Alder Creek
Watershed Assessment and Monitoring Plan

July 2007

Submitted by:
The City of Folsom
Department of Public Works
50 Natoma Street
Folsom, CA 95630

Prepared by:
EDAW

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PURPOSE

The Alder Creek Watershed Assessment and Monitoring Plan (ACWAMP) is a key component of the Alder Creek Watershed (ACW) Project. The purpose of the ACWAMP is to gather and evaluate existing and new data and information that will be used to: 1) characterize the existing (baseline) conditions of the creek and its resources, 2) provide clues as to the historic form and function of the creek and associated watershed, 3) study the drainage functions and response of the natural creek system under existing and future land use scenarios, and 4) 'identify stakeholders' values, concerns and goals for the future of the ACW. The ACWAMP will document the methods that will be used to characterize conditions in the watershed and how stakeholder interests will be compiled and integrated into work products. Once data has been gathered, compiled, and interpreted, recommendations can be made about future actions to protect, restore, and/or enhance the creek and watershed resources in years to come.

The assessment work will cover the entire ACW, including uplands and tributaries that feed into the upper watershed; however, new field surveys will be focused on the primary creek corridor (i.e., creek and associated riparian corridor). Availability of survey sites will depend on access to areas on private property and seasonally influenced environmental conditions (e.g., precipitation and runoff events).

BACKGROUND

The ACW Project is funded by a Proposition 50 watershed grant through the State Department of Water Resources (DWR) and managed by the City of Folsom (DWR/City of Folsom Grant Agreement No. 4600004717). The grant provides funding for the Year One monitoring efforts; therefore this document describes work to be conducted during the 2007 calendar year. Some information about potential future monitoring efforts is also included.

The City of Folsom's Public Works Department handles all stormwater management issues for the City, from design and construction of the storm drain system to operation and maintenance, and urban runoff pollution prevention through its stormwater quality program, designed to comply with the City's NPDES Municipal Stormwater Permit. The City secured the watershed grant funds in order to gather stakeholders together to prepare a watershed management plan (WMP) that would describe existing conditions and recommend projects to protect the health and integrity of the watershed in light of planned future development.

DESCRIPTION

Alder Creek originates in the western slopes of the Sierra Nevada foothills (maximum elevation 600 feet) in the northeastern corner of Sacramento County, southeast of the City of Folsom. From its headwaters, the creek flows in a southwest direction approximately 15 miles until it enters the American River at Lake Natoma (Folsom State Recreation Area) (see Exhibit 1). Alder Creek drains the area generally west of the El Dorado County line, north of the Buffalo Creek watershed, and a 2.5-square mile portion of the City of Folsom north of State Highway 50. Eleven square miles of blue oak and mixed oak mosaic woodlands in northeastern Sacramento County are located within the watershed. The watershed is an important resource for the region, providing habitat for wildlife, avian, plant, and aquatic species. The mouth of Alder Creek at Lake Natoma is located on the Lower American River, an important aquatic habitat for several anadromous fish species and source of drinking water for the region.

Due to its proximity to the rapidly growing Sacramento Metropolitan Area, the ACW is subject to urban development. Currently, about one quarter of the watershed has been developed or is still undergoing development within the City of Folsom. Preliminary development plans have been prepared for 1,400 acres of land adjacent to the creek ("Easton Development") presently owned by GenCorp in unincorporated Sacramento County. Additionally, the area around the creek headwaters, which is also part of unincorporated Sacramento County, is slated for future development.

GRANT PROJECT DESCRIPTION

As stated previously, the goal of the project is to gather stakeholders together to prepare a WMP that will describe existing conditions and recommend projects to protect the health of the watershed and the creek in light of planned future development. The watershed-scale approach to the project will allow the stakeholders to develop integrated solutions that address the physical, chemical, and biological problems contributing to water quality and habitat degradation affecting the whole watershed. The project will assess the current structure, function, and value of the watershed from the headwaters to Lake Natoma.

In spring 2007, the technical consulting team presented the proposed assessment approach to the Alder Creek Technical Advisory Committee (TAC) and other watershed stakeholders at the first (of several) stakeholder meeting(s). Assessment topics included review and synthesis of existing data and studies, maps, and aerial photography, and collection of new data in the field. During the meeting, questions were raised to solicit input from the TAC and other stakeholders regarding types of data to be collected, the methods of data collection, and if there were any data/studies that have been completed that were not already being considered in the assessment. Prior to initiating the field monitoring, a Quality Assurance Project Plan (QAPP) and Project Assessment and Evaluation Plan (PAEP) will be prepared and submitted to the City of Folsom project manager and California Department of Water Resources (DWR) grant manager.

PROJECT TEAM

The Program and Project Managers of the ACW Project and Grant Program directly involved with the ACWAMP are listed in Table 1 below.

Table 1
Alder Creek Watershed Project Management

Task	Managers
DWR Grant Manager	Megan Fidell, State DWR Watershed Group
City of Folsom Grant Manager	Sarah Amaya, City of Folsom
Project Manager	Carmel Brown, Principal, CKB Consulting Inc.
Stakeholder Facilitation	Joan Chaplick, MIG
Technical Project Team – Watershed Assessment and Management Plan	Debra Bishop, Technical Team Project Manager, EDAW Chris Fitzer, Lead Biologist, EDAW Brad Hall, Lead Hydrologist/Geomorphologist, Northwest Hydraulic Consultants

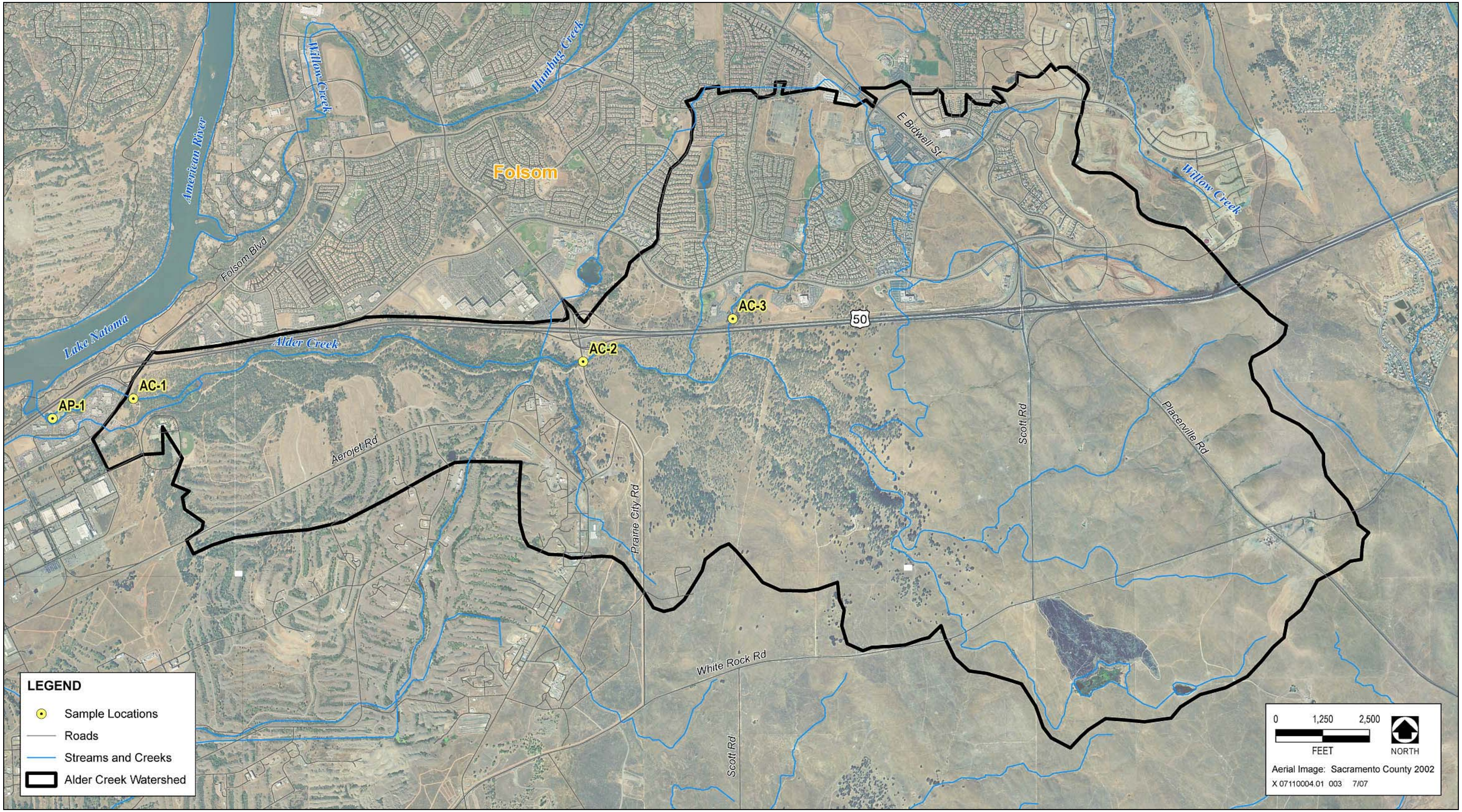
MONITORING PROGRAM GOALS

The objectives of ACWAMP are as follows:

1. Identify available data that can be used to establish baseline biological, chemical, physical, habitat, and hydrogeomorphological conditions in the watershed.

2. Collect new data to supplement any pre-existing data to be used to establish baseline watershed conditions.

3. Synthesize all data to establish baseline watershed conditions and guide/inform the identification of future restoration opportunities and continued monitoring.



Source: NHC 2007, Sacramento County 2007

Alder Creek Watershed **Exhibit 1**

4. Compile and present data in a user-friendly GIS-based map format for use and reference by all stakeholders and audiences, and others outside the watershed.

5. Identify meaningful, collaborative opportunities for local schools to get involved with the monitoring program.

DATA COLLECTION

EDAW's team of ecologists, biologists, planners, and hydrologists/geomorphologists will both review and synthesize existing reports written on different areas in the watershed and collect new data consistent with the watershed assessment plan to address data gaps along Alder Creek as well as key tributaries. The process of reviewing existing information available from projects/studies that have occurred or are occurring in the watershed will help establish areas (topical and geographical) lacking data. This will help concentrate field data collection efforts toward generating new data and establishing existing conditions for the watershed.

The following types of data will be collected during the watershed assessment using the methods indicated:

- historic and anecdotal information – collected through interviews and literature/historic aerial review;
- problem areas (e.g., localized flooding, erosion, sedimentation, channel instability, poor water quality or aesthetics) – identified by watershed residents and streamside property owners and project team members;
- maintenance issues and problems – collected through interviews with key maintenance managers working for the local agencies, as well as through observations made by field staff;
- water quality data (common constituents and biotic information as proxy [see bioassessment below]) – collected from representative sections of the creek system in spring and fall 2007;
- flow data – collected from representative sections of the creek system during the spring and fall 2007;
- natural resources and bioassessment data – collected from representative sections of the creek system in spring and fall 2007;
- hydrologic and hydraulic data and modeling results – obtained from Sacramento County and City of Folsom; and
- hydrogeomorphologic data – collected from representative sections of the creek system in spring 2007.

EXISTING DATA

To date, there have been no comprehensive efforts to study the watershed as a whole. Previous efforts by developers and local interest groups have focused on discrete portions of the watershed. As part of the planning process for potential development projects, landowners within the watershed have conducted a variety of studies on their properties. These studies include phase 1 environmental assessments, cultural resources assessments, biological resource assessments, special-status species evaluations, wetland delineations, arborist reports, and mitigation and management plans for specific resources. A table that provides a list of these reports is attached as Appendix A. EDAW staff will review these reports and compile the information to generate a picture of what information is known for different areas in the watershed. This will expose data gaps and allow EDAW to develop their study plans and conduct efficient field data collection. Where applicable, existing data will be incorporated with newly generated data to establish baseline conditions for the greater ACW.

NEW DATA

The work to generate new data will build upon, rather than duplicate, previous monitoring work conducted by scientists and engineers on behalf of watershed landowners. This work will include characterizations of aquatic and riparian habitat, aquatic macroinvertebrate community, physical habitat composition, and flow and channel patterns that may affect the hydrogeomorphic function of the stream channel. Following the collection of new data, EDAW GIS specialists will work with the technical team to update the GIS database/map layers and generate figures to be included in the final work products. Also, if budget allows, EDAW can employ GIS modeling techniques to determine water quality vulnerability (e.g., risk associated with different land use changes and patterns), ecological sensitivity, and land stability for the ACW.

