose of the Phase 1 and 2 studies is to develop information regarding the geomorphic and riparian conditions in the river reaches downstream of the MFP dams and reservoirs. Information developed as part of these studies will be used as a basis for designing and implementing future, more focused technical studies that are designed to evaluate Project effects, and to provide the information needed to develop appropriate protection, mitigation, and enhancement (PM&E) measures.

3.0 GENERAL APPROACH

During Phase 1, information on geomorphic and riparian resources was developed using existing data sources and by conducting qualitative field surveys. The geomorphology studies focused on characterizing current geomorphic conditions, including mapping stream reaches based on the Rosgen Level I and Montgomery-Buffington stream classification systems, identifying potential sediment sources, and comparing historical and recent aerial photography along the study streams in the vicinity of the MFP. The riparian studies focused on developing qualitative information on riparian resources, including identifying, mapping, and describing the riparian habitat along the study streams. The Phase 1 study activities also provided information regarding the accessibility of the study stream reaches.

The Phase 2 geomorphology studies will focus on collecting additional information on current geomorphic conditions of the study streams using the methodology defined by Rosgen (1996) under Level II Morphological Description and Level III Assessment of Stream Condition and Departure from Potential. The Phase 2 studies provide a quantitative assessment of channel classification and conditions. In combination, these analyses are intended to provide a thorough description of channel condition and stability, and to identify stream reaches that are relatively more sensitive to alterations of the flow and sediment regime. The Level III analysis results in a description of stream stability, potential, and function.

The focus of the Phase 2 riparian studies is to collect additional qualitative and quantitative riparian data at each of the Rosgen Level II and III study sites to further characterize and assess the condition of the riparian resources in the study streams. These data, when combined with the information collected during the geomorphology studies, can be used to evaluate the condition of the riparian resources in relation to the life history strategies of the dominant species and fluvial geomorphic processes.

The Phase 2 geomorphology and riparian studies are coordinated to allow for future more detailed analysis of physical processes in the study streams and their related effects on geomorphic and riparian conditions.

4.0 STUDY METHODOLOGY

As outlined in the Draft Study Plan, the following activities will be completed during 2006 as part of the Phase 2 geomorphology and riparian studies:

- Select study reaches and quantitative study sites in consultation with the resource agencies.
- Conduct quantitative Phase 2 studies at quantification study sites.
- Assess potential Middle Fork American River Watershed (Watershed) and land use activities that may influence the morphology of the rivers and streams associated with the MFP.
- Map mass wasting and streambank erosion sites downstream of Ralston Afterbay, using methods agreed upon with the resource agencies.
- Evaluate potential reference reaches, addressing objectives determined in consultation with the resource agencies.
- Prepare a report documenting the Phase 2 study results.

The methods associated with each of these activities are described in the following subsections.

4.1 SELECTION OF STUDY REACHES AND QUANTITATIVE STUDY SITES

In the Draft Study Plan (PCWA 2006), PCWA proposed to use a three-step process to select sites for quantitative study, as follows:

1. Identify study reaches that are potential candidates for quantitative studies based on the Phase 1 study results and access conditions.

2. Inspect candidate study reaches and select and flag potential quantitative study sites.

3. Visit potential study sites with the resource agencies to obtain agreement on quantitative study sites and transect placement.

These three steps were completed in July and August of 2006. The site visit with the resource agencies was conducted on August 22, 2006. The selection process is further explained in the following.

4.1.1 Step 1 - Identify Potential Study Reaches

The first step in the selection process involved the selection of potential study reaches. In the Draft Study Plan (PCWA 2006), PCWA proposed to use a stratified sampling approach to identify candidate reaches for quantitative studies. In this approach, stream reaches are first stratified by geomorphic type (Rosgen Level I classification), as mapped during the Phase 1 geomorphology study. The Level I stream reaches are further stratified by accessibility. PCWA did not propose to conduct quantitative studies in stream reaches that are unsafe to access.

Figure 1 shows the study reaches that were identified in the Draft Study Plan as potential candidates for quantitative studies based on geomorphic information developed during Phase 1 and on accessibility, as determined in the field and using United States Geological Survey (USGS) topographic maps, aerial photography and aerial video.

Table 1 shows the study reaches that were identified as potential candidates for quantitative studies, by river and river mile. As indicated, 43 stream reaches were initially evaluated as candidates for quantitative studies. Of these, ten were determined to be inaccessible and were not considered for further study. The remaining 33 stream reaches were evaluated in more detail in 2006 because they were either considered to be accessible or possibly accessible.

The accessibility ratings were updated based on field inspections completed in summer 2006. Of the 33 stream reaches that were originally thought to be accessible or possibly accessible, 25 reaches were determined to be accessible. Access to two reaches (both on the Middle Fork American River) have been determined to be possible, but extremely difficult. Therefore, studies are not planned for these two reaches. The approximate locations of each of the 2006 quantification study sites are shown on Figure 1 (3 sheets).

4.1.2 Step 2 - Inspect Candidate Study Reaches and Select and Flag Potential Quantitative Study Sites

A team consisting of geomorphologists and riparian ecologists visited each of the candidate study reaches to evaluate access conditions and to select potential quantitative study sites. Each potential quantification study site contains two to three cross-section transects (depending upon how many can be surveyed in a day) extending across the valley floor to each canyon wall. The quantitative study sites and transects were located to best represent the range of geomorphic and riparian conditions within the stream reach. The endpoints of the proposed transects were flagged and recorded with a Global Positioning System (GPS).

4.1.3 Step 3 - Final Selection

After identifying each of the potential study reaches and flagging the transects, PCWA coordinated and conducted a field trip to visit the sites with the resource agencies and other interested parties. This field trip occurred on August 22, 2006.

4.2 DATA COLLECTION AT QUANTITATIVE STUDY SITES

The following describes the Phase 2 data collection methods proposed at each quantitative study site. The geomorphology methods are described first, followed by the riparian habitat mapping methods.

4.2.1 Geomorphology Studies

The Phase 2 geomorphology studies will consist of the following components:

- Rosgen Level II Analysis
- Calibration of Bankfull Stage to Known Streamflows
- Rosgen Level III Analysis
- Data Reduction and Development of Work Products

Each of these components is described in the following.

4.2.1.1 Rosgen Level II Analysis

A Rosgen Level II morphological description (Rosgen 1996) will be completed at each of the proposed quantification study sites. The Rosgen Level II stream classification is based on detailed field measurements. This differs from the Level I classification, which is based on valley form and channel dimensions observable on maps, aerial photos, or visual ground inspection. The Level II classification is based on more rigorous, quantitative, and measured parameters. As such, the Level II assessment allows for:

- Refinement of Level I stream type classifications, and

- Quantitative morphological delineation of stream types.

The Level II classification hierarchy is shown in Appendix A. Level II classification is based on field measurements of five primary morphometric parameters:

- Entrenchment ratio (floodprone width divided by the bankfull width; Wfp/Wbf)
- Width-to-depth ratio (bankfull width divided by the average bankfull depth; Wbf/Dbf)
- Sinuosity (ratio of stream distance to valley distance)
- Water surface slope
- Bed particle size

These morphometric parameters will be measured at each approved quantification study site. Measurements will be taken at two to three transects per quantification study site, depending upon how many can be surveyed in one day. The endpoints of all approved study transects will be monumented with rebar and recorded with GPS. Standard procedures will be used to identify bankfull width using field indicators and to measure bankfull width, flood prone width, and slope, as outlined in Harrelson et al. (1994) and Rosgen (1996). A quantification study site will be approximately 10 bankfull widths in length. For mapping purposes, a Level II classified stream reach will have a minimum length of 0.2 mile.

A pebble count will be performed at each approved quantification study site based on procedures developed by Wolman (1954) and Rosgen (1996). Additional pebble counts were initially proposed at 36 sites where Phase 1 studies identified a potential transition in dominant bed material within a stream reach. These locations of particle size transitions were identified during the Level I field and aerial reconnaissance surveys conducted in 2005. After determining the location of the potential quantitative study sites during summer 2006 and final determination of accessibility to stream reaches, there are 20 additional pebble count sites needed (Table 2). These additional 20 pebble count measurements will provide a complete, quantitative assessment for the Level II classification.