SAMPLING AND SURVEY METHODS

Field sampling will take place on various sites within the ACW to characterize aquatic and riparian habitat, water quality, aquatic community, physical composition (i.e., bioassessments), hydrogeomorphic functioning of the stream channel, and flood hydrology on the creek. Data collection protocols will be consistent with standardized procedures including: the Storm Water Ambient Monitoring Program (SWAMP) being developed by the California Department of Fish and Game (DFG) for the Regional Water Quality Control Board (RWQCB) for low gradient urban streams, California Native Plant Society (CNPS) Rapid Assessment protocol, and hydrogeomorphic survey protocols (e.g., cross-sections, longitudinal profiles, etc.). Furthermore, field reconnaissance-level surveys (i.e., basic visual observations) will be conducted throughout the watershed to characterize upland vegetation communities and verify existing maps of sensitive resources.

FIELD SAMPLING

Field sampling site selection for focused aquatic bioassessment and rapid vegetation assessment was based on five primary criteria: 1) access is safe, 2) permission to access private property is granted, 3) sample site/area is representative of the part of the sub-watershed and/or water body of interest, and when taken together, all sites are representative of the watershed as a whole, 4) conditions are appropriate for sampling method (e.g., wadeable streams), and 5) location complements or supplements historical data (e.g., DFG reference sites, USGS monitoring, etc.). Based on these criteria, three stream sites were selected. An additional site, Alder Pond (mouth of creek at Lake Natoma), was also selected for field sampling; however, different methods were used for assessment due to the nature of the resource (i.e., pond versus stream). All of the sample sites are depicted on Exhibit 1.

1. Lower Alder Creek (AC-1)—150-meter (m) reach along the mainstem of Alder Creek beginning immediately upstream of the Regional Transit Light Rail Bridge (upstream of Folsom Boulevard). The watershed condition above this sample site can be characterized as being dominated by oak woodlands and dredger tailings with limited development.

2. Middle Alder Creek (AC-2)—150-m reach along the mainstem of Alder Creek immediately upstream of the Prairie City Road bridge. The watershed condition above this sample site can be characterized as semirural grassland and oak woodland with residential development influence to the north of Highway 50.

3. Upper Alder Creek Tributary (AC-3)—150-m reach along a tributary to Alder Creek upstream of HWY 50 adjacent to (east) a parking lot at the end of Iron Point Circle. The watershed condition above this sample site can be characterized as urbanized/suburbanized with residential and commercial development.

4. Alder Pond (AP-1)—Pond formed by Lake Natoma backwater at mouth of Alder Creek immediately upstream of HWY 50. The watershed condition above this sample site is variable and is immediately downstream of the Folsom Auto Mall.

Hydrogeomorphic surveys (e.g., cross-sections, profiles) will be conducted at several locations throughout the watershed. The specific location of these surveys will be determined based on review of existing information and during initial site visits.

Sampling Schedule

EDAW field biologists will conduct field sampling in the spring/summer and fall 2007. Hydrogeomorphic field assessments will be conducted during the spring/summer of 2007.

Aquatic Bioassessment

In accordance with DFG's Aquatic Bioassessment Laboratory (ABL) standard operating procedures (SOPs) for data collection, 150 m stream reaches are divided into 11 equidistant transects arranged perpendicular to the direction of flow and sampled. At each transect, a 1 square foot area will be sampled for benthic macroinvertebrates. All samples will be compiled to comprise one aquatic invertebrate sample for the stream reach. Physical habitat characteristics will also be recorded at each transect along with basic water quality measurements (Table 2) at each reach.

Table 2
Aquatic Bioassessment Water Quality Sampling Parameters

Parameter	Units	Comments
Temperature	°C	Measured using a YSI 55 multi-meter
Dissolved Oxygen (DO)	mg/L	
pH	pH units	Measured using a Hanna Combo HI 98129 multi-meter
TDS	mg/L	
Conductivity	µS	
Alkalinity	mg/L	Measured using a LaMotte WAT-DR field test kit
Aquatic Benthic Macroinvertebrates	NA	CSBP, collected and sent to DFG ABL facility

Once a sample site has been selected, it is divided and marked into 11 equidistant transects perpendicular to the stream flow. Upon arrival at the sampling site, the reach documentation section of the field forms (site and project identification, stream and watershed name, crew members, date/time, and GPS coordinates) is completed. Initial survey observations are made from the stream banks, making sure not to disturb the instream habitat.

Ambient water chemistry data is measured (pH, dissolve oxygen [DO], conductivity, total dissolved solids [TDS], water temperature) with either a YSI 55 multi-meter or a Hanna HI 98129 multi-meter and recorded at the downstream end of the reach. Alkalinity is measured using a LaMotte WAT-DR field test kit. Photographs are taken from the upstream end of the reach looking downstream, from the center of the reach looking both up and downstream, and from the downstream end of the reach facing upstream. Dominant land use/land cover is recorded for the 50 meters on either side of each transect and evidence of disturbance (flooding, fire, grazing, etc.) is recorded.

Biological samples will be collected before any other physical habitat data to avoid disturbing the substrates. Benthic macroinvertebrates are collected using the multiple-habitat method. A 500 µ mesh D-frame net is placed on the downstream end of a selected 1 square foot area. The sample area is disturbed by reaching into the substrate with the collectors hand and removing attached materials from rocks and allowing drift that is dislodged to be carried into the net by the current or with the collector's foot if water depth is substantial. SOPs for the DFG ABL's invertebrate collection procedures are provided in the QAPP (see below, Appendix B).

QUALITY ASSURANCE POLICY AND PROTOCOLS

The U.S. Environmental Protection Agency (USEPA), State Water Resources Control Board (SWRCB), River Watch Network, and RiverKeeper programs nationwide all recommend the formation of a QAPP for volunteer monitoring programs. In fact, USEPA-funded and SWRCB-funded monitoring programs must have an approved QAPP before sample collection begins. A QAPP, *The Alder Creek Watershed Monitoring Program Quality Assurance Project Plan* (ACWMP QAPP), has been developed for the Alder Creek Watershed Monitoring Program that outlines the procedures for volunteer monitors to collect, manage, and report data (see Appendix B).

SAMPLE ANALYSES

The only samples to be collected in this project that require laboratory analysis are aquatic macroinvertebrate samples taken for stream bioassessment. These samples will be properly labeled and delivered to the DFG ABL in Rancho Cordova. Laboratory results will be sent directly to field biologists and stored in-house.

DATA MANAGEMENT

Completed field data forms will be scanned into electronic pdf format and stored with project materials. Raw data will be entered into Microsoft Excel spreadsheets and saved digitally. This data will be compiled and incorporated into technical memoranda and ultimately into the WMP.

REPORTING

Technical memoranda will be written and delivered to the City grant and project managers following each field collecting season in the spring and fall of 2007. All information gathered during the project will be synthesized in the WMP and project report and will be delivered to the City grant and project manager in spring 2009. GIS-based maps will be used to present the results where appropriate.

FUTURE MONITORING EFFORTS

Environmental professionals (Carmel Brown, Chris Fitzer) will oversee the design and implementation of a citizen monitoring and stewardship program that features both standardized stewardship projects from reach to reach (i.e., visual surveys, water quality monitoring) and reach-specific projects that may including stream habitat visual surveys, volunteer stream bioassessment, tree planting, watershed tours, nature walks, workshops, special events, and lectures. Field monitoring methods will adhere to the ACWAMP and QAPP, and projects will build on successful programs implemented by the Sacramento Urban Creeks Council and other local organizations. Watershed monitoring methods discussed above were selected so that monitoring could be repeated and data could be replicated by volunteers in the future. This will allow for more effective application and evaluation of monitoring results in the future.

PRODUCTS OF THE WATERSHED ASSESSMENT

OPPORTUNITIES AND CONSTRAINTS MAP AND DATABASE

The ACWAMP will generate the information to evaluate the current state and overall condition of the ACW. The main decision-making tool generated by the ACWAMP will be an "opportunities and constraints" map and associated database. This map will identify and describe sites with reported and observed problems (e.g., erosion, localized flooding, poor water quality, habitat degradation) as well as areas that have potential for protection, restoration, or enhancing resources. The map will be used by the technical consultants to guide decisions about recommended actions. The information will also be used by the stakeholders in order to consider the recommendations and determine priorities for implementation.

TECHNICAL MEMORANDUM WITH WATERSHED ASSESSMENT RESULTS

A technical memorandum will be prepared that will summarize the data (existing and new) collection efforts, methods, limitations, and results. It will include photographs, measurements, cross sections and laboratory data results, and will incorporate the opportunities and constraints information described above. The first technical memo will be prepared in 2007, after data from the spring 2007 bioassessment monitoring work is available. The memo will then be updated in 2008 to add results of the fall 2007 bioassessment studies. Once the technical memorandum is complete, the project team can begin to make decisions about recommended actions for the WMP.

APPENDIX A

List of Environmental Studies

Appendix A
List of Environmental Studies Relevant to the Alder Creek Watershed

Title	Prepared by	Date of Document	Location in watershed	Content	Notes
South Folsom Specific Plan: Parcel Ownership Map	RRM Design Group	November 2006	**Upper watershed**	Parcel map of middle and upper watersheds	A map showing parcel location and ownership in the middle and upper watershed areas
Jurisdictional Delineation & Special Status Species Evaluation – Carpenter Ranch Property	Gibson & Skordal, LLC	November 2006	**Upper watershed** Borders: north: Highway 50, east at Placerville Road, west at Prairie City Road, and south at Grant Line Road and various other parcels	Special-status species assessment and wetland delineation	Wetland delineations done and SS species assessment done with review of CNDDB and historical data – multiple large maps included *
Carpenter Ranch Cultural Resources Inventory Volume 1 of 3: Technical Report and Appendices A–D	Ric Windmiller, R.P.A.	November 2006	**Upper watershed** Borders: north: Highway 50, east at Placerville Road, west at Prairie City Road, and south at Grant Line Road and various other parcels	Cultural resource assessment	Review of historical land use and cultural resources of site
Phase I Environmental Site Assessment Carpenter Ranch, Three Additional Parcels, US Highway 50 & Scott Road	Versar, Inc.	May 16, 2006	**Upper watershed** At intersection of Highway 50 and Scott Road	Phase 1 Environmental Assessment looking at presence of hazardous substances	Visual inspection of site and literature review, looking at current and historic land uses
Carpenter Ranch – Folsom SOI Project Site Initial Arborist Report and Inventory Summary	Sierra Nevada Arborists	February 17, 2006	**Upper watershed** Borders: north: Highway 50, east at Placerville Road, west at Prairie City Road, and south at Grant Line Road and various other parcels	Arborist report of site and tree inventory	Trees counted and speciated on whole project site, also further examined and tagged within residential, Business/Professional and Executive parcels
Delineation of Waters of the United States Folsom South +/- 1,400 Acre Site Sac. County, CA	Foothill Associates	April 28, 2006	**Upper watershed** Borders White Rock Road on the south and a portion of Highway 50 to the north	Wetland delineation	Literature review and on-site fieldwork. – multiple maps provided including one large topographical map *

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Title	Prepared by	Date of Document	Location in watershed	Content	Notes
Results of a Focused Plant Survey on the Folsom South Site/Special-status Amphibian and Reptile Surveys on the Folsom South Site (Draft)	Foothill Associates	June 22, 2006 & April 26, 2006	**Upper watershed** Borders White Rock Road on the south and a portion of Highway 50 to the north	Special-status plant, reptile and amphibian species survey	Literature research and field survey done. Many plant species associated with seasonal wetlands were found, no reptile or amphibian species
Phase I Environmental Site Assessment for Russell Ranch South El Dorado Hills Area Sacramento County, CA	Youngdahl & Associates, Inc.	February 1995	**Upper watershed** Between Highway 50 and White Rock Road, bordered on the west by Placerville Rd and the Sacramento/ El Dorado County line to the east	Environmental site assessment	Review of literature and available resources and a visual site reconnaissance visit to determine presence of hazardous materials
Area 41 Expanded Field Trail Bioremediation of Soils with High Perchlorate Loevels by Applying Composted Maure	GeoSyntec Consultants	August 2002	**Upper watershed** On a parcel known as “area 41;” the report does not provide a detailed description of location	Bioremediation field trials	Field trials of two methods to remediate perchlorate hotspots from waste materials due to land use between 1960 and 1970
Biological Resources Assessment Folsom South +/- 1,400 Acre Site Sacramento County, CA	Foothill Associates	January 3, 2006	**Upper watershed** Borders White Rock Road on the south and a portion of Highway 50 to the north	Biological resources assessment	Site surveyed on foot, wetlands delineated, soils categorized, site assessed for potential to serve as plant and wildlife habitat – multiple maps included *
Cultural Resources Assessment of the Proposed White Rock Springs Golf Course, Sacrament County, CA	Peak & Associates, Inc.	September 3, 1993	**Upper watershed** The parcel borders White Rock Road to the south, Placerville Road to the east, and Grant Line Road to the north	Cultural resources assessment	Literature review and field surveys performed for project site to understand human history on project site

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Title	Prepared by	Date of Document	Location in watershed	Content	Notes
Biological Resources Assessment +/-130 Acre Folsom 138 Property Sacramento County, CA	Foothill & Associates	September 24, 2004	**Upper watershed** The parcel borders White Rock Road to the south, Placerville Road to the east, and Grant Line Road to the north	Biological resource assessment	Literature and data review, field surveys. Soil categorization, wetland delineation, biological community assessment, and potential for occurrence of special-status species analysis – a large topographical map included *
Environmental Site Assessment Folsom 138 Property	Wallace Kuhl & Associates Inc.	September 10, 2004	**Upper watershed** The parcel borders White Rock Road to the south, Placerville Road to the east, and Grant Line Road to the north	Phase 1 Environmental site assessment	Visual inspection of site and literature review, looking at current and historic land uses in relation to potential hazardous materials on site
Arborist Report on trees on Whiterock Springs Golf Course Project	R-B Enterprises	August 29, 1993	**Upper watershed** The parcel borders White Rock Road to the south, Placerville Road to the east, and Grant Line Road to the north	Arborist report	Evaluation of 11 trees on the project site; trees measured, evaluated for "health," and recommendations are included
Preliminary Geotechnical Engineering Report Folsom 138 Property	Wallace Kuhl & Associates	August 31, 2004	**Upper watershed** The parcel borders White Rock Road to the south, Placerville Road to the east, and Grant Line Road to the north	Geotechnical engineering report	Geology: subsurface and surface conditions analysis, many test pits excavated and analyzed
Wetland Preservation & Mitigation Plan Sacramento Country Day School	Gibson & Skordal, LLC	June 2005	**Upper watershed** Borders White Rock Road on the parcel's southern end, midway between Prairie City Road and Scott Road	Brief biological resource assessment and wetland mitigation plan	Biological resource assessment including wetland delineation was done. Impacts to wetlands, and a mitigation plan are included – A large school plan layout is included

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Title	Prepared by	Date of Document	Location in watershed	Content	Notes
Sacramento Country Day School Folsom Campus Archaeological Resources Inventory	Ric Windmiller, R.P.A.	March 2005	**Upper watershed** Borders White Rock Road on the parcel's southern end, midway between Prairie City Road and Scott Road	Archaeological resources inventory	History of human presence in the project area, review of literature/press regarding the project area, list of archaeological resources
Special-Status Plant and Wildlife Report Sacramento Country Day School White Rock Road	Virginia Dains/ Susan Sanders	June 27, 2005	**Upper watershed** Borders White Rock Road on the parcel's southern end, midway between Prairie City Road and Scott Road	Special-status species investigation	Project site was visually surveyed and a review of literature for potential special-status species presence
Cultural Resources Survey Report Folsom Area South Group – 30-Acre Parcel	ECORP Consulting, Inc.	August 2006	**Upper watershed** The project site is located in the middle of the rectangle created by Highway 50, Scott Road, White Rock Road, and Prairie City Road	Cultural resources survey	Literature and fieldwork research done to assess human history on project site
Draft Biological Resources Assessment Report Centex-Folsom Heights Property	EDAW	July 2006	**Upper watershed** (possibly drains to Cosumnes River)	Biological resources assessment	Description of habitats, plants and wildlife (including special-status species), and regulatory setting – aerial photography figures included *
Preliminary Delineation of Waters of the United States Centex – Folsom Heights Property	EDAW	June 28, 2006	**Upper watershed** (possibly drains to Cosumnes River)	Wetland delineation	Evaluation of wetland areas on the project site – aerial photography figures included *
Tree Survey for Centex – Folsom Heights Property	EDAW	June 29, 2006	**Upper watershed** (possibly drains to Cosumnes River)	Tree survey	Assessment of trees on the project site – an aerial photo containing points for each tree is included *
Environmental Site Assessment Folsom Heights Property	Wallace Kuhl & Associates		**Upper watershed** (possibly drains to Cosumnes River)	Environmental site assessment	Review of literature and resources regarding hazardous materials

Appendix A
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Title	Prepared by	Date of Document	Location in watershed	Content	Notes
Cultural Resources Inventory Folsom Heights Property Development Project Sacramento County, CA	EDAW	July 17, 2006	**Upper watershed** (possibly drains to Cosumnes River)	Cultural resources assessment	Review of the history of human presence on the project site
Cultural Resources Survey Report. Folsom Area South Group–0.66 Acre Parcel	ECORP Consulting, Inc.	August, 2006	**Upper watershed** In the corner formed by the Sacramento/El Dorado County line to the east and White Rock Road to the south	Cultural resources assessment	Review of literature and historical resources and field surveys – Maps included *
Adaptation of a bioassessment reference site selection methodology to creeks and sloughs of California's Sacramento Valley and alternative strategies for applying bioassessment in the valley	CDFG	2005	**Middle watershed** Alder Creek at Folsom Blvd.	Bioassessment	Bioassessment survey results for Alder Creek and other Central Valley streams and sloughs
Easton Development. Alder Creek Watershed Analysis	MacKay and Somps, Inc.	June 16, 2004	**Middle watershed** The north end of the project site borders Highway 50 and the eastern edge borders Prairie City Road	Watershed analysis	Appendices include mitigation plans for impacted natural resources, an operations and management plan and more – Many maps and figures utilizing GIS *
Wetland Mitigation and Monitoring Plan for Easton, Sacramento County, CA.	ECORP Consulting, Inc.	September 24, 2004	**Middle watershed** The north end of the project site borders Highway 50 and the eastern edge borders Prairie City Road	Wetland mitigation and monitoring plan	Inventory of wetlands on the project site and a mitigation and monitoring plan – Figures included and large aerial photo inserts included *
Conceptual Elderberry Mitigation Plan for Easton, Sacramento, CA.	ECORP Consulting, Inc.	September 24, 2004	**Middle watershed** The north end of the project site borders Highway 50 and the eastern edge borders Prairie City Road	Mitigation plan	Description of existing conditions (vegetation community) and impact analysis and habitat conservation plan – aerial photo figures included *

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Title	Prepared by	Date of Document	Location in watershed	Content	Notes
Wetland Delineation for Easton, Sacramento County, CA.	ECORP Consulting, Inc.	June 17, 2004	**Middle watershed** The north end of the project site borders Highway 50 and the eastern edge borders Prairie City Road	Wetland delineation	Description of site conditions and delineation of wetlands – aerial photos incorporated with GIS into figures and maps *
Easton Resource Conservation Management Plan	ECORP Consulting, Inc.	March 3, 2005	**Middle watershed** The north end of the project site borders Highway 50 and the eastern edge borders Prairie City Road	Resource conservation management plan	Description of existing conditions (vegetation, wetlands, special-status species, cultural resources), evaluation of impacted and preserved resources, future mitigation, and long-term resource management – many aerial photo figures and large inserts included *
Conceptual plans for restoration of Lower Alder Creek.	Alder Creek Coalition	2003	**Lower watershed** Alder Pond	Conceptual restoration plan	Conceptual restoration plan
Water quality and sediment study of Alder Pond	Bureau of Reclamation	2002	**Lower watershed** Alder Pond	Mercury study	Water quality/plant monitoring in Alder Pond which showed levels of mercury below water quality standards, but elevated levels of nutrients which may have contributed to excessive water hyacinth growth

The upper watershed is defined from east of Prairie City Road.
The middle watershed is defined between Folsom Blvd and Prairie City Road.
The lower watershed is defined as Alder Pond and the lowest reach of Alder creek before it reaches Lake Natoma.
* = Indicates a figure utilizing GIS data is included.
Source: Data compiled by EDAW, July 2007

APPENDIX B

Quality Assurance Project Plan

Quality Assurance Project Plan

For:

Alder Creek Watershed Assessment and Management Plan

Project Number: 994818BRO

March 2007

Submitted by:
City of Folsom

Prepared by:
EDAW

1. APPROVAL SIGNATURES

City of Folsom:

Title:	Name:	Signature:	Date:
Project Manager	Sarah Amaya		
QA Officer	Carmel Brown, CKB Environmental Consulting		

Department of Water Resources:

Title:	Name:	Signature:	Date:
Contract Manager	Megan Fidell		

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3. DISTRIBUTION LIST

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Element 3: Distribution List

Title:	Name (Affiliation):	Tel. No.:
City of Folsom, Grant Manager	Sarah Amaya	(916) 351-3545
Project Manager	Carmel Brown, CKB Environmental Consulting	(916) 296-3167
Department of Water Resources Grant Manager	Megan Fidell	(916) 651-9619
Contractor Project Manager	Debra Bishop, EDAW	(916) 414-5800
Contractor QA Officer	Chris Fitzer, EDAW	(916) 414-5800

4. PROJECT/TASK ORGANIZATION

4.1 INVOLVED PARTIES AND ROLES

Folsom's Public Works Department handles all stormwater management issues for the City of Folsom (City), from design and construction of the storm drain system to operation and maintenance, and urban runoff pollution prevention. Alder Creek drains the Alder Creek watershed in northeastern Sacramento County and delivers water to Lake Natoma in Folsom, which is an impoundment on the lower American River, an important drinking water source for the region. Utilizing a grant provided by CALFED and administered through the state Department of Water Resources (DWR), the City identified the Alder Creek watershed as a target area to improve and ensure future stream health and subsequently, water quality.

Sarah Amaya is the City's Grant Manager. She will be responsible for all aspects of managing the project grant.

Carmel Brown of CKB Consulting has been retained by the City to manage the project and serve as the City's QA officer. She will be responsible for all aspects of the project including the management of the stakeholder facilitator and the technical team.

Joan Chaplick of MIG will conduct stakeholder facilitation. Joan will be responsible for all aspects of the stakeholder process including outreach to watershed stakeholders, publishing project information materials, and coordinating with residents and groups to engage them in assessment work. Joan will also be responsible for facilitation of the interest-based planning process with the watershed stakeholders.

Debra Bishop of EDAW will serve as the technical team project manager. Debra will be responsible for all aspects of the project's technical assessment and management plan development including the organization of field staff, scheduling of sampling days, and interactions with the contract laboratory. Chris Fitzer will serve as the assistant project manager for the technical team. The technical team consists of experienced environmental professionals and water resource engineers that will direct and conduct the technical work necessary to assess water quality, habitat and drainage conditions, and develop solutions which balance the needs of water quality improvement, habitat protection, drainage/flood control, recreation, and open space conservation. Field assessments and office research will be conducted to assess existing watershed water quality, habitat, drainage, and other conditions. Problems and opportunities will be identified and mapped and presented to the Watershed Management Plan (WMP) Technical Advisory Committee (TAC) for feedback. Then projects will be identified to address the problems and take advantage of opportunities (e.g., land availability, sponsors, etc.). For each recommended project, the project team will outline in a fact sheet a project description, stakeholders, order of magnitude budget estimates and projected benefits. They will then use weighted evaluation criteria to rank the projects in terms of priority. Ranking results will be presented to the WMP TAC, and then to the broader community in an open house to get feedback before proceeding with development of the final WMP document. The challenge will be in selecting and prioritizing actions that have the greatest chance of success, but there are several successful implementation models in the San Francisco Bay Area and Pacific Northwest that can guide the effort. The strategy is to facilitate collaboration between agencies, citizens, developers and landowners, in order to foster a sustainable stewardship culture within the watershed. This, in turn, will increase the capability of sustaining the water quality benefits derived from the activities.

The California Department of Fish Game (CDFG) Aquatic Bioassessment Laboratory (ABL) will process and analyze all macroinvertebrate samples collected during bioassessment activities.

Table 2
Element 4: Personnel Responsibilities

Name	Organizational Affiliation	Title	Contact Information (Telephone number, fax number, email address.)
Sarah Amaya	City of Folsom Department of Public Works	City Grant Manager	(916) 351-3545
Megan Fidell	State Department of Water Resources (DWR)	State Grant Manager	(916) 651-9619
Carmel Brown	CKB Environmental	Project Manager	(916)452-3557
Joan Chaplick	MIG	Stakeholder Facilitator	(510)845-7549
Diana Sherman	MIG	Facilitation Assistance	(510)845-7549
Debra Bishop	EDAW Inc.	Technical Team Project Manager	(916) 414-5800
Chris Fitzer	EDAW Inc.	Technical Team Asst. Project Manager/Biological Resources	(916) 414-5800
Brad Hall	Northwest Hydraulic Consultants (NHC)	Technical Team-Hydrology	(916) 371-7400

Table 2 Element 4: Personnel Responsibilities			
Name	Organizational Affiliation	Title	Contact Information (Telephone number, fax number, email address.)
Rene Leclerc	Northwest Hydraulic Consultants (NHC)	Technical Team-Hydrology	(916) 371-7400

4.2 QUALITY ASSURANCE OFFICER ROLE

Carmel Brown is the City's Quality Assurance Officer. Carmel's role is to establish the quality assurance and quality control procedures found in this QAPP as part of the sampling, field analysis, and laboratory analysis procedures.