4.2.1.2 Calibration of Bankfull Stage to Known Streamflows

Prior to data collection at the Level II quantification study site, bankfull elevation will first be calibrated by the field crews at available gaging station locations with long-term flow records, using procedures described by Rosgen (1996). This calibration procedure assists with distinguishing bankfull elevation from other elevations, which is an important key to channel classification. Twelve gaging stations have sufficiently long and recent records to support field calibration (Table 3). After field inspection during the summer of 2006 to locate staff gages and further evaluation of the flow records, bankfull calibration is possible at four of these 12 gaging stations (Table 3). Field determined bankfull stage elevations and associated bankfull channel dimensions will be calibrated

to known recurrence interval discharges at the gaging stations. This calibration first requires calculating annual flood flow frequency at gaged stations prior to conducting field work. Flood flow frequency analysis will be developed using the USGS Bulletin 17B, Guidelines for Determining Flood Flow Frequency (USGS 1982).

4.2.1.3 Rosgen Level III Analysis

A Rosgen Level III assessment of stream condition and departure from potential analysis (Rosgen 1996) will also be completed at each of the proposed quantification study sites. The Level III analysis provides a description of channel morphological stability and function. Stream stability is morphologically defined as the ability of the channel to maintain its dimension, pattern, and profile so that it is neither aggrading nor degrading. An objective of the Level III analysis is to determine the extent to which the present-day channel condition matches its functional stream potential, based on quantifiable morphological characteristics. Stream classification forms the basis for assessing the degree to which existing conditions differ from an accepted range of morphological values.

There are three approaches for determining the degree of departure for an existing stream condition from its full functional potential (Rosgen 1996):

- Comparing existing stream condition to a geomorphological database for similar stream types;

- Comparing the same stream reach over different time periods, usually through the use of historical aerial photography, ground photography, or by comparison to historic data; and

- Comparing river conditions at different points in space (i.e., upstream and downstream of Project facilities or to a reference stream).

Level III parameters will be collected at all approved Level II quantification study sites using a combination of field surveys, with supporting data from aerial surveys, aerial photography, and topographic maps. The Level III data collection will be performed concurrent with the Level II data collection. Information from the riparian vegetation mapping will be integrated into the Level III assessment. This information will be used to help identify the relative responsiveness of stream reaches to bank erosion or slope instability.

The following parameters are to be collected at each quantification study site:

- Deposition patterns

- Meander patterns

- Stream order

- Steambank erosion potential

- Description of the extent and relative influence of large woody debris on channel morphology

- Channel stability rating

Deposition patterns essentially categorize bar features. Rosgen (1996) has identified eight depositional pattern types that will be used to classify bar features at each quantification study site. Meander patterns will be classified based on a categorization system described by Rosgen (1996), which distinguishes eight types. Stream order will be determined based on the system developed by Strahler (1964), which is a method for organizing and comparing channels of different size within the Watershed stream network. Stream order will be determined from USGS topographic maps, not from field data.

Streambank erosion potential will be determined based on a method developed by Rosgen (1996), that classifies reaches into categories of relative bank erosion potential (i.e., very low, low, moderate, high, very high, and extreme). Measured criteria include ratio of streambank height to bankfull stage, ratio of riparian vegetation rooting depth to streambank height, degree of root density, bank angle, and degree of bank surface protection. The bank erodibility rating guide developed by Rosgen (1996) is provided in Appendix B.

A large woody debris inventory to be performed during the Phase 2 Aquatic Habitat Characterization Study will provide most of the information needed to describe the influence of large woody debris on channel morphology. However, the geomorphology study will describe the relative extent of woody debris in the channel based on field observations at each quantification study site. The extent of large woody debris will be categorized according to Rosgen (1996). In addition, the observed geomorphic function(s) of large woody debris will be described.

Channel stability ratings provide an index that describes the potential for changes in the sediment supply or flow regime to have effected the vertical and lateral stability of a channel. The rating system provides an indication of channel stability, but is not a quantitative measure of actual hydraulic conditions that cause the transport of bedload material, result in scour or deposition, or erode banks. Channel stability will be rated using the Pfankuch (1975) method as modified by Rosgen (1996). The stability ratings are based on field observations and measurements that result in categories ranging from poor to excellent stability. The parameters evaluated in the stability rating system are provided in the attached form (Appendix C). Channel stability ratings will be performed at each of the selected quantification study sites.

4.2.1.4 Data Reduction and Work Products

The work products for Phase 2 of the geomorphology study will consist of Level II stream reach classifications delineated on a base map or aerial photographs. For each quantification study site, data associated with each of the Level II parameters will be shown in a tabular format. Transect locations will be photo-documented and

monumented with rebar pins, and GPS coordinates recorded so that they can be relocated for future use, if necessary. Transects and longitudinal profiles will be graphically plotted, with bankfull and floodprone widths identified. Pebble counts will be graphically plotted as cumulative particle size distribution curves and frequency histograms.

The Level III information will be presented in tabular format, spatially designated on maps, or presented in narrative format, as appropriate. Channel reaches most susceptible to disturbance and those relatively more geomorphically resilient reaches will be identified and ranked. Potentially disturbed or altered reaches will be identified, and the nature of the likely channel alteration will be described. The results of the 2006 studies, including Geographic Information System (GIS) maps, aerial videos, and other products, will be cross-referenced with the results from the 2005 studies. Datasheets and GIS shape files will be provided to the resource agencies. Maps will be provided in the report and on compact disk (CD).

4.2.2 Riparian Studies

The Phase 2 riparian studies will focus on collecting both quantitative and qualitative data at each quantitative study site. The information will be used to refine the description of the composition, distribution, and age class structure of the riparian habitat, including regeneration and encroachment, developed during the Phase 1 studies. Riparian data collection at all the Phase 2 quantitative study sites, unless specified, include the following activities:

- Photo Documentation
- Vegetation Transect Composition and Structure
- Stream Bank Composition
- Data Reduction and Work Products

Each of these activities is discussed in the following.

4.2.2.1 Photo Documentation

Photo documentation will provide a visual record of the conditions of the riparian community and surrounding land uses. Permanent photo points will be established during the 2006 studies at each transect location. Each point will be clearly identified and documented in a photolog. In addition, the location of each point will be recorded with GPS coordinates so that it can be relocated for future use, if necessary. The photographs will be stored electronically in a photolog with pertinent information including date, time, number, and environmental information (such as recent high flows, etc). The datasheet for documenting the photo points is provided in Appendix D.

4.2.2.2 Vegetation Transect Composition and Structure

Quantitative data will be collected at each quantitative study site using the line-intercept method and with plots distributed along transects established perpendicular to the channel. Riparian data will be collected along transects within each quantification study site. The width of the riparian corridor will be measured at all transects. Vegetation will be sampled from the low flow water's edge to the valley walls or hillslope, and will include bars if present.

At all reaches, quantitative and qualitative information on the riparian community will be collected, as described in the 2005-2006 Existing Environment Study Package (PCWA 2005). The datasheets are provided in Appendix D.

Composition

Data collected using the line-intercept method will be used to characterize the species distributions, cover of litter, woody debris, woody vegetation[1], and conifers, and substrate particle size within the riparian corridor (Canfield 1941; Winward 2000). Community composition (dominant ground, shrub, and tree species present), is obtained by walking along the transect tape and measuring and recording the length of each dominant species or community type that intersects the tape along the transect. In addition, the length of areas of bare ground, leaf litter, large woody debris, and different substrate size classes will be recorded along each transect. The lengths of the vegetation and other corridor attributes are then related to the width of the entire riparian corridor to determine the proportion of each within the corridor.

Structure

Data will be collected in paired plots placed at changes in elevations and shifts in dominant species characteristics along each transect to evaluate possible changes or shifts in riparian characteristics, including age class and densities, in relation to potential differences in flow connectivity and hydroperiod. Data will be collected in two plot sizes at each plot location. Herbaceous and other cover data will be collected within 1 m^2 plots along transects. Shrub and tree data will be collected within 5 x 2 m plots along transects.

[1] All cover measurements will be made with a densiometer.