Carmel will review and assess all procedures during the life of the contract against QAPP requirements. Carmel will report all findings to Megan Fidell and Sarah Amaya, including all requests for corrective action. Carmel may stop all actions, including those conducted by the technical team if there are significant deviations from required practices or if there is evidence of a systematic failure.

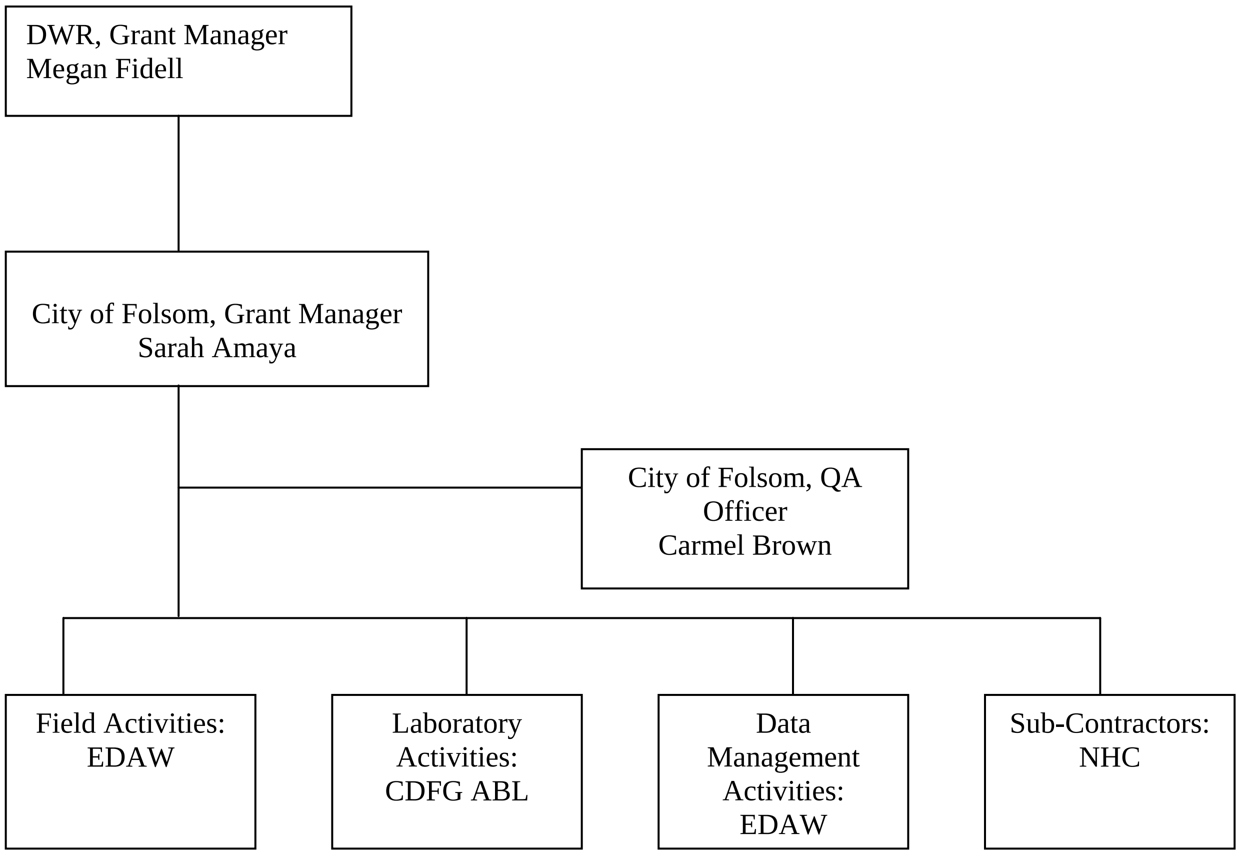
4.3 PERSONS RESPONSIBLE FOR QAPP UPDATE AND MAINTENANCE

Changes and updates to this QAPP may be made after a review of the evidence for change by the City's Project Manager and Quality Assurance Officer, and with the concurrence of the state's (DWR) Grant Manager. The City's Quality Assurance Officer will be responsible for making the changes, submitting drafts for review, preparing a final copy, and submitting the final for signature.

4.4 ORGANIZATIONAL CHART AND RESPONSIBILITIES

See Figure 1 below.

Figure 1. Organizational Chart.



5. PROBLEM DEFINITION/BACKGROUND

5.1 PROBLEM STATEMENT

Despite a history of mining, flood control, water diversions, agricultural practices and urban development, Alder Creek with its surrounding blue oak woodlands remains an important resource in the region, providing habitat for several threatened and special status species of plants and wildlife. Only about one-quarter of the watershed is developed today, but plans are underway to convert a very large portion of the watershed to urban land uses in the future. These activities within the watershed have potential to degrade the water quality of Alder Creek. The project goals are to assess current environmental conditions, identify problems and sources of pollutions, recommend prioritized projects, and guide the future of the Alder Creek watershed through a stakeholder-driven process. Through the development of the WMP, the project will provide a mechanism to enhance physical and functional connections in the watershed while protecting water quality and open space.

The main issues facing/to be addressed by this program include:

- **A lack of a dedicated stakeholders group.** Although initial efforts at developing a stakeholders group are underway, past participation has been limited to large landowners and business interests within the watershed. In 2002, representatives from various stakeholder organizations began meeting regularly to discuss water quality concerns and restoration strategies for Alder Creek. This group, known as the Alder Creek Coalition, submitted a grant proposal for a Lower Alder Creek Restoration Project to the U.S. Army Corps of Engineers in the fall of 2003. The funds were reprogrammed and the group lost its momentum. There is a critical need now, before development plans are finalized, to conduct an objective, holistic watershed planning process to protect the creek resources, while considering and balancing the interests of all stakeholders. The WMP, to be developed as part of this project, should be stakeholder driven and reflective of all stakeholder interests within the watershed, and therefore the current lack of an inclusive watershed stakeholder group is a potential challenge for the project. The timing of this project represents a unique opportunity to establish public-private partnerships and build a solid foundation for sustainable, long-term watershed stewardship.

- **Development plans within the watershed.** Time is a constraint for this project as development plans for areas within the watershed have already been drafted. GenCorp is a major landowner within the watershed and has already generated momentum for its Easton housing development. The threat of large-scale development creates an urgent need to develop community-based vision for the watershed before a different vision is defined by development projects.

- **Property ownership within the watershed/site access.** Although public access is available at numerous sites, much of the watershed is private property and access to many areas may be limited. The WMP will contain a full assessment of the health of Alder Creek; therefore, access to different reaches of the creek is essential. Further, private property within the watershed may limit certain opportunities for watershed enhancement and restoration. Permission from private property owners will likely be required for many restoration projects in the watershed and may, in many cases, be difficult to secure.

5.2 DECISIONS OR OUTCOMES

Through the stakeholder-driven process, the project will provide the following benefits:

- Improved communication and collaboration between watershed stakeholders.
- A common vision and goals for along-term protection of the Alder Creek Watershed.
- A management plan which becomes a 'blueprint' for creek protection that is supported, endorsed, and 'owned' by all stakeholders because they were involved in the process and their interests are represented.
- Data that characterizes existing conditions of the creek system, compiled and presented in a user-friendly format for use and reference by all stakeholders and audiences, and others outside the watershed.
- A WMP that addresses diverse interests and objectives (e.g., water quality, habitat, flood control/drainage, recreation, education and interpretation) in a balanced fashion and can be a model for reference by other watershed programs.
- Recommended policies, programs and projects that will contribute to improved water quality delivered to the American River, an important drinking water, fisheries and recreational resource for the region.
- Recommended policies, programs and projects that will offer protection for various endangered and threatened species of plants, trees, aquatic species and wildlife.
- A protected, healthy creek and riparian corridor with recreational, educational and interpretive opportunities for existing and future community residents and local schools.

5.3 WATER QUALITY OR REGULATORY CRITERIA

There is no regulatory information, criteria, nor action limits applicable to this project within the Alder Creek Watershed.

6. PROJECT/TASK DESCRIPTION

6.1 WORK STATEMENT AND PRODUCED PRODUCTS

Alder Creek will be studied in a watershed-scale approach in order to develop integrated solutions that address the physical, chemical and biological problems contributing to water quality degradation and habitat impacts affecting the whole watershed. The project will assess the current status of the watershed from top to bottom.

In conjunction with the City's project manager and facilitator, EDAW will participate in up to five public meetings and two field trips to gather input from watershed residents in an effort to determine those issues, opportunities, and constraints most relevant for the watershed plan. This input will be used to refine the set of goals and objectives, and to develop an initial list of watershed enhancement opportunities and constraints.

EDAW specialists will assess land usage throughout the watershed through analysis of GIS data and aerial photos of the watershed. Reconnaissance surveys and ground truthing site visits will confirm gathered information. Professional field monitors will perform work necessary to fully assess the health of the watershed. EDAW biologists will conduct stream biological assessments, which include the sampling of benthic macroinvertebrates, physical habitat assessment, and water quality analysis. Aquatic invertebrate samples will be sent to the CDFG ABL for processing and analysis. Professional hydrogeomorphological field surveying will be performed by hydrologists from Northwest Hydraulic Consultants, in conjunction with EDAW field technicians.

The project consists of these major elements/tasks:

- Establish a stakeholder advisory team.
- Define interests; develop goals, and a common vision for Alder Creek Watershed management.
- Conduct an environmental assessment of the Creek.
- Complete a WMP for the watershed.

Documents to be produced in the project include:

- Technical memoranda regarding stream health, riparian community, and watershed resources.

- A watershed-wide assessment addressing water quality, stream hydraulics/watershed hydrology, aquatic invertebrate populations, habitat (aquatic, riparian, and upland), and land use practices (current and future).

- A WMP that identifies specific protection/restoration/enhancement activities within each reach and an implementation strategy. It will include indicators for evaluating and assessing the effectiveness of plan implementation.

6.2. CONSTITUENTS TO BE MONITORED AND MEASUREMENT TECHNIQUES

Monitoring will consist of in-field measurements of water quality including: temperature, dissolved oxygen (DO), pH, conductivity, total dissolved solids, and alkalinity. Water temperature and DO will be measured with a YSI multi-meter. Specific conductance, pH, and TDS will be measured with a Hanna multi-meter. Alkalinity will be measured with a LaMotte field test kit.

The aquatic benthic macroinvertebrate (BMI) community will be assessed through specimen collection and laboratory identification. BMIs will be collected in a D-frame kick net and sent to the CDFG ABL for processing.

Physical attributes of the stream channel and the riparian vegetation community will be evaluated through measurements and visual assessment. Additional resources throughout the watershed shall be assessed based on existing information (e.g., reports, etc.) aerial photography, and site reconnaissance and windshield surveys.

6.3 PROJECT SCHEDULE

See Table 3 below.

Table 3
Element 6: Project Schedule Timeline

Activity	Date (MM/DD/YY)		Deliverable	Deliverable Due Date
	Anticipated Date of Initiation	Anticipated Date of Completion		
Task 1: Project Administration	Jan 2007	June 2009	DWR-City Grant Agreement consultants selected; consultant agreement executed	NA
	ongoing	ongoing	Monthly progress reports (34)	15th of each month
Task 2: Environmental Permits	Jan 2007	March 2007	Categorical Exemption CDFG permit	4/15/07
Task 3: Monitoring Plan/QAPP	Jan 2007	March 2007	Monitoring Plan and QAPP	4/15/07
Task 4: Evaluation Plan	Jan 2007	March 2007	Evaluation Plan	4/15/07
Task 5: Stakeholder Process	ongoing	ongoing	Publish 1st Project Fact Sheet (1 of 4)	6/15/07
	Feb 2007	March 2007	Establish Stakeholder Advisory Group Mission/vision, goals and meeting agendas and minutes	3/15/07
Task 6: Watershed Assessment	Jan 2008	Feb 2008	California Watershed Assessment Manual review and discussion	NA
	April 2007	May 2007	Field trips/watershed tours presentations to stakeholder group by Technical Consultant Team	NA
	April 2007	May 2007	Refined goals/objectives	NA

Table 3 Element 6: Project Schedule Timeline				
Activity	Date (MM/DD/YY)		Deliverable	Deliverable Due Date
	Anticipated Date of Initiation	Anticipated Date of Completion		
	April 2007	May 2007	Conceptual model	NA
	March 2007	May 2007	Tech Memo containing WS Assessment Plan	5/15/07
	March 2007	Oct 2007	Lab reports, field reports/notes (to be included in 6.10 tech memo)	Fall 2007
	April 2007	July 2007	Hydrologic modeling results to be included in 6.10 tech memo	NA
	Aug 2007	March 2008	Results of evaluation of potential new development impacts to be included in 6.10 tech memo	NA
	March 2007	March 2008	Tech Memo describing WS Assessment findings	6/15/08
Task 7: Watershed Management Plan	March 2008	April 2008	'Long' list of action options	NA
	April 2008	May 2008	Methodology, screening criteria	NA
	May 2008	May 2008	'Short' list of ranked options	NA
	May 2008	June 2008	Relative costs, potential sources of funding and stakeholder roles, and schedule information	NA
	May 2008	June 2008	Draft Tech Memo w/ recommended actions	NA
	July 2008	Aug 2008	Comments by tech advisors	NA
	Aug 2008	Sept 2008	Final tech memo	NA
	Sept 2008	Feb 2009	Draft WS Management Plan	Fall 2008
	Feb 2009	April 2009	Final WS Management Plan	6/15/09
	April 2009	May 2009	Presentation materials, meeting agendas	Spring 2009
Task 8: Reporting	ongoing	ongoing	Monthly Progress Reports (34)	15th of the month
	NA	NA	Annual reports	NA
	May 2009	June 2009	Final report	6/15/09

6.4 GEOGRAPHICAL SETTING

The Alder Creek watershed is located south of the city of Folsom and east of Lake Natoma in Sacramento County. Alder Creek originates on the western slope of the Sierra Nevada foothills (maximum elevation approximately 600 feet), southeast of Folsom. From its headwaters, the creek flows in a northwest direction approximately 15 miles until it enters the American River at Lake Natoma (Folsom Lake Recreation Area). The project includes the upper and lower watershed and the GPS center point of reference is: 38°38'19' N, 121°12'20 W.

6.5 CONSTRAINTS

Historically, there has not been a dedicated stakeholders group reflective of all current and future watershed interests. In 2002, representatives from various stakeholder organizations began meeting regularly to discuss water quality concerns and restoration strategies. Known as the Alder Creek Coalition, they submitted a grant proposal for creek restoration; however, the funds were not allocated and the group lost momentum. Subsequently, development plans have proceeded for projects within the watershed.

Comprehensive data on the watershed is limited. Project-related data has been collected over the past several years; however, none of this information is on a watershed-level scale. Therefore, the available data will be synthesized and used where possible, and comprehensive field data will be collected to generate baseline conditions for the watershed.

Time is a constraint for this project as development plans for areas within the watershed have already been drafted. The potential impending large-scale development creates an urgent need to develop a community-based vision for the watershed before development projects dictate land use. Site access to many areas may be difficult as much of the watershed is owned by private entities. This may also serve as a constraint to implementing and maintaining restoration projects.

7. QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

7.1 DATA QUALITY OBJECTIVES

Table 4
Element 7: Measurements and DQOs

Measurement or Analyses Type	Applicable Data Quality Objective
Temperature	Accuracy, Precision, Completeness
DO	Accuracy, Precision, Completeness
pH	Accuracy, Precision, Completeness
Conductivity	Accuracy, Precision, Completeness
Total Dissolved Solids	Accuracy, Precision, Completeness
Alkalinity	Accuracy, Precision, Completeness

DQO’s will be determined through SWAMP guidelines.

Table 5
Element 7: DQOs for Field Measurements

Group	Parameter	Units	Accuracy	Precision	Target reporting limit	Completeness
Field Testing	Dissolved Oxygen	mg/L	±0.5 mg/L	± 0.5	NA	90%
	Temperature	°C	± 0.5°C	± 0.5°C	NA	90%
	pH	pH units	± 0.5 units	± 0.5 units	NA	90%
	Conductivity	µs	± 5%	± 5%	NA	90%
	Alkalinity	mg/L	± 25%	± 20%	NA	90%
	TDS	mg/L	±0.5 mg/L	± 0.5	NA	90%

Table 6
Element 7: DQOs for Laboratory Measurements

Parameter	Method/range	Units	Detection Limit	Sensitivity	Precision	Accuracy	Completeness
Benthic Macroinvertebrates	California Stream Bioassessment Procedure	NA	Family level, to species level when possible	NA	NA	NA	100%

8. SPECIAL TRAINING NEEDS/CERTIFICATION

8.1 SPECIALIZED TRAINING OR CERTIFICATIONS

Field biologists performing aquatic biological assessments have California stream bioassessment training. The CDFG Aquatic Bioassessment Laboratory (ABL) will be utilized for aquatic invertebrate sample processing and analysis. All new ABL staff members are trained by experienced members or by project managers. Before each field season, all staff members are involved in training sessions to review protocols used in physical habitat, chemical and biological surveys. These training sessions involve practice sampling and habitat assessment. Most of the ABL taxonomists in the lab have graduate degrees (M.S. or Ph.D.) in entomology or ecology, and have many years of experience in invertebrate taxonomy and identification. Lab technicians receive training and direct oversight from taxonomists.

No additional training will be necessary for personnel involved in this project. However, if the need does arise to provide training, the Quality Assessment Officer will be responsible for oversight.

9. DOCUMENTS AND RECORDS

All field results will be recorded during sampling, using the field data sheets (see Appendix 1). Data sheets will be reviewed for outliers and omissions before leaving the sample site. Data sheets will be stored in hard copy form at the EDAW office in Sacramento, and scanned into pdf format and catalogued electronically as well. Data will be entered into electronic spreadsheets (Microsoft Excel) and will be stored in digital form in the EDAW office. Updated QAPP information will be distributed to project staff and appropriate persons by the project manager.

GROUP B: DATA GENERATION AND ACQUISITION

10. SAMPLING PROCESS DESIGN

Only in recent years, with encouragement from the U.S. Environmental Protection Agency (EPA), have states started to collect adequate data on the physical and biological health of water bodies. In 1993, California initiated the first step in developing a state-wide bioassessment program by introducing the California Stream Bioassessment Procedure (CSBP). The CSBP is a standardized protocol for assessing biological and physical/habitat conditions of wadable streams in California, and is a regional adaptation of the national Rapid Bioassessment Protocols outlined by the EPA (EPA 841-D-97-002). The CSBP is a cost-effective tool that utilizes measures of a stream's BMI community and its physical/habitat characteristics to determine the stream's biological and physical integrity. BMIs can have a diverse community structure with individual species residing within the stream for a period of months to several years. They are also sensitive in varying degrees to temperature, dissolved oxygen, sedimentation, scouring, nutrient enrichment and chemical and organic pollution. Biological and physical assessment measures integrate the effects of water quality over time, are sensitive to multiple aspects of water and habitat quality and can provide the public with a familiar expression of ecological health. Now in its third edition, the CSBP is recognized as California's standard protocol for conducting physical and biological surveys, and forms the basis of California's effort to develop a state-wide bioassessment program (Davis et al. 1996).

Field sampling will take place at various locations within the Alder Creek watershed to characterize aquatic and riparian habitats, aquatic community (i.e., BMIs) and physical composition (i.e., bioassessments), hydrogeomorphic functioning of the stream channel, water quality, and the flood variations of the creek. The primary goal in selecting sampling sites is to represent the major stream reaches, vegetation zones, stream orders, and elevations within the watershed. Field sampling will be limited to selected stream reaches for water quality and bioassessment sample collection. Data collection protocols will be consistent with the CSBP, the Surface Water Ambient Water Monitoring Program (SWAMP) being developed by CDFG for the Regional Water Quality Control Board for low gradient urban streams as well as other commonly used survey protocols such as the California Native Plant Society (CNPS) Rapid Assessment protocol. Sample sites from the upper, middle, and lower portions of the watershed will be used to generate a broad understanding of conditions. In accordance with CDFG's ABL standard operating procedures (SOPs) for data collection, 150 meter stream reaches broken up into 11 equidistant transects arranged perpendicular to the direction of flow, will be sampled. At each transect, a 1 square foot area will be sampled for BMIs. All samples will be composited to comprise one BMI sample for the stream reach.

The following criteria will be evaluated in choosing sampling locations:

- access is safe,
- permission to cross private property is granted,
- sample is representative, and
- location complements or supplements historical data.

Reference sites will be sampled as ‘controls’ for comparison purposes. These locations will be chosen upstream of potentially impacted areas to avoid contamination of samples. Inflow from adjacent land uses, tributaries, and heavily modified sites will all be treated as impacted areas and will be sampled for comparison with reference sites.

Prior to final site selection, permission to access the stream will be obtained from the property owner(s). If access to the site is not possible, another suitable site will be selected.

11. SAMPLING METHODS

For this project, sample collection will be limited to BMIs that will be placed in plastic jars filled with 90% ethyl alcohol and delivered to the CDFG ABL. This sampling effort will adhere to SOPs for collecting benthic macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California, prepared by CDFG’s ABL (CDFG ABL 2006). Sampling locations have yet to be determined.

Once a sample site has been selected, it will be divided and marked into 11 equidistant transects perpendicular to the stream flow. Upon arrival at the sampling site, the reach documentation section of the field forms (site and project identification, stream and watershed name, crew members, date/time, and GPS coordinates) will be completed. Initial survey observations will be made from the stream banks, making sure not to disturb the instream habitat. Ambient water chemistry data is measured (pH, DO, conductivity, total dissolved solids (TDS), water temperature) with either a YSI 55 multi-meter or a Hanna HI 98129 multi-meter and recorded at the downstream end of the reach. Alkalinity is measured using a LaMotte WAT-DR field test kit. Photographs are taken from the upstream end of the reach looking downstream, from the center of the reach looking both up and downstream, and from the downstream end of the reach facing upstream. Dominant land use/cover will be recorded for the 50 meters on either side of each transect and evidence of disturbance (flooding, fire, etc.) will also be documented.

Biological samples will be collected before any other physical habitat measures to avoid disturbing the substrate. Benthic macroinvertebrates will be collected using the multiple habitat composite (MHC) method. A 500 µ mesh D-frame net is placed on the downstream end of a selected 1 ft^2 area. The sample area is disturbed by reaching into the substrate by hand and removing attached materials from rocks and allowing drift that is dislodged to be carried into the net by the current or with the collector’s foot if water depth is substantial. See SOPs for the CDFG ABL’s invertebrate collection procedures (Appendix 2) for full details.

12. SAMPLE HANDLING AND CUSTODY

Samples will be collected in appropriately labeled plastic containers and sealed. Identification information for each sample will be recorded on the field data sheets (see Appendix 2) when the sample is collected. Samples that are not processed immediately in the field (BMIs) will be labeled with the water body name, sample location, sample number, date and time of collection, and sampler’s name. BMI samples will be placed in plastic jars filled with 90% ethyl alcohol and labeled appropriately in accordance with standard operating procedures from the CDFG ABL CSBP. Samples will be held by EDAW until delivered to the ABL for analysis. The conventional water quality monitoring tests do not require specific custody procedures because they will, in most cases, be conducted immediately by the same person who performs the sampling.

When samples are transferred from one institution to another, a Chain of Custody form will be used. This form identifies the water body name, sample location, sample number, date and time of collection, sampler’s name, and method used to preserve sample (if any). It also indicates the date and time of transfer, the name and signature of the sampler, and the sample recipient. In cases where the sample remains in the custody of the monitoring organization, then the field data sheet may be allowed to double as the chain of custody form. It is recommended that when a sample leaves the custody of the monitoring group, then the Chain of Custody form used be the one provided by the outside professional laboratory. Similarly, when quality control checks are performed by a professional lab, their samples will be processed under their chain of custody procedures with their labels and documentation procedures. For benthic macroinvertebrate samples, the CDFG Aquatic Bioassessment Laboratory Chain of Custody form (Appendix 3) will be used.

The ABL procedure for chain of custody (COC) for samples taken by any agency or organization other than the ABL is listed below:

> Samples delivered from other agencies/organizations must be accompanied by a COC form at the time of delivery, and must contain the following information in addition to that listed above:

1. The name of the agency that completed the original sampling, the name of that agencies’ project advisor, the name of at least one crew member that participated in sampling, and address/telephone numbers for both.

2. A list of sample ID numbers (if ID numbers have been assigned by the originating agency; otherwise, ID numbers are assigned to each sample during sample log in.