Plot-transect data collection will be used to collect quantitative data, including:

Shrub and Tree Layers (5 x 2 m plots):

- Canopy coverage class (%)
- Total number of stems (class)
- Stem count per individual or species (class)[2]
- Tree diameter (diameter at breast height)
- Dominant species relative decadence (%)
- Dominant species coverage (%)
- Total plot decadence (%)

Ground Layer (1 x 1 m plots)

- Dominant species coverage (%)
- Total canopy coverage
- Ground layer canopy coverage
- Shrub layer canopy coverage
- Tree layer canopy coverage

Other pertinent information will be recorded as observed in the field, including: substrate, channel encroachment, large woody debris within the riparian corridor, bank instability, and evidence of recreational and other land use activities (e.g. fishing trails, vegetation trampling or clipping, horses or cattle present). Evidence of unusual stress or mortality, and/or evidence of wildlife use, will also be noted. In addition, noxious weed and special-status plant species will be documented (see datasheets in Appendix D) if encountered during field surveys.

The total plot number along each transect will vary depending on the width of the riparian corridor. However, plots will be established to sample at least 5% of the total transect length, with a minimum of 4 5 x 2 plots and 6 1 x 1 plots per transect, as feasible based on the width of the valley bottom. A plot will always be established at the water's edge, and plots will also be established on bar features, if present along the transect.

In reaches with poorly developed and narrow floodplains in which only 1 or 2 plots would be placed along the transect, additional plots will be established parallel to the channel to evaluate a minimum of 4 5 x 2 plots and 6 1 x 1 plots per transect.

[2] Many observers have difficulty differentiating willow and mountain alder individuals, particularly mature individuals. Stems per individual will not be assessed if this occurs; rather stems per area (densities) will be determined. Seedlings or young individuals will be identified as this information is important for assessing regeneration. In addition, when stem densities are high, the accuracy of the counting tends to decrease. To minimize this error in the field, stem densities have been grouped. The groupings are finer at lower densities and are broader as densities increase.

4.2.2.3 Stream Bank Composition

Stream bank composition and cover will be characterized at each quantification study site using a modified greenline method[3] (minimum of 100m long)[4] (Winward 2000; Coles-Ritchie et al. 2004). At least one surveyed transect will intercept the greenline. Data on community composition and dominant species (dominant ground, shrub, and tree species present), bare ground, leaf litter, and large woody debris will be collected following a procedure similar to that described above for the line-intercept method, with the exception that the information will be collected parallel to the channel rather than perpendicular to it. The lengths of the vegetation and other corridor attributes are then related to the length of the greenline to determine the proportion of each along the stream bank. In addition, the number of seedlings of woody species (riparian and upland, if present) along a 6-foot wide belt along the greenline will also be tallied.

Other observational information, such as channel encroachment, other land uses, substrate, evidence of unusual stress or mortality, and/or evidence of wildlife use, will also be noted. A sample datasheet is provided in Appendix D.

4.2.2.4 Age Class Structure

During the 2005 riparian studies, lines of seemingly similarly aged white alder and/or cottonwoods were observed along certain reaches of the Rubicon River and the Middle Fork American River[5]. During the 2006 field studies, a study of tree ages will be conducted on white alder and/or cottonwoods present within a sub-sample of the following quantitative study sites:

- Middle Fork American River, French Meadows to Ralston Afterbay: RM 29.1-27.7
- Middle Fork American River, Downstream of Ralston Afterbay: RM 24.4-10.8
- Middle Fork American River, Downstream of Ralston Afterbay: RM 9.6-0.0
- Rubicon River: RM 21.0-19.7
- Rubicon River: RM 3.3-3.7

---

[3] The greenline is defined as: '*The first perennial vegetation that forms a lineal grouping of community types on or near the water's edge. Most often it occurs at or slightly below the bankfull stage' (Winward 2000).*

[4] In addition to vegetation composition data, this sampling procedure provides information on bank stability.

[5] This has been observed on numerous regulated and non-regulated streams (Auble et al. 1994; Braatne et al. 1996; Scott et al. 1997; Mahoney and Rood 1998; Roberts et al. 2002; Rood et al. 2003; Merigliano 2005) and has been attributed to the life history strategies of the species and specific years with successful recruitment during a year with a relatively high flow event, favorable high flow recession limb, and low mortality from drought or erosion/abrasion during subsequent years.

Tree increment cores will be collected and dated at selected reaches with the even-aged stands of cottonwoods or alders, following methods similar to those described in Maeglin (1979); Phipps (1985). A minimum of 20 and maximum of 40 trees will be sampled. The sampled trees will intersect at least one surveyed transect. If more than one line of trees of similar ages is observed within the reach, then additional lines will be sampled. The trees will be aged in the laboratory and the ages of the individuals will be related, in general, to the hydrologic regime at the time of seedling establishment and subsequent years.

4.2.2.5 Data Reduction and Work Products

Work products resulting from the Phase 2 riparian studies will include GIS maps showing the location and extent of riparian vegetation along the channels. The vegetation community type mapping will be overlaid on the Level II channel classification. Information collected on the location of invasive or special status species will also be incorporated on GIS base maps. Quantitative and qualitative data collected at each study site will be summarized by study stream, and will include text descriptions, tables, graphs, figures, photographs, and maps, as appropriate in Microsoft Excel or other formats. The results of the 2006 studies, including GIS maps, aerial videos, and other products, will be cross-referenced with the results from the 2005 studies. Datasheets and GIS shape files will be provided to the resource agencies. Maps will be provided in the report and on CD.

4.3 WATERSHED AND LAND USE ACTIVITIES

The geomorphic and riparian resources along the study streams and rivers may be affected by a variety of factors, including historic and recent land and water uses and naturally-occurring events such as fires and floods. General information regarding historic and recent land and water uses and naturally-occurring events will be developed and evaluated as part of the Phase 2 riparian and geomorphology studies. This effort will focus on information that provides perspective and context regarding the Project setting and possible sediment sources and land use activities that may influence stream morphology and riparian habitat. PCWA does not propose to develop quantitative information regarding these topics as part of the 2005-2006 Existing Environment Studies. This information will be further developed during subsequent phases of the relicensing process.

4.4 SEDIMENT RECRUITMENT DOWNSTREAM FROM RALSTON AFTERBAY

The location and relative abundance of sediment recruitment to channels from hillslope mass-wasting and bank erosion processes downstream of Ralston Afterbay will be evaluated. This assessment will focus on the inner gorge area of the Middle Fork American River, between Ralston Afterbay and the confluence with the North Fork American River, and the North Fork American River from the Middle Fork confluence to the high water mark of Folsom Reservoir. Sediment sources located between the active stream channel and the tops of the valley walls (e.g., up to the ridgeline) will be identified. Mass-wasting and significant bank erosion sites will be mapped. Aerial

reconnaissance, ground survey, and aerial photography will be used to identify the sediment recruitment sources.

4.5 POTENTIAL COMPARISON STREAMS

PCWA will characterize the geomorphic and riparian resources upstream of Project diversions if suitable, or on other unregulated streams and rivers. The best comparison streams are preferably those unimpaired by water diversions, but within the same Watershed, and with similar and well-defined historic and current land use activities. Streams with an existing hydrologic record are also preferable in order to understand how regulated flows may be influencing geomorphic conditions and riparian resources.

The purpose for conducting the field surveys above diversion facilities is to provide a complete picture of the "river continuum", from the upper Watershed reaches, downstream through the diversion sites. PCWA will map the geomorphology and riparian habitat for five miles upstream of the diversions. In addition, PCWA will characterize the conditions along two major tributaries to Project streams, including the North Fork Middle Fork American River and North Fork American River. PCWA will map the geomorphology and riparian habitat for five miles and qualitatively describe each for an additional five miles upstream of the confluence with the Middle Fork American River and Lake Clementine, respectively. The geomorphic study objectives are to provide information on channel geomorphic classification and a basic understanding of how the entire channel network recruits and transports sediment loads beginning in the upper Watershed areas. The riparian studies focus is on characterizing the riparian distribution and composition. An additional objective is to provide a first-step towards evaluating the suitability of above-diversion reaches and the non-Project streams as potential comparison streams.

The geomorphic and riparian studies above diversion facilities and along certain reaches of the North Fork Middle Fork and North Fork American rivers will be conducted in the same manner as the 2005 Physical Habitat Characterization studies, using a combination of helicopter aerial and foot surveys, to be supplemented with information from topographic maps and aerial photography. A Rosgen Level I geomorphic classification will be performed. Additionally, the types and relative amount of sediment recruitment to streams above diversion facilities will be characterized, including mapping any large-scale mass-wasting features such as landslides or significant areas of bank erosion. The riparian assessment will focus on developing qualitative information on riparian resources, including mapping the distribution of riparian vegetation along the streams and characterizing the species composition and age class structure of the woody riparian vegetation. The findings of these studies will be included in the Technical Study Report.