Upon transfer of samples, the presence of each sample listed on the COC form is verified by ABL staff. After verification, the relinquisher signs and dates that portion of the COC form titled ‘Relinquished by’ and the ABL lab technician signs and dates the section titled ‘Received by’ to complete this stage of the COC procedure.

All COC forms are kept in a clearly marked file folder in the general files of the ABL. Three separate COC files have been established as follows:

1. QA-QC projects
2. enforcement cases
3. standard ambient bioassessment projects

At all times, the original COC will accompany the samples. Once subsampling has been completed, the original COC accompanies the sampled macroinvertebrates, and a photocopy of the COC will remain with the original samples and sampling remnants. Any time a sample or set of samples is removed from the lab for any reason, the transfer is noted on the appropriate COC, including the date and person responsible for transfer.

13. ANALYTICAL METHODS

Table 7
Element 13: Field Analytical Methods

Analyte	Laboratory / Organization	Project Action Limit (units, wet or dry weight)	Project Quantitation Limit (units, wet or dry weight)	Analytical Method		Achievable Laboratory Limits	
				Analytical Method/ SOP	Modified for Method yes/no	MDLs (1)	Method (1)
pH	EDAW field biologists	NA	pH units	HI 98120 multi-meter	No	NA	NA
DO	EDAW field biologists	NA	mg/L	YSI 55 multi-meter	No	NA	NA
Temperature	EDAW field biologists	NA	°C	YSI 55 multi-meter	No	NA	NA
Conductivity	EDAW field biologists	NA	µS	HI 98120 multi-meter	No	NA	NA
TDS	EDAW field biologists	NA	mg/L	HI 98120 multi-meter	No	NA	NA
Alkalinity	EDAW field biologists	NA	mg/L	LaMotte 4491-DR field test kit	No	NA	NA
Benthic Macroinvertebrates	EDAW field biologists	NA	NA	SOP’s CDFG ABL, 2006	No	NA	NA

(*) *Standard Methods for the Examination of Water and Wastewater*, 20th edition.

Table 8 Element 13: Laboratory Analytical Methods						
Analyte	Laboratory/ Organization	Project Action Limit (units, wet or dry weight)	Analytical Method		Achievable Laboratory Limits	
			Analytical Method/ SOP	Modified for Method yes/no	MDLs (1)	Method (1)
Benthic Macroinvertebrates	CDFG ABL	NA	SOP's CDFG ABL, 2006	None	Not applicable	Not applicable

14. QUALITY CONTROL

Quality control samples will be taken to ensure valid data are collected. Depending on the parameter, quality control samples will consist of repeated sampling and occasionally with multiple instruments. In addition, quality control sessions (a.k.a. intercalibration exercises) will be held annually to verify the proper working order of equipment and determine whether the data quality objectives are being met.

Replicate Samples: Replicate samples are two or more samples collected at the same time and place. When there are only two replicates, these are referred to as duplicates. Duplicate samples will be collected as soon as possible after the initial sample has been collected, and will be subjected to identical handling and analysis.

Parameter	Blank	Duplicate Sample	Split Sample to lab	QC session
temperature	none	5% or a minimum of once a year	none	once a year
dissolved oxygen	none	5% or a minimum of once a year	none	once a year
pH	none	5% or a minimum of once a year	none	once a year
conductivity	daily	5% or a minimum of once a year	none	once a year
alkalinity	daily	5% or a minimum of once a year	none	once a year

15. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Before each use, conductivity, DO, temperature, TDS, and pH meters are checked to see if they are clean and in good working order. The YSI 55 meter and Hanna 98129 meter are calibrated before use each sample day. pH buffers are for single use only and are not to be re-used. Consumables such as pH buffer solution, DO sensor membranes and alkalinity solutions are periodically assessed and replaced.

Table 9
Element 15: Testing, Inspection, Maintenance of Sampling Equipment

Equipment/Instrument	Maintenance Activity, Testing Activity or Inspection Activity	Responsible Person	Frequency	SOP Reference
Temperature/YSI 55 meter Dissolved Oxygen/YSI 55 meter	rinse probe with water between uses and before storage. Membranes to be replaced as needed	Chris Fitzer, EDAW	rinse before and after each use and before storage. Membrane replacement as needed	YSI 55 operations manual
pH/Hanna multi meter Electrical Conductivity/ Hanna multi-meter Total Dissolved Solids/ Hanna Multi-meter	rinse electrode with water, store with a few drops of storage (HI 70300) solution on electrode	Chris Fitzer, EDAW	before and after each use	HI 98129 instruction manual
Alkalinity/ LaMotte field test kit	inspect vial, syringe, wash materials	Chris Fitzer, EDAW	each use	LaMotte operations manual

The following field equipment and inspection schedule is required for bioassessment:

Equipment Item	**Inspection Schedule**
D-shaped Kick Net (0.5mm mesh)	prior to each sampling event
wide-mouth Plastic Jars	prior to each sampling event
measuring Tape (100 meter)	prior to each sampling event
pencils/Permanent Markers	prior to each sampling event
flagging	prior to each sampling event
forceps	prior to each sampling event
water-proof Paper	prior to each sampling event
YSI-85 Meter	prior to each sampling event
pH and conductivity Meter	prior to each sampling event
alkalinity test kit	prior to each sampling event
thermometer	prior to each sampling event
flow Meter	prior to each sampling event
GPS Unit	prior to each sampling event
digital Camera	prior to each sampling event
stadia Rod	prior to each sampling event

16. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Table 10
Element 16: Calibration of Sampling Equipment

Parameter/ Instrument	SOP reference	Calibration Description and Criteria	Frequency of Calibration	Responsible Person
Temperature/YSI 55 meter Dissolved Oxygen/YSI 55 meter	YSI 55 operations manual	manual calibration following procedure outlined in manual	before each use	Chris Fitzer, EDAW
pH/Hanna multi meter Electrical Conductivity/ Hanna multi-meter Total Dissolved Solids/Hanna Multi-meter	HI 98129 instruction manual	calibration done manually with the electrode submerged in a standardized buffer solution	every sample day	Chris Fitzer, EDAW
Alkalinity/ LaMotte field test kit	LaMotte operations manual	NA	NA	Chris Fitzer, EDAW

17. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Consumables needed for this project include pH buffer solutions, dissolved oxygen sensor membranes, and solutions that are part of the LaMotte alkalinity test kit.

Table 11
Element 17: Inspection/Acceptance Testing Requirements for Consumables and Supplies

Project-Related Supplies/Consumables	Inspection/Testing Specifications	Acceptance Criteria	Frequency	Responsible Individual
LaMotte alkalinity titration reagent	date of manufacture, shelf life	2 year shelf life	Once a year	Chris Fitzer, EDAW
LaMotte alkalinity indicator tablets	date of manufacture, shelf life	2 year shelf life	Once a year	Chris Fitzer, EDAW
Hanna HI 70300 storage solution	date of manufacture, shelf life	2 year shelf life	Once a year	Chris Fitzer, EDAW

18. NON-DIRECT MEASUREMENTS (EXISTING DATA)

EDAW's team will collect and utilize existing information where possible. The team will, review available existing data and literature, including aerial photography and GIS data, biological resources assessment and watershed analysis by GenCorp for the Easton development, physical survey and BMI data from CDFG, creek flood stage data, CDFG's California Natural Diversity Data Base (CNDDB), the CNPS Inventory of Rare and

Endangered Plants of California, and other existing data sets to identify data gaps and determine the need for additional field data to adequately characterize baseline physical and biological characteristics within the Alder Creek Watershed. This information will help to understand the geography of the watershed, its boundaries, land use characteristics, and biological health. Maps and figures will be generated to characterize vegetation communities, habitat type and integrity, and threats from encroaching development activities.

19. DATA MANAGEMENT

Field data collected by EDAW biologists will be recorded on standardized field data collection forms. Forms will be compiled in the EDAW Sacramento office, scanned into pdf file format, and raw numbers will be input into Microsoft Excel spreadsheets. BMI samples will be delivered by EDAW biologists to the CDFG ABL in Sacramento County. CDFG will analyze the samples and send (via email) excel spreadsheets containing the BMI taxa list to the same EDAW biologists who collected the samples. Data sheets will be compiled electronically and will be utilized in technical memoranda and report preparation by EDAW staff.

Standardized data collection, GIS, fieldwork, and data management protocols will be used to ensure consistency and compatibility of data with other data collected in the watershed and throughout the region.

GROUP C: ASSESSMENT AND OVERSIGHT

20. ASSESSMENTS AND RESPONSE ACTIONS

One of the project goals will be to establish a stakeholder advisory team comprised of staff from government entities, businesses with interests in the Alder Creek watershed, watershed landowners and residents, and regional environmental groups. The goal will be to conduct an interest-based planning process whereby the assessment work and final WMP reflect the interests of the stakeholders. This will help ensure ownership of a feasible, implementable WMP and long-term sustainability of the document and relationships between watershed stakeholders. The advisory group will oversee the assessment and preparation of the WMP and other documents prepared during the project timeline.

21. REPORTS TO MANAGEMENT

EDAW will prepare monthly progress reports in DWR-specified format. A draft alternatives analysis technical memorandum will be written in spring 2008. A draft WMP will be written in 2008/2009 and a draft project report for client review summarizing the results of all activities will be provided to the City of Folsom in the spring of 2009. A final project report based on comments received from the City of Folsom, DWR, and other agencies.

Table 12
Element 21: QA Management Reports

Type of Report	Frequency (daily, weekly, monthly, quarterly, annually, etc.)	Projected Delivery Dates(s)	Person(s) Responsible for Report Preparation	Report Recipients
Progress Report	Monthly	15th of each month	Carmel Brown	Megan Fidell
Alternatives Analysis Technical Memorandum	NA	April 2008	Debra Bishop	Carmel Brown / Megan Fidell
Draft Progress Report	NA	Spring 2009	Debra Bishop	Carmel Brown / Megan Fidell
Draft Final Progress Report	NA	June 30, 2009	Debra Bishop	Carmel Brown / Megan Fidell
Draft Watershed Management Plan	NA	September 1, 2008	Debra Bishop	Carmel Brown / Megan Fidell
Draft Final Watershed Management Plan	NA	February 1, 2009	Debra Bishop	Carmel Brown / Megan Fidell

GROUP D: DATA VALIDATION AND USABILITY

22. DATA REVIEW, VERIFICATION, AND VALIDATION REQUIREMENTS

The California Stream Bioassessment Protocol is designed to produce consistent, random samples of BMIs. It is important to prevent bias in transect placement.

Data sheets or data files will be reviewed quarterly by the technical advisors to determine if the data meet the QAPP objectives. The technical advisors will identify outliers, spurious results or erroneous trends in collected data; they will also evaluate compliance with the data quality objectives and suggest corrective action that will be implemented by the field biologists. Problems with data quality and corrective action will be addressed in final reports.

23. VERIFICATION AND VALIDATION METHODS

EDAW biologists will be present when field data are collected. As data is recorded it will be scrutinized to be sure that it is within an expected range of values. Values are often generated by one individual and recorded by another; therefore the recorder is able to act as a quality control measure. Data is checked again as it is entered into the digital database. If data is erroneous and not usable, a subsequent site visit will be made to collect data. Old data will be classified as invalid and data users will be notified.

Internal QC is conducted by ABL taxonomists on samples that have been processed by the ABL itself. Internal QC procedures target two specific stages of sample processing: the subsampling (‘picking’) stage and the identification stage.

Subsampling QA (Remnant Evaluation): All remnant samples from every project are examined by a QC taxonomist at the time subsampling is completed. These samples are examined for organisms that may have been overlooked during subsampling. The number of unpicked BMI’s (if any) and their identity is recorded in the ABL Quality Control Worksheet. For subsamples containing 300 or more organisms, the remnant sample should contain fewer than 10% of the total organisms subsampled. The remnant should contain fewer than 30 organisms for samples containing fewer than 300 organisms. If these criteria are not met, then corrective action is initiated.

Internal Taxonomic Identification QA: Taxonomic identifications are evaluated by the ABL’s QC taxonomist with the goal of checking the accuracy and consistency of individual taxonomists. Ten percent of the samples from any given project are randomly selected and then checked for taxonomic accuracy. All taxa from each of the randomly selected samples are re-identified by the QC taxonomist, and the number of specimens in each vial is re-checked. Any errors in taxonomy, including misidentification, multiple taxa per vial, counting error and deviation from standard taxonomic effort are recorded in spreadsheet form, and then are analyzed with QC MANAGER, an ACCESS© program that summarizes the types of discrepancy and their frequencies. If a taxonomist is discovered to consistently misidentify a particular taxon, that person will receive instruction from the QC taxonomist about how to properly identify specimens in that group, and all future ID's involving that taxon will be checked until the problem is resolved.