5.0 REPORTING

A report describing Phase 2 of the geomorphology and riparian habitat studies will be prepared. The report will provide a description of the study objectives, methods, and results and will include documentation regarding the study reach selection process. All

work products described in this plan will be incorporated into the report, with text descriptions, tables, graphs, and photographs, as appropriate. In addition, for perspective, the report will include a discussion of recent climatic and hydrologic conditions prior to and during the period of study.

The results of the 2006 studies, including GIS maps, aerial videos, and other products, will be cross-referenced with the results from the 2005 studies. All quantification study sites will be identified on a base map to be included with the report. All GIS shape files and datasheets will be provided on an accompanying CD.

6.0 AGENCY CONSULTATION AND NEXT STEPS

PCWA is currently conducting the studies presented in this study plan, based on feedback obtained during a meeting held with the resource agencies on June 1, 2006 and during the August 22, 2006 field visit. The Phase 2 study results will be documented in a report, which will be provided to the resource agencies and other interested stakeholders in January 2007. The combined results of the 2005-2006 Geomorphology and Riparian Habitat Characterization Study will be utilized to identify the need for additional studies. Any future studies will be developed in consultation with the resource agencies and other interested stakeholders as part of a collaborative stakeholder process, and documented in the Technical Study Plans to be included in PCWA's Pre-Application Document (PAD). The PAD will be circulated for review and comment in late 2007.

PCWA plans to continue to consult with the resource agencies and other interested stakeholders regarding the methods presented in this study plan, and to address any outstanding issues or questions. Consultation would occur by telephone, or in person, if necessary. At a minimum, PCWA plans to continue to consult with the resource agencies regarding:

- The selection of potential comparison reaches.

- The collection and evaluation of data and information regarding general Watershed conditions that may influence stream morphology and riparian habitat.

As requested by the resource agencies, PCWA developed a schedule showing the dates during which fieldwork is expected to be conducted during the 2006 field season. The field schedule was provided to specific individuals identified by the resource agencies. Updated field schedules will be provided if the field schedule is modified. PCWA encourages and looks forward to participation by the resource agencies in the field work.

7.0 SCHEDULE MILESTONES

The 2006 studies (Phase 2) will be carried out in accordance with the following generalized schedule.

Phase 2 Schedule

Date	Milestone
May – June 2006	Consultation with resource agencies regarding Phase 2 study plan
June – July 2006	Conduct field inspections to identify and flag potential Phase 2 quantification study sites
August 2006	Conduct site visit with agencies and stakeholders to select Phase 2 quantification study sites and transects
July – Oct 2006	Conduct Phase 2 studies, including data tabulation, reduction and preliminary analysis
Sept – Nov 2006	Continue data reduction and analysis
Nov 2006	Report preparation
Jan. 2006	Distribute Technical Study Report to resource agencies and interested parties for review and comment

8.0 REFERENCES

Auble, G. T., J. M. Friedman, and M. L. Scott. 1994. Relating riparian vegetation to present and future streamflows. Ecological Applications 4:544-554.

Braatne, J. H., S. B. Rood, and P. E. Heilman. 1996. Life history, ecology, and conservation of riparian cottonwoods in North America. Pages 57-85 in R. F. Steller, editor, *Biology of Populus and its implications for management and conservation*. National Research Council of Canada, NRC Research Press, Ottawa, ON.

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. Journal of Forestry 39:388-394.

Coles-Ritchie, M. C., R. C. Henderson, E. K. Archer, C. Kennedy, and J. L. Kershner. 2004. Repeatability of riparian vegetation sampling methods: how useful are these techniques for broad-scale, long-term monitoring? USDA Forest Service Gen. Tech. Rep. RMRS-GTR-138.

Harrelson, Cheryl C., C.L. Rawlins, and John P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. USDA Forest Service, GTR RM-245. Fort Collins, CO, 61pp.

Maeglin, R. R. 1979. Increment Cores How to Collect, Handle, and Use Them. United States Department of Agriculture Forest Service General Technical Report FPL 25.

Mahoney, J. M., and S. B. Rood. 1998. Streamflow requirements for cottonwood seedling development - an integrative model. Wetlands 18:634-645.

Merigliano, M. F. 2005. Cottonwood understory zonation and its relation to floodplain stratigraphy. Wetlands 25:356-374.

Pfankuch, D.J. 1975. Stream reach inventory and channel stability evaluation. USDA Forest Service, R1-75-002. Washington D.C., 26pp.

Phipps, R. L. 1985. Collecting, Preparing, Crossdating, and Measuring Tree Increment Cores. U.S. Geological Survey Water-Resources Investigations Report 85-4148.

Placer County Water Agency (PCWA). 2005. 2005-2006 Existing Environment Study Package. Middle Fork American River Hydroelectric Project (FERC No. 2079). June 17, 2005.

PCWA. 2006. Draft 2005 Physical Habitat Characterization Report. January 30, 2006.

Roberts, M. D., D.E. Peterson, D.E. Jukkola, and V. L. Snowden. 2002. A pilot investigation of cottonwood recruitment on the Sacramento River. The Nature Conservancy, Sacramento River Project.

Rood, S. B., J. H. Braatne, and F. M. Hughes. 2003. Ecophysiology of riparian cottonwoods: stream flow dependency, water relations, and restoration. Tree Physiology 23:1113-1124.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Scott, M. L., G. T. Auble, and J. M. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana, USA. Ecological Applications 7:677-690.

Strahler, A.N. 1964. Quantitative geomorphology of drainage basins and channel networks; Section 4-2 in *Handbook of Applied Hydrology* (ed. Ven te Chow), McGraw-Hill, New York.

U.S. Geological Survey. 1982. Guidelines for determining flood flow frequency. Bulletin 17B of the hydrology subcommittee, Interagency Advisory Committee on Water Data Coordination, Reston, VA 22092 (Mar 82).

Winward, A. H. 2000. Monitoring the Vegetation Resources in Riparian Areas. United States Department of Agriculture Forest Service, Rocky Mountain Research Station RMRS-GTR-47.

Wolman, M.G. 1954. A method of sampling coarse river-bed material. Transactions of American Geophysical Union 35: 951-956.

TABLES

Table 1. Phase 2 Study Site Locations.

Reach	Level 1 Rosgen type[1]	Reach River Stationing	Quantification Study Site Stations (approx.)	Nearest RM Access Points	Accessibility[2]	Final Access Rating[3]	Type of Access Location and Access Description
Middle Fork American River – French Meadows to Interbay							
10	A	47.2-44.2	44.7-44.82	44.8	Accessible	Accessible	• 4-wheel drive and rough hike • Near French Meadows Reservoir
	B	44.2-42.0	--	44.8	Inaccessible	Inaccessible	• 4-wheel drive • Requires at least a 0.6 mile hike within channel
	A	42.0-39.7	--	44.8	Inaccessible	Inaccessible	• 4-wheel drive • Requires a 2.8 mile hike within channel
	Fb or A	39.7-37.4	--	35.9	Inaccessible	Inaccessible	• Car • Requires a 1.5 mile hike within channel
	A	37.5-36.5	--	35.9	Inaccessible	Inaccessible	• Car access at Interbay • Channel is impassible
9	Fb or G	36.5-36.0	36.2-36.1	35.9	Accessible	Accessible	• Car • Interbay dam and reservoir • (PCWA key required)
Middle Fork American River – Interbay to Ralston Afterbay							
	N/A	36.0-35.6					Interbay
8	Fb or B	35.6-33.4	--	35.6	Difficult/ Unknown	Extremely Difficult/ Challenging	• Access requires taking stairs at face of dam and hiking to the channel along unstable hill slope • Unsafe option with gear
7	Fb	33.4-29.1	29.46-29.3	29.4	Accessible	Accessible	• Helicopter

Table 1. Phase 2 Study Site Locations (continued).

Reach	Level 1 Rosgen type[1]	Reach River Stationing	Quantification Study Site Stations (approx.)	Nearest RM Access Points	Accessibility[2]	Final Access Rating[3]	Type of Access Location and Access Description
Middle Fork American River – Interbay to Ralston Afterbay (continued)							
6	F or B	29.1-27.7	28.87-28.53	29.4	Accessible	Accessible	• Helicopter
5	Fb or B	27.7-26.1	--	27.7	Difficult/ Unknown	Extremely Difficult	• 950-foot descent over 1 mile on steep trail to river • Strenuous hike and challenging with gear
4	Fb	26.1-25.7	26.2-26.1	25.9	Accessible	Accessible	• Car
	N/A	25.7-24.7					Ralston Afterbay
Middle Fork American River – Oxbow to Folsom Reservoir High Water Mark							
3	F	24.7-10.8	17.4-16.25		Accessible	Accessible	• Helicopter landing zones at RM 17.4, RM 16.8, and RM 16.3
2	F or B	10.8-9.6	TBD		Accessible	Accessible	• Gated road to trail which parallels entire “Ruck-A-Chucky” reach
1	F	9.6-0	5.75-3.95	4.2	Accessible	Accessible	• Helicopter landing zones at RM 5.8, Philadelphia Bar, RM 4.7 Buckeye Bar, RM 3.9 Hoosier Bar, or 4-wheel drive, or trail along river
Duncan Creek							
3	B or G	8.6-7.9	8.4-8.25	8.4	Accessible	Accessible	• 4-wheel drive and gage trail
2	B	7.9-5	6.37-6.19	6.15	Accessible	Accessible	• 4-wheel drive and rough trail
1	B or G	5-4	4.63-4.4	4.5	Difficult/ Unknown	Accessible	• 4-wheel drive and rough trail

Table 1. Phase 2 Study Site Locations (continued).

Reach	Level 1 Rosgen type[1]	Reach River Stationing	Quantification Study Site Stations (approx.)	Nearest RM Access Points	Accessibility[2]	Final Access Rating[3]	Type of Access Location and Access Description
Duncan Creek (continued)							
	G	4.0-3.1	--	4.5, 0.3	Inaccessible	Inaccessible	• Channel obstructions and steep valley walls downstream of RM 4.5 limit access to lower reaches • Requires at least a 0.5 mile hike within channel
	B	3.1-1.0	--	4.5, 0.3	Inaccessible	Inaccessible	• Requires at least a 1.4 mile hike within channel
	A	1.0-0	--	0.3	Inaccessible	Inaccessible	• 4-wheel drive on Red Star Road (FS locked gate) • Extremely difficult 1,020 ft descent over at least 1.1 miles (no trail)
Rubicon River							
16	B	30.3-27.5	28.2-28.07	27.7, 28.7	Accessible	Accessible	• Helicopter landing zone at RM 27.7 or trail at RM 28.7 is 700 ft descent over 1.5 miles
15	F or B	27.5-24.7	25.8-25.6	25.0, 25.4	Accessible	Accessible	• Helicopter landing zone at RM 25.4 or trail at RM 25 is 900-ft descent over 0.8 mile
	G	24.7-24.2	--	25	Inaccessible	Inaccessible	• Hike • Cannot walk channel from access point
	F	24.2-23.4	--	25	Inaccessible	Inaccessible	• Hike • Cannot walk channel from access point

Table 1. Phase 2 Study Site Locations (continued).

Reach	Level 1 Rosgen type[1]	Reach River Stationing	Quantification Study Site Stations (approx.)	Nearest RM Access Points	Accessibility[2]	Final Access Rating[3]	Type of Access Location and Access Description
Rubicon River (continued)							
14	F or G	23.4-22.5		22.6	Accessible	Inaccessible	• Trail hike from RM 21.2 to 22.6 in disrepair due to landslide • At least a 0.8 mi hike in channel. • South Fork Rubicon confluence at RM 22.6
	F	22.5-21.9	--	21.2	Inaccessible	Inaccessible	• Hike • Requires at least a 0.7 mile hike within channel
13	F or G	21.9-19.7	21.0-20.6	21.2	Accessible	Accessible	• Trail from Rd 2 at Ellicott Bridge
12	F or G	19.7-17.6	19.65-19.28	20.25	Accessible	Accessible	• Trail from Rd 2 at Ellicott Bridge
11	G	17.6-14.6	--	14.3	Difficult/ Unknown	Inaccessible	• Inaccessible from Reach 10 • Steep bedrock confined channel with step pools
10	F or G	14.6-13.5	14.42-14.1	14.3	Difficult/ Unknown	Accessible	• Helicopter landing zone at RM 14.3
9	G	13.5-8.7	--	14.3	Difficult/ Unknown	Inaccessible	• Helicopter landing zone at RM 9.5 washed out in 2006 • Requires difficult, and possibly inaccessible 0.8 mile hike from helicopter landing zone in Reach 10
8	F or G	8.7-6.1	--	14.3	Difficult/ Unknown	Inaccessible	• No helicopter landing zone
7	G	6.1-5.6	--	5.3	Difficult/ Unknown	Inaccessible	• 4-wheel drive and difficult hike • Requires 1,540 ft descent over 2.5 miles to reach channel, then at least 0.4 mile channel hike

Table 1. Phase 2 Study Site Locations (continued).

Reach	Level 1 Rosgen type[1]	Reach River Stationing	Quantification Study Site Stations (approx.)	Nearest RM Access Points	Accessibility[2]	Final Access Rating[3]	Type of Access Location and Access Description
Rubicon River (continued)							
6	F	5.6-4.4	--	5.3	Difficult/ Unknown	Inaccessible	• 4-wheel drive and difficult hike • Requires 1,540 ft descent over 2.5 miles to reach channel
5	G	4.4-3.7	4.0-3.73	3.4	Accessible	Accessible	• Helicopter landing zone at RM 3.4 and hike channel upstream, or 4-wheel drive to RM 3.4
4	F	3.7-3.3	3.55-3.4	3.4	Accessible	Accessible	• Helicopter landing zone at RM 3.4 or 4-wheel drive to RM 3.4. Long Canyon confluence at RM 3.6
3	F or G	3.3-2.1	2.95-2.28	2.3, 3.4	Accessible	Accessible	• Helicopter landing zone at RM 2.3 or 4-wheel drive RM 3.4
2	F	2.1-0.8	1.42-1.07	0.5	Difficult/ Unknown	Accessible	• Car
1	G	0.8-0.5	0.77	0.5	Accessible	Accessible	• Car
North Fork Long Canyon Creek							
1	B	3.1-0	1.9-1.78	1.7	Accessible	Accessible	• Car
South Fork Long Canyon Creek							
1	B	3.3-0	2.5-2.25	2.2	Accessible	Accessible	• Car
Long Canyon Creek							
2	B	11.4-7.0	9.1-8.83	8.6	Accessible	Accessible	• Car
1	A	7.0-0	0.17-0.1	3.4 (Rubicon River)	Accessible	Accessible	• Helicopter or 4-wheel drive at RM 3.4 • Access from Rubicon River Reaches 3 to 5

[1]Reaches are defined by breaks in Rosgen Level I channel classification.
[2]Reaches in blue text indicate difficult channel accessibility. Reaches in red text are inaccessible.
[3]Final access ratings are based on inspections of candidate study sites and selection of quantification study sites during mid-summer 2006.

Table 2. Additional Pebble Count Sites for Rosgen Level II Classification.