24. RECONCILIATION WITH USER REQUIREMENTS

The Technical Advisory Committee (TAC) working with the monitoring leader(s) will review data annually to determine if the data quality objectives (DQOs) have been met. A quorum of 1/2+1of the TAC will be required for committee decisions. If a quorum is not met at the meeting, work will still proceed. The work product (e.g., review and comments on data or reports) will then be sent to the TAC for approval within a 30-day review period.

If data do not meet the project's specifications, the following actions will be taken. First, the technical advisors working with the monitoring leader(s) will review the errors and determine if the problem is equipment failure, calibration/maintenance techniques, or monitoring/sampling techniques. They will suggest corrective action. If the problem cannot be corrected by training, revision of techniques, or replacement of supplies/equipment, then the technical advisors and the TAC will review the DQOs and determine if the DQOs are feasible. If the specific DQOs are not achievable, they will determine whether the specific DQO can be relaxed, or if the parameter should be eliminated from the monitoring program. Any revisions to DQOs will be appended to this QA plan with the revision date and the reason for modification. The appended QAPP will be sent to the quality assurance panel that approved and signed this plan. When the appended QAPP is approved, the citizen monitoring leader will work with the data coordinator to ensure that all data meeting the new DQOs are entered into the database. Archived data can also be entered.

APPENDIX 1

Field Data Sheet

REACH DOCUMENTATION

Standard Reach Length (wetted width ≤ 10 m) = 150 m Distance between transects = 15 m
Alternate Reach Length (wetted width >10 m) = 250 m Distance between transects = 25 m

Project Name:	Date:	Time:
Stream Name:	Site Name/ Description:	
Site Code:	Crew Members:	
Latitude: ºN	datum: NAD27 NAD83	
Longitude: ºW		

AMBIENT WATER QUALITY MEASUREMENTS

Temperature (°C)		pH		Alkalinity (mg/L)		Turbidity (optional)	
Dissolved O_2 (mg/L)		Specific Cond. (µs)		Salinity (ppt)		Silica (optional)	

REACH LENGTH

150 m		Other	
Actual Length (m)			
Explanation:			

PHOTOGRAPHS:

A (up): ☐	F (up): ☐	F (down): ☐	K (down): ☐
Additional Photographs (optional):	A (down): ☐	K (up): ☐	Others:

DISCHARGE MEASUREMENTS (first measurement = left bank)

check if measurement not possible ☐

VELOCITY AREA METHOD (preferred) — Transect Width:

	Distance from Bank (cm)	Depth (cm)	Velocity (m/sec)		Distance from Bank (cm)	Depth (cm)	Velocity (m/sec)
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

BUOYANT OBJECT METHOD

	Float 1	Float 2	Float 3
Distance			
Float Time			

Float Reach Cross Section

width (m) depth (cm)	Upper Section	Middle Section	Lower Section
Width			
Depth 1			
Depth 2			
Depth 3			
Depth 4			
Depth 5			

NOTABLE FIELD CONDITIONS (check one box per topic)

Evidence of recent rainfall (enough to increase surface runoff)	NO		minimal		>10% flow increase	
Evidence of fires in reach or immediately upstream (<500 m)	NO		< 1 year		< 5 years	
Dominant land use/ land cover in area surrounding reach	Agriculture		Forest		Rangeland	
	Urban/ Indus		Suburb/Town		Other	

Site Code:	Date: __ __ / __ __ / __ __ __ __

SLOPE and BEARING FORM (transect based - for Full PHAB only)

CL=clionometer **OT**=other **TR**=autolevel **HL**=handlevel		MAIN SEGMENT					SUPPLEMENTAL SEGMENT				
Transect	**Method**	**Slope (%) or Elevation Difference (cm)**		**Segment Length (m)**	**Bearing (0°-359°)**	**Propor-tion (%)**	**Slope (%) or Elevation Difference (cm)**		**Segment Length (m)**	**Bearing (0°-359° C)**	**Propor-tion (%)**
K-J	CL TR HL OT		% cm					% cm			
J-I	CL TR HL OT		% cm					% cm			
I-H	CL TR HL OT		% cm					% cm			
H-G	CL TR HL OT		% cm					% cm			
G-F	CL TR HL OT		% cm					% cm			
F-E	CL TR HL OT		% cm					% cm			
E-D	CL TR HL OT		% cm					% cm			
D-C	CL TR HL OT		% cm					% cm			
C-B	CL TR HL OT		% cm					% cm			
B-A	CL TR HL OT		% cm					% cm			

REACH SLOPE (BASIC version only, use as many segments as needed)								**METHOD**	CL		HL		TR	HL	
SEGMENT 1		**SEGMENT 2**		**SEGMENT 3**		**SEGMENT 4**		**SEGMENT 5**			**SEGMENT 6**				
Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)		Slope (%) or Elevation Difference (cm)			Slope (%) or Elevation Difference (cm)				
	% cm		% cm		% cm		% cm			% cm					% cm

ADDITIONAL HABITAT CHARACTERIZATION

Parameter	Optimal	Suboptimal	Marginal	Poor
Epifaunal Substrate/ Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover (50% for low-gradient streams); mix of submerged logs, undercut banks, cobble or other stable habitat	40-70% mix of stable habitat (30-50% for low-gradient streams); well-suited for full colonization potential	20-40% mix of stable habitat (10-30% in low-gradient streams); substrate frequently disturbed or removed	Less than 20% stable habitat (10% in low-gradient streams); lack of habitat is obvious; substrate unstable or lacking
Score:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition (>20% in low-gradient streams)	Some new increase in bar formation, mostly from gravel, sand, or fine sediment; 5-30% of the bottom affected (20-50% in low-gradient streams)	Moderate deposition of new gravel, sand, or fine sediment on bars; 30-50% of the bottom affected (50 - 80% in low-gradient streams)	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently (>80% in low-gradient streams)
Score:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern	Some channelization present, (e.g., bridge abutments); evidence of past channelization (> 20yrs) may be present but recent channelization not present	Channelization may be extensive: embankments or shoring structures present on both banks; 40 to 80% of stream reach disrupted	Banks shored with gabion or cement; Over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely
Score:	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

SWAMP Stream Habitat Characterization Form *FULL VERSION* *Original Issue Date: March 1, 2007*

Site Code:	Site Name:	Date: __ __ / __ __ / __ __ __ __

Wetted Width (m):	Bankfull Width (m):	Bankfull Height:	**Transect:**

TRANSECT SUBSTRATES				**Cobble Embed (%)**
Position	**mm or Size Class**	**Depth (cm)**	**CPOM**	
L Bank			P A	
LeftCtr			P A	
Center			P A	
RightCtr			P A	
R Bank			P A	

BANK STABILITY 5m up and 5m downstream of transect and from bankfull to wetted width			
Left Bank	eroded	vulnerable	stable
Right Bank	eroded	vulnerable	stable

HUMAN INFLUENCE

0 = Not Present CH - Within Channel B = On Bank
C = Between Bank and 10 m from Channel P = >10 m and <50 m of Channel

	Left Bank	**Channel**	**Right Bank**
Walls/ Rip-rap/ Dams	0 B C P	CH	0 B C P
Buildings	0 B C P	CH	0 B C P
Pavement/ Cleared Lot	0 B C P		0 B C P
Road/ Railroad	0 B C P	CH	0 B C P
Pipes (Inlet/ Outlet)	0 B C P	CH	0 B C P
Landfill/ Trash	0 B C P	CH	0 B C P
Park/ Lawn	0 B C P		0 B C P
Row Crops	0 B C P		0 B C P
Pasture/ Range	0 B C P		0 B C P
Logging Operations	0 B C P		0 B C P
Mining Activity	0 B C P	CH	0 B C P
Vegetation Management	0 B C P		0 B C P
Bridges/Abutments	0 B C P	CH	0 B C P
Orchards/ Vineyards	0 B C P		0 B C P

RIPARIAN VEGETATION (downstream)

0 = Absent (0%) 3 = Heavy (40-75%)
1 = Sparse (<10%) 4 = Very Heavy>75%)
2 = Moderate (10-40%) **circle one**

Vegetation Class	**Left Bank**	**Right Bank**
Upper Canopy (>5 m high)		
Trees and saplings >5 m high	0 1 2 3 4	0 1 2 3 4
Lower Canopy (0.5 m-5 m high)		
Woody shrubs and saplings 0.5 m to 5 m	0 1 2 3 4	0 1 2 3 4
Ground Cover (<0.5 m high)		
Woody shrubs and saplings <0.5 m	0 1 2 3 4	0 1 2 3 4
Herbs/ grasses	0 1 2 3 4	0 1 2 3 4
Barren, bare soil/ duff	0 1 2 3 4	0 1 2 3 4

INSTREAM HABITAT COMPLEXITY

0 = Absent (0%)
1 = Sparse (<10%)
2 = Moderate (10-40%)
3 = Heavy (40-75%)
4 = Very Heavy (>75%)

Filamentous Algae	0 1 2 3 4
Aquatic Macrophytes/ Emergent Vegetation	0 1 2 3 4
Boulders	0 1 2 3 4
Woody Debris >0.3 m	0 1 2 3 4
Woody Debris <0.3 m	0 1 2 3 4
Undercut Banks	0 1 2 3 4
Overhang. Vegetation	0 1 2 3 4
Live Tree Roots	0 1 2 3 4
Artificial Structures	0 1 2 3 4

DENSIOMETER READINGS (0-17)
count covered dots

Center Left	
Center Upstream	
Center Downstream	
Center Right	

Inter-transect:
not needed for last transect

indicate upper/ lower transects		Wetted Width (m):

FLOW HABITATS (% between transects, T=100%)

Channel Type	**%**
Cascade/ Fall	
Rapid	
Riffle	
Run	
Glide	
Pool	
Dry	

INTER-TRANSECT SUBSTRATES (measure in mm or use size classes)

Position (%)	**mm or Size Class**	**Depth (cm)**	**CPOM**
L Bank			P A
LeftCtr			P A
Center			P A
RightCtr			P A
R Bank			P A

Note: Substrate sizes can be recorded either as direct measures of the median axis of each particle or one of the size classes listed to right

SUBSTRATE SIZE CLASS CODES

RS = bedrock smooth (>car)
RR = bedrock rough (> car)
RC = concrete/asphalt
XB = large boulder (1-4 m)
SB = sml blder (.25 m-1 m)
CB = cobble (64-250 mm)
GC = coarse gravel (16-64 mm)
GF = fine gravel (2-16 mm)
SA = sand (0.06-2 mm)
FN = fines (<0.06 mm)
HP = hardpan (consol fines)
WD = wood
OT = other

CPOM/ COBBLE EMBEDDEDNESS

CPOM: Record presence (P)/ absence (A) of coarse particulate organic matter (>1.0 mm) within 1 cm of each particle.

Cobble Embeddedness: visually estimate % embedded by fine particles (record to nearest 5%)

Site Code:	Date: __ __ / __ __ / __ __ __ __	FULL FORM

Site Map:

Field Notes/ Comments:

APPENDIX 2

SOP's For CDFG ABL Bioassessment

SWAMP
Surface Water Ambient Monitoring Program

SWAMP Bioassessment Procedures 2007

Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California

February 2007

CALIFORNIA Water Boards

www.waterboards.ca.gov/swamp

Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California

Prepared by: ______________________ Peter Ode, SWAMP Bioassessment Coordinator, California Department of Fish and Game, Aquatic Bioassessment Laboratory

Preparation Date: January 23rd 2007

Approved by: ______________________ Beverly van Buuren, SWAMP QA Officer

Approval Date: 01/17/07

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ACKNOWLEDGEMENTS A

The protocols described here represent the contributions of a wide range of researchers and field crews. Most of the physical habitat methods are close modifications of those used in the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring and Assessment Program (EMAP) and developed by EPA's Office of Research and Development (ORD, Peck et al. 2004). The benthic macroinvertebrate collection methods are based on EMAP methods (EPA's targeted riffle methods were derived in turn from methods developed at Utah State University; Hawkins et al. 2003).

The current version of these protocols was established by Peter Ode (Department of Fish and Game's (DFG's) Aquatic Bioassessment Laboratory (ABL)) and David Herbst (UC Santa Barbara's Sierra Nevada Aquatic Research Laboratory) with significant contributions from staff at the ABL (Jim Harrington, Shawn McBride, Doug Post, Andy Rehn, and Jennifer York), the Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance (QA) Team, Thomas Suk and other members of the SWAMP bioassessment committee (Mary Adams, Lilian Busse, Matt Cover, Robert Holmes, Sean Mundell, and Jay Rowan) and three external reviewers: Chuck Hawkins, Dave Peck, and Phil Kaufmann.