Stream	Pebble Count Reach (RM)	Dominant Particle Size[a]	Rosgen Level I Classification Type
Middle Fork American River			
	33.0 - 33.4	2/3	Fb
	22.0 – 20.3	2	F
	20.3 – 19.4	1/2	F
	14.5 – 12.4	3/4	F
	12.1 – 10.8	5	F
	8.5 – 7.4	2/3	F
	2.0 – 1.7	2	F
	1.7 – 1.0	3	F
	1.0 – 0.0	3/4	F
Long Canyon Creek			
	10.5- 11.4	2/3	B
	6.7 – 6.4	1/2/3/4	A
	6.4 – 6.2	1/2	A
North Fork Long Canyon Creek			
	2.6 – 3.1	N.D.	B
	2.6 – 1.9	2/3	B
	1.6 – 1.4	2/3	B
	1.4 – 0.3	N.D.	B
	0.3 – 0.0	1/2	B
South Fork Long Canyon Creek			
	1.6 – 1.2	1/2/3/4	B
	1.2 – 1.0	2	B
	1.0 – 0.1	2/3/4	B

[a]Dominant particle size estimated from Level I surveys in 2005.
N.D. = no data
Particle size key (Rosgen, 1996): 1 = bedrock, 2 = boulder, 3 = cobble, 4 = gravel, 5 = sand

Table 3. Level II Bankfull Calibration Sites at USGS Gaging Stations.[a]

Location	USGS Gage	Period of Flow Record	Notes
Middle Fork American River			
French Meadows	**11427500**	**1951-2004**	
Above Middle Fork Powerhouse Near Foresthill (above Interbay)	**11427760**	**1965-2004**	
Below Interbay Dam Near Foresthill	11427770	1965-2002	Since 1985, gaging station has only recorded flows less than 35 cfs.
Near Foresthill (below Oxbow Powerhouse)	**11433300**	**1958-2004**	**Flow is calculated from the amount of power generated at the powerhouse.**
Near Auburn	11433500	1911-1986	Gaging station has been discontinued for a relatively long period of time and will not be useful for field calibration, due to shifts in the rating curve or lack of known, stable elevation points such as that defined by a staff gage.
Rubicon River			
Below Hell Hole Dam	11428800	1965-2004	Spill flows are not included in the gaging station discharge measurements or the stage-discharge rating curve.
Near Georgetown (below So Fork Rubicon)	11431000	1910-1964	Gaging station has been discontinued for a relatively long period of time and will not be useful for field calibration, due to shifts in the rating curve or lack of known, stable elevation points such as that defined by a staff gage.
Near Foresthill	11433200	1958-1984	Gaging station has been discontinued for a relatively long period of time and will not be useful for field calibration, due to shifts in the rating curve or lack of known, stable elevation points such as that defined by a staff gage.
Duncan Creek			
Duncan Canyon Below Diversion Dam Near French Meadows	**11427750**	**1964-2004**	
Long Canyon Creek			
Near French Meadows	11433100	1960-1992	Gaging station is discontinued. Staff gage no longer exists.
South Fork Long Canyon Creek			
Release Below Diversion Tunnel Near Volcanoville	11433065	1988-2003	The gaging station only records low flows, spills not included.
North Fork Long Canyon Creek			
Release Below Diversion Tunnel Near Volcanoville	11433085	1988-2004	The gaging station only records low flows, spills not included.

[a]Bankfull field calibration will be completed at the gaging stations in **bold** font.

FIGURES

Placeholder for Figure 1, Sheet 1

Figure 1 2006 Geomorphology, Riparian, and Aquatic Study Reaches

Non-Internet Public Information

These Figures have been removed in accordance with the Commission regulations at 18 CFR Section 388.112.

These Figures are considered Non-Internet Public information and should not be posted on the Internet. This information may be accessed from the Placer County Water Agency's (PCWA) Public Reference Room, but is not expected to be posted on PCWA's Website, except as an indexed item.

Placeholder for Figure 1, Sheet 2

Figure 1 2006 Geomorphology, Riparian, and Aquatic Study Reaches

Non-Internet Public Information

These Figures have been removed in accordance with the Commission regulations at 18 CFR Section 388.112.

These Figures are considered Non-Internet Public information and should not be posted on the Internet. This information may be accessed from the Placer County Water Agency's (PCWA) Public Reference Room, but is not expected to be posted on PCWA's Website, except as an indexed item.

Placeholder for Figure 1, Sheet 3

Figure 1 2006 Geomorphology, Riparian, and Aquatic Study Reaches

Non-Internet Public Information

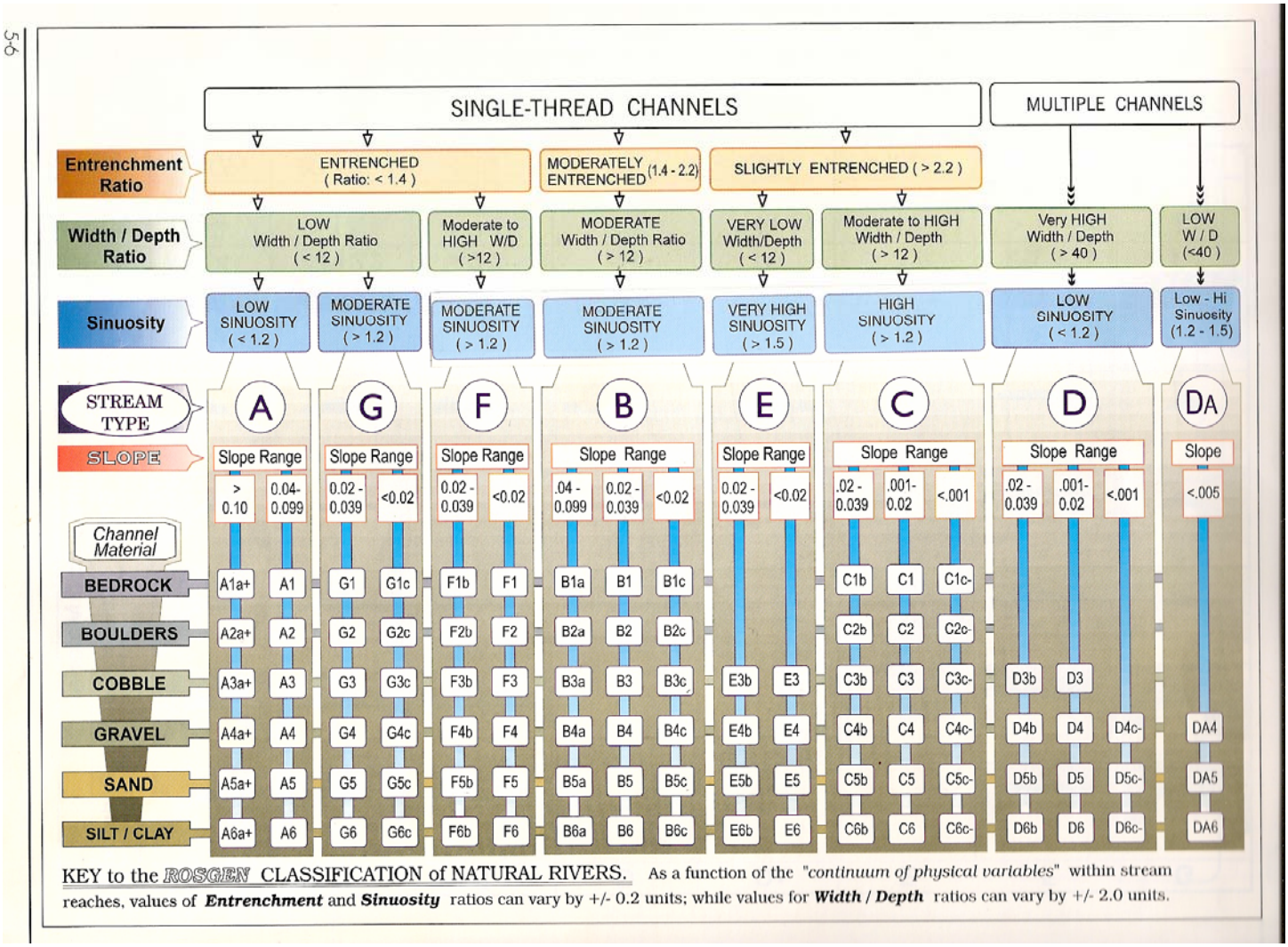
These Figures have been removed in accordance with the Commission regulations at 18 CFR Section 388.112.

These Figures are considered Non-Internet Public information and should not be posted on the Internet. This information may be accessed from the Placer County Water Agency's (PCWA) Public Reference Room, but is not expected to be posted on PCWA's Website, except as an indexed item.

APPENDIX A

Rosgen (1996) Classification Key For Natural Rivers

Appendix A. Rosgen (1996) Classification Key for Natural Rivers.



KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the "*continuum of physical variables*" within stream reaches, values of ***Entrenchment*** and ***Sinuosity*** ratios can vary by +/- 0.2 units; while values for ***Width / Depth*** ratios can vary by +/- 2.0 units.

APPENDIX B

Bank Erosion Potential Rating

Appendix B. Bank Erosion Potential Rating (Source: Rosgen, 1996).

BANK EROSION POTENTIAL

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.19	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	10
Root Depth/Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05	8.0-9.0	<.05	10
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	5-14	8.0-9.0	<5.0	10
Bank Angle (Degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-90	6.0-7.9	91-119	8.0-9.0	>119	10
Surface Prot. (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10
TOTALS												
		5-9.5		10-19.5		20-29.5		30-39.5		40-45		46-50
Numerical Adjustments												

BANK MATERIALS: BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW
BOULDERS: BANK EROSION POTENTIAL LOW
COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT
GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND
SAND: ADJUST VALUES UP BY 10 POINTS
SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

APPENDIX C

Channel Stability Rating

Appendix C. Channel Stability Rating (Source: Rosgen, 1996).

CHANNEL STABILITY (PFANKUCH) EVALUATION AND STREAM CLASSIFICATION SUMMARY (LEVEL III)

	Category	POOR	
UPPER BANKS	1 Landform Slope	Bank Slope Gradient 60%+	8
	2 Mass Wasting	Frequent or large causing sediment nearly year long or imminent danger of same.	12
	3 Debris Jam Potential	Moder. to heavy amounts, predom. larger sizes.	8
	4 Vegetative Bank Protection	<50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass.	12
LOWER BANKS	5 Channel Capacity	Inadequate. Overbank flows common. W/D ratio >25	4
	6 Bank Rock Content	<20% rock fragments of gravel sizes, 1-3" or less.	8
	7 Obstructions to Flow	Sediment traps full, channel migration occurring.	
	8 Cutting	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9 Deposition	Extensive deposits of predom. fine particles. Accelerated bar development.	16
BOTTOM	10 Rock Angularity	Well rounded in all dimensions, surfaces smooth.	4
	11 Brightness	Predom. bright, 65%+ exposed or scoured surfaces.	4
	12 Consolidation of Particles	No packing evident. Loose assortment easily moved.	8
	13 Bottom Size Distribution	Marked distribution change. Stable materials 0-20%.	16
	14 Scouring and Deposition	More than 50% of the bottom in a state of flux or change nearly year long.	24
	15 Aquatic Vegetation	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	4
		TOTAL	

Stream Width _____ x avg. depth _____ x mean velocity _____ = Q _____ cfs

Gauge Ht _____ Reach Gradient _____ Stream Order _____ Sinuosity Ratio _____

Width $_{BF}$ _____ Depth $_{BF}$ _____ W/D Ratio _____ Discharge (Q_{BF}) _____

Drainage Area _____ Valley Gradient _____ Stream Length _____ Valley Length _____

Sinuosity _____ Entrenchment Ratio _____ Length Meander (Lm) _____ Belt Width _____

Sediment Supply
Extreme _____
Very High _____
High _____
Moderate _____
Low _____

Stream Bed Stability
Aggrading _____
Degrading _____
Stable _____

Width/Depth Ratio Condition
Normal _____
High _____
Very High _____

TOTAL SCORE for Reach E____ = G____ + F____ + P____ = ____ Pfankuch Rating

Remarks _____ from table ____ Reach Condition

Stream Type ____

CONVERSION OF STABILITY RATING TO REACH CONDITION BY STREAM TYPE*

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
GOOD	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60
FAIR	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78
POOR	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+

Stream Type	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
GOOD	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
FAIR	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
POOR	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream Type	DA3	DA4	DA5	DA6	E3	E4	E5	E6
GOOD	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63
FAIR	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86
POOR	87+	87+	87+	87+	87+	97+	97+	87+

Stream Type	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
GOOD	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
FAIR	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
POOR	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

**Generalized relations ... need additional Level IV data to expand data base for validation.*

APPENDIX D

Phase 2 Riparian Study Data Sheets

Key for Detailed Riparian Assessment Datasheet

	Ground Layer[4]		Shrub[4]		Tree[4]	
Canopy Cover[1,3] Relative % Cover [2,3]	**Levels**	**Cover**	**Levels**	**Cover**	**Levels**	**Cover**
	1	<1%	1	<10	1	<10
	2	2-9%	2	10-24%	2	10-24%
	3	10-39%	3	25-39%	3	25-39%
	4	40-59%	4	40-59%	4	40-59%
	5	60-99%	5	60-99%	5	60-99%
	6	100%	6	100%	6	100%

Size Classes[3]	**Shrub**		**Shrub[5]**		**Tree[4]**		**Substrate[6]**	
	Levels	**No. Stems**	**Levels**	**dbh**	**Levels**	**dbh**	**Levels**	**Size (mm)**
	1	1	1	Seedlings or sprouts	1 True seedling	S	Bedrock	-
	2	2-5	2	< 1/2“	2 seedling tree	< 1"	Boulder	> 256
	3	6-10	3	½-1”	3 sapling tree	1"-3"	Cobble	64 to 256
	4	11-30	4	1”–3”	4 sapling tree	3”-6"	Gravel	2 to 64
	5	31-60	5	3”–5”	5 pole tree	6”-9”	Sand	0.063 to 2
	6	60-100	6	>5”	6 pole tree	9”-11”	Silt	0.062 to 0.002
	7	101-150			7 small tree	11"-24"	Clay	≤ 0.002
	8	150-200			8 med/large tree	>24		
	9	>200						

[1] The amount of area the canopy layer covers within the plot area
[2] Relative cover of each species within the plot area
[3] Record all size classes present for each species recorded. Circle the dominate size class
[4] Mayer and Laudenslayer 1988
[5] USFWS 1999
[6] based on Udden-Wentworth size classes.

Greenline Datasheet

Stream and QSS ID: _____Date:_____ Name:_____

GPS Waypoint:_____ River Mile:_____

Left Bank Greenline Length (m): _____ Left bank transect crosses greenline at (m):_____

Right Bank Greenline Length (m): _____ Right bank transect crosses greenline at (m):_____

L or R Bank	Attribute[1]						Distance on Greenline (m)	Notes[2]
	Dominant Species			Sub-Dominant Species	Other[3]			
	Species	% Cover[4]	Tree Height[5]					
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		

[1] Species, community type, or attribute (litter, bare ground, substrate, woody debris, dead vegetation).
[2] Fluvial landform, decadence, senescence, grazing, other land use activities.
[3] Litter, duff, woody debris, bedrock, boulder, cobble, gravel, sand, fines, dead vegetation.
[4] Percent cover for the species.
[5] Average tree height of the species.

L or R Bank	Attribute[1]						Distance on Greenline (m)	Notes[2]
	Dominant Species			Sub-Dominant Species	Other[3]			
	Species	% Cover[4]	Tree Height[5]					
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		

Line-Intercept Datasheet

Stream and QSS ID: _____Date:_____ Name:_____

Transect Number:_____ GPS Waypoint:_____ River Mile:_____

Total Riparian Zone Width (m): _____

L or R Bank	Attribute[6]						Distance on Transect (m)	Notes[7]
	Dominant Species			Sub-Dominant Species	Other[8]			
	Species	% Cover[9]	Tree Height[10]					
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		

[6] Species, community type, or attribute (litter, bare ground, substrate, woody debris, dead vegetation).
[7] Fluvial landform, decadence, senescence, grazing, other land use activities.
[8] Litter, duff, woody debris, bedrock, boulder, cobble, gravel, sand, fines, dead vegetation.
[9] Percent cover of the species.
[10] Average tree height of the species.

L or R Bank	Attribute[6]						Distance on Transect (m)	Notes[7]
	Dominant Species			Sub-Dominant Species	Other[8]			
	Species	% Cover[9]	Tree Height[10]					
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		
						Start		
						Stop		

Regeneration Datasheet
Along Greenline Transect

Stream and QSS ID: _____ **Date:**_____ **Name:**_____

GPS Waypoint:_____ **River Mile:**_____

L or R Bank	Species[11]	Total Number Young[12]	Total Number Seedling/Sprout[13]

[11] Include only woody riparian species (*Alnus rhombifolia*, *Alnus* incana, *Salix* ssp., *Populus fremontii*, *Populus balsamifera*).
[12] Young: <10 stems/individual shrub or dbh <3" for trees
[13] Seedling: 1 stem at the ground surface for shrub species; Sprout: dbh <1" for tree species

L or R Bank	Species[11]	Total Number Young[12]	Total Number Seedling/Sprout[13]

Notes or Other Observations (e.g. land use activities, fluvial landforms, substrate)

Noxious Weed Observation Form

<table>
<tr><td colspan="2">Species:</td><td colspan="3">Stream:

Quantification Study Site ID:
Transect:</td></tr>
<tr><td colspan="2">Population ID:</td><td>Collected? (Y or N)</td><td colspan="2">Date:</td></tr>
<tr><td colspan="3">Area covered: (length x width in meters)</td><td colspan="2">Observers:</td></tr>
<tr><td colspan="3">Density: (high, medium, low)</td><td colspan="2">Photo #:</td></tr>
<tr><td>UTM Zone:</td><td>Easting:</td><td>Northing:</td><td>Elevation:</td><td>Map #:</td></tr>
<tr><td colspan="5">Description of location: (geomorphic setting, habitat, etc.)</td></tr>
<tr><td colspan="5">Current land use: (include structures)</td></tr>
<tr><td colspan="5">Associates: (noxious weed dominant?)</td></tr>
<tr><td colspan="5">Other location notes:</td></tr>
<tr><td colspan="5">Phenology: (flowering? fruiting?)</td></tr>
</table>

Special-status Plant Observation Form

Species:		**Stream:** **Quantification Study Site ID:** **Transect:**		
Population ID (=number on CNDDB form)**:** **Area covered by Species:** (length x width in meters)		**Collected? (Y or N)**	**Date:** **Observers:**	
Density (high, medium, low)**:**			**Photo #** (photograph diagnostic feature if possible)**:**	
Source of coordinates (GPS, map)**:**		**GPS model:**	**Accuracy** (meters)**:**	
UTM Zone: (use NAD 83)	**Easting:**	**Northing:**	**Elevation:**	**Map #:**
Phenology:	**%** vegetative / **%** flowering / **%** fruiting	**Previously located?**	**Y**	**N**

HABITAT DESCRIPTION

Plant communities:

Dominants:

Associates:

Soils:

Aspect/slope:

Other rare taxa seen at this site on this date:

SITE INFORMATION

Site quality *(circle one)**:*** **Excellent Good Fair Poor**

Current/surrounding land use:

Visual disturbances:

Threats *(include noxious weeds)**:***

Notes:

Determination

Keyed *(cite reference)**:***

By another person *(include name)**:***

Other:

Complete CNDDB form using this information

Detailed Riparian Assessment Datasheet: 1 x 1 m^2 plot

Stream & QSS ID:_____ **Date:**_____ **Name(s):**_____ **GPS Waypoint:**_____ **River Mile:**_____ **Riparian Width (m):**_____

	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6	
L or R Bank?												
Location of Plot Pair (distance along the transect tape in meters):												
Substrate (dominant and sub-dominant):												
Total % Ground Cover												
% Tree Layer Canopy												
% Shrub Layer Canopy												
Total % Canopy												
	Species	% Cover	Species	% Cover	Species	% Cover	Species	% Cover	Species	% Cover	Species	% Cover
1												
2												
3												
4												
5												
Exotic/ invasive Species?												
Other Species												
Notes:												

Detailed Riparian Assessment Datasheet: 5 x 2 m^2 plot

Stream & QSS ID:_____ **Date:**_____ **Name(s):**_____

Riparian width (m):_____ **GPS Waypoint:**_____ **River Mile:**_____

Location of Plot Pair (dist. along the transect tape in meters):		**L/R bank**:		

PLOT 1 **Substrate** (dominant and sub-dominant):

Shrub	Species (note individual or multiple individuals, I or M)		Dominant (Yes or No)	%Cover	Rel% Decadence	# stems by size class (tally by size class)						**Levels**	**No. Stems**
						Seedling	<1/2"	1/2"-1"	1"-3"	3"-5"	>5"	1	1
% shrub cover	1											2	2-5
	2											3	6-10
	3											4	11-30
	4											5	31-60
% cover dead	5											6	60-100
	6											7	101-150
	7											8	150-200
	8											9	>200

Tree	Species	Dominant (Yes or No)	% Cover	Rel% Decadence	# trees by DBH (tally by size class)							
					Seedling	< 1"	1" - 3"	3"- 6"	6"-9"	9"-11"	11" - 24"	>24"
% tree canopy	1											
	2											
	3											
	4											
% canopy dead	5											
	6											
	7											
	8											

PLOT 2 **Substrate** (dominant and sub-dominant):

Shrub	Species (note individual or multiple individuals, I or M)		Dominant (Yes or No)	%Cover	Rel% Decadence	# stems by size class						**Levels**	**No. Stems**
						Seedling	<1/2"	1/2"-1"	1"-3"	3"-5"	>5"	1	1
% canopy	1											2	2-5
	2											3	6-10
	3											4	11-30
	4											5	31-60
% canopy dead	5											6	60-100
	6											7	101-150
	7											8	150-200
	8											9	>200

Tree	Species	Dominant (Yes or No)	% Cover	Rel% Decadence	# trees by DBH (tally by size class)							
					Seedling	< 1"	1" - 3"	3"- 6"	6"-9"	9"-11"	11" - 24"	>24"
% canopy	1											
	2											
	3											
	4											
% canopy dead	5											
	6											
	7											
	8											

Notes:

Photo Point Documentation

Date:_____

Stream & QSS ID:_____ **GPS Waypoint:**_____ **River Mile:**_____

Photo ID	Photographer	Location of Photographer	Description of Permanent Marker	Description of Photograph	Other

Quantification Study Site Information

Date:_____ **Name:**_____

Stream & QSS ID:_____ **GPS Waypoint:**_____ **River Mile:**_____

GPS coordinates (UTM NAD 83): E_____ **N**_____

Presence of Wildlife/Diagnostic Sign:

Wildlife Habitat Suitability (circle): EXCELLENT GOOD POOR

Land Use (circle): FIRE RECREATION GRAZING TIMBER MGMNT OTHER (describe)

Evidence of Unusual Mortality/Stress: (circle) Y or N (describe if yes)

Riparian Encroachment (circle): None Minimal Moderate Extensive

1. Is riparian vegetation encroaching into the stream?

2. Is the vegetation resulting in the formation of a new bank location?

3. Is the vegetation changing the channel form or impacting instream habitat?

Sketch the cross-section. Include general topography, substrate, vegetation, etc within the channel, on bars, and floodplain.

Sketch a plan view of the cross-section. Include general topography, substrate, vegetation, etc within the channel, on bars, and floodplain for approximately 50 m upstream and downstream of the transect.

Provide a general description of the transect (geomorphology, riparian, aquatics).

(after third folds, refold first to close)

Datasheet for Moss Collection

third fold forward

third fold forward

second fold back
(tightly under first, then unfold first and flip)

first fold back

Collector:_____ **Number:**_____ **Date:**_____

Country:_____ **State/Province:**_____ **County/other:**_____

Location:_____

_____ **Elevation:**_____**m/ft**

Coordinates:_____ **Datum:**_____

(circle ALL that apply)

LIGHT: sunny, open, filtered, partial shade, full shade **ASPECT: W N E S facing** **SLOPE:**_____**°**

WATER: dry, moist, seeping, saturated, splash-zone, wet, submerged _____ **m/ft; periodic, occasional**

POSITION: top, cliff, slope (ridge, upper, mid, toe, fan), ledge, flat, swale, canyon HYDROLOGY: upland, floodplain, dry channel, riparian, spring, seep, meadow, bog, fen, swamp, pool, snow, ice; edge, bank, beach

DISTURBANCE: glacial, fire, grazed (bovid, equid), human, structure, road (paved, graded), trail, other; edge

VEGETATION: old-growth, dense, open, sparse, barren; cut, cultivated, altered; forest, woodland, glade, savanna, grassland, forbs, chaparral, shrubland, heath, tundra, non-vascular; dwarf; broadleaf, needleleaf, microphyllous, succulent; evergreen, deciduous;DOMINANTS:_____

_____

SUBSTRATE: acidic, felsic (granite, rhyolite, dacite, quartzite, sandstone, chert), neutral sedimentary or metamorphic (silt- / mud- / clay-stone or shale; slate, phyllite, schist, gneiss), mafic (andesite, diorite, basalt, gabbro, serpentine), basic (limestone, dolomite, marble, chalk, gypsum), alkaline (evaporite visible)

ROCK: boulder, outcrop, slab; crevice, underhang; SOIL: rocky, gravel, sand, silt, mud, clay, litter, peat, humus; loose, compact; PLANT: root, base, trunk, stump, branch, stem, twig; bark, wood, leaf; live, dead, rotten; standing, fallen; evergreen, deciduous; lichen, moss, epiphyte, parasite, succulent, shrub, climber, tree (conifer, hardwood, fern, palm); _____**m/ft above ground on** _____