Ode, P.R.. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.

SWAMP GUIDANCE SG

SWAMP GUIDANCE FOR MACROINVERTEBRATE FIELD PROTOCOLS FOR WADEABLE STREAMS

Background: The SWAMP Bioassessment Committee met in December, 2004, and agreed that the SWAMP Quality Assurance Management Plan (QAMP) should be amended to provide greater consistency in bioassessment sampling protocols for wadeable streams. The Committee's recommendations were reviewed and accepted by the full SWAMP Roundtable[1] in February, 2005 (some of the key considerations are contained in Appendix A).

The current guidance for macroinvertebrate sampling under the SWAMP program is as follows:

1. For ambient bioassessment monitoring of wadeable streams in California, two methods are to be used at sites with riffle habitats (i.e., one "multihabitat" sample, and one sample that targets the "richest" habitat):
   - **For sites with sufficient riffle habitat,** the two samples shall be: (1) the reachwide benthos (RWB) method (also known as "multihabitat" sampling.); and (2) the targeted-riffle composite (TRC) method.
   - **For low-gradient sites that do not have sufficient riffle habitat**, the RWB method is the standard method, but we also recommend the option of collecting a sample with (2) the "Margin-Center-Margin" (MCM) method until ongoing methods comparisons are completed (see Appendix A).
   - **Notes:** (1) The protocols for each method are provided in this document; (2) Other appropriate method(s) will be allowed if the specific monitoring objectives require use of alternative method(s). (See Item #2, below.); (3) The protocol recommendations specified above will be reevaluated as results become available from ongoing methods comparison studies. (See Appendix A for more information.)

2. The SWAMP QAMP allows flexibility in sampling methods so that the most appropriate method(s) may be used to address hypothesis tests and project-specific objectives that differ from program objectives. Such situations may include, but are not necessarily limited to, special studies (e.g., evaluation of point source discharges, above/below comparisons where statistical replication is needed), stressor identification investigations, and long-term monitoring projects where consistent data comparability is desired and an alternative method is needed to achieve that comparability. In addition, in some rare cases where funding limitations would make it cost-prohibitive to complete a project in compliance with the protocols listed in #1, above, the project proponent may request to complete laboratory analysis of only one sample, and "archive" one of the macroinvertebrate samples (i.e., the RWB sample in streams with riffles) to reduce lab costs. Deviations from the protocols specified in #1 above may be granted by the SWAMP Bioassessment Coordinator or the full SWAMP Roundtable.

1. The SWAMP Roundtable is the coordinating entity for the program. Participants include staff from the State and Regional Water Boards, USEPA, the Department of Fish and Game, the Marine Pollution Studies Laboratory, Moss Landing Marine Laboratories, contractors, and other interested entities.

SECTION 1 INTRODUCTION

This document describes two standard procedures (TRC and RWB) for sampling benthic macroinvertebrate (BMI) assemblages for ambient bioassessments. This document also contains procedures for measuring instream and riparian habitats and ambient water chemistry associated with BMI samples. These sampling methods replace previous bioassessment protocols referred to as the California Stream Bioassessment Procedure (CSBP, Harrington 1995, 1999, 2002).

These procedures can produce quantitative and repeatable measures of a stream's physical/habitat condition and benthic invertebrate assemblages, but they require field training and implementation of QA measures throughout the field season.

The sampling layout described here provides a framework for systematically collecting a variety of physical, chemical, and biological data. The biological sampling methods are designed to nest within the overall framework for assessing the biotic, physical, and chemical condition of a reach. The layout used in these procedures and most of the physical habitat methods are close modifications of those used in EPA's EMAP and developed by EPA's ORD (Peck et al. 2004). Data collected using this methodology are generally directly comparable to equivalent EMAP data, except for the difference in reach length. Other exceptions are noted in the text.

The following steps are presented in an order suggested for efficient data collection. The specific order of collection for the physical parameters may be modified according to preferences of field crews, with the caveat that care must always be taken to not disturb the substrates within the streambed before BMI samples are collected.

PHYSICAL HABITAT METHODS

The physical habitat scoring methods described here can be used as a stand-alone evaluation or used in conjunction with a bioassessment sampling event. However, measurements of instream and riparian habitat and ambient water chemistry are essential to interpretation of bioassessment data and should always accompany bioassessment samples. This information can be used to classify stream reaches, associate physical and chemical condition with biotic condition, and explain patterns in the biological data.

Because bioassessment samples can be collected to answer a variety of questions, this document describes the component measures of instream and riparian habitat as independent modules. Although individual modules can be added or subtracted from the procedure to reflect specific project objectives, a standard set of modules will normally accompany bioassessment samples. This document describes two standard groupings of modules that represent two different levels of intensity for characterizing the chemical and physical habitat data (Table 1). The BASIC physical habitat characterization represents a minimum amount of physical and chemical data that should be taken along with any ambient BMI sample, the FULL physical habitat characterization represents the suite of data that should be collected with most professional level bioassessment samples (e.g., SWAMP regional monitoring programs). In addition to these data, we also briefly introduce additional data modules (e.g., excess sediment, periphyton) that can be collected as supplements to the full set (OPTIONAL). Table 1 lists the physical and chemical variables that should be measured under the different levels.

Note: *SWAMP intends to develop guidance for selecting appropriate physical habitat modules to the intended uses of data. Until this guidance is available, users of these protocols should consult with representatives of the Regional Water Quality Control Boards (Regional Boards) or the SWAMP Bioassessment Coordinator when selecting modules.*

FIELD CREW SIZE AND TIME ESTIMATES

These methods are designed to be completed by either two or three (or more) person field crews. A very experienced field crew can expect to complete the full suite of physical habitat measurements and the two BMI sampling protocols in approximately two hours. Less experienced crews will probably take closer to three or four hours to complete the work depending on the complexity of the reach. Note that this estimate includes only time at the site, not travel time between sites.

Equipment and Supplies

Recommended equipment and supplies are listed in Table 2.

Table 1. Summary of physical habitat and water chemistry and proposal for basic, full, and optional levels of effort.

Survey Task	Parameter(s)	Basic	Full	Option	Comments
REACH DELINEATION and WATER QUALITY [Conducted before entering stream to sample BMIs or conduct any habitat surveys]	Layout reach and mark transects, record GPS coordinates	X	X		Use 150-m reach length if wetted width ≤10 m; Use 250-m reach length if wetted width > 10 m
	Temperature, pH, specific conductance, DO, alkalinity	X	X		Multi-meter (e.g., YSI, Hydrolab, VWR Symphony)
	Turbidity, Silica			X	Use test kit or meter
	Notable field conditions	X	X		Recent rainfall, fire events, dominant local landuse
CROSS-SECTIONAL TRANSECTS BASIC Measurements at main 11 transects only FULL Measurements at 11 main transects (A, B, C, D, E, F, G, H, I, J, K) or 21 transects (11 main plus 10 inter-transects) for substrate size classes only	Wetted width	X	X		Stadia rod is useful here
	Flow habitat delineation	X	X		Record proportion of habitat classes in each inter-transect zone
	Depth and Pebble Count + CPOM		X		5 -point substrate size, depth and CPOM records at all 21 transects
	Cobble embeddedness		X		All cobble-sized particles in pebble count. Supplement with "random walk" if needed for 25
	Slope (%)	See reach scale	X		Average slope calculated from 10 transect to transect slope measurements. Use autolevel for slopes ≤ 1%; clinometer is OK for steeper gradients
	Sinuosity		X		Record compass readings between transect centers
	Canopy cover	X	X		Four densiometer readings at center of channel (facing L bank R bank, Upstream +Downstream)
	Riparian Vegetation		X		Record % or categories
	Instream Habitat		X		
	Human Influence		X		
	Bank Stability	X	X		Eroding / Vulnerable / Stable
	Bankfull Dimensions		X		
	Excess Sediment Transect Measures (optional)				
	Bankfull width and height, bank angles			X	
	Large woody debris counts			X	Tallies of woody debris in several size classes
	Thalweg profile			X	100 equidistant points along thalweg

Survey Task	Parameter(s)	Basic	Full	Option	Comments
DISCHARGE TRANSECT	Discharge measurements		X		Velocity-Area Method or Neutrally Buoyant Object Method
REACH SCALE MEASUREMENTS:	EPA-RBP visual scoring of habitat features	*		X	*Used for citizen monitoring and comparison with legacy data
	Selected RBP visuals:		X		Channel alteration, sediment deposition, epifaunal substrate (redundant if doing EPA-RBP scoring)
	Slope (%, not degrees)	X	See transect scale		Single measurement for entire reach only for BASIC. Use autolevel for slopes ≤ 1%, clinometer is OK for higher gradients
	Photo documentation	X	X		Upstream (A, F, K) Downstream (F)
OTHER OPTIONAL COMPONENTS					
FOOD RESOURCE QUANTIFICATION	Periphyton (3 replicates)			X	Qualitative characterization of diatom growth and filamentous algal growth, quantification of biomass (AFDM, chl-a)
	CPOM & FPOM (3 replicates)			X	CPOM field measure of wet mass >1 mm particles, FPOM as 0.25 – 1 mm fraction (AFDM in lab)

Table 2. Field equipment and supplies

Physical Habitat	BMI Collection	General/ Ambient Chemistry
• GPS receiver • topographic maps • measuring tape (150-m) • small metric ruler or gravelometer for substrate measurements • digital watch, random number table or ten-sided die • stadia rod • clinometer • autolevel (for slopes < 1%) • handlevel (optional) • current velocity meter • stopwatch for velocity measurements • convex spherical densitometer • flags/ flagging tape • rangefinder	• D-frame kick net (fitted with 500-μ mesh bag) • standard # 35 sieve (500-μ mesh) • wide-mouth 500-mL or 1000 mL plastic jars • white sorting pan (enamel or plastic) • 95% EtOH • fine tipped forceps or soft forceps • waterproof paper and tape for attaching labels • 10-20-L plastic bucket for sample elutriation • preprinted waterproof labels (e.g., Rite-in-the-Rain™) • disposable gloves/ elbow length insulated gloves	• sampling SOP (this document) • hip or chest waders, or wading boots/shoes • field forms printed on waterproof paper (e.g., Rite-in-the-Rain™) • clip board and pencils • digital camera • centigrade thermometer • pH meter • DO meter • conductivity meter • field alkalinity meter • water chemistry containers • calibration standards • spare batteries for meters • first aid kit

SECTION 2
REACH DELINEATION AND WATER QUALITY

REACH LAYOUT AND GENERAL DOCUMENTATION

The systematic positioning of transects is essential to collecting representative samples and to the objective quantification of physical habitat measures. The standard sampling layout consists of a 150-m reach (length measured along the bank) divided into 11 equidistant transects that are arranged perpendicular to the direction of flow (Figure 1, Figure 2). Ten additional transects (designated "inter-transects") located between the main transects give a total of 21 transects per reach. Main transects are designated A through K while inter-transects are designated by their nearest upstream and downstream transects (e.g., AB, BC, etc.). In extreme circumstances, reach length can be shorter than 150 m (e.g., if upstream and downstream barriers preclude a 150-m reach), but this should be avoided whenever possible. If the actual reach length is other than 150 m or 250 m this should be noted and explained on the field forms.

Note 1: *The standard reach length differs from that used in the EMAP design, in which reach length was defined as 40x stream width, with a minimum reach length of 150 m. The EMAP reach length approach is used to ensure that enough habitat is sampled to support accurate fish assemblage estimates and relatively precise characterization of channel characteristics (e.g., residual pool volumes and woody debris estimates, which that are critical for relative bed stability estimates). Programs wishing to sample fish assemblages or produce relative bed stability estimates should strongly consider adopting the EMAP guidance for setting reach length.*

Note 2: *Streams > 10 m wetted width should use a reach length of 250 m. Some very large streams (i.e., > 20-m wetted width) may not be adequately represented even by a 250-m reach. In these cases, field crews should define a reach length that is representative of the larger stream segment being studied (i.e., attempt to include two to three meander cycles, or four to six riffle-pool sequences when possible).*

Note 3: *When the exact reach location is not restricted by the sampling design, attempt to position reaches upstream of bridges to avoid this influence.*

Step 1. Upon arrival at the sampling site, fill out the reach documentation section of the field forms (site and project identification, stream and watershed name, crew members, and date/time). If known at the time of sampling, record the Site Code following SWAMP site code formats. Determine the geographic coordinates of the downstream end of the reach (preferably in decimal degrees to at least four decimal places) with a GPS receiver and record the datum setting of the unit (preferably NAD83/ WGS84).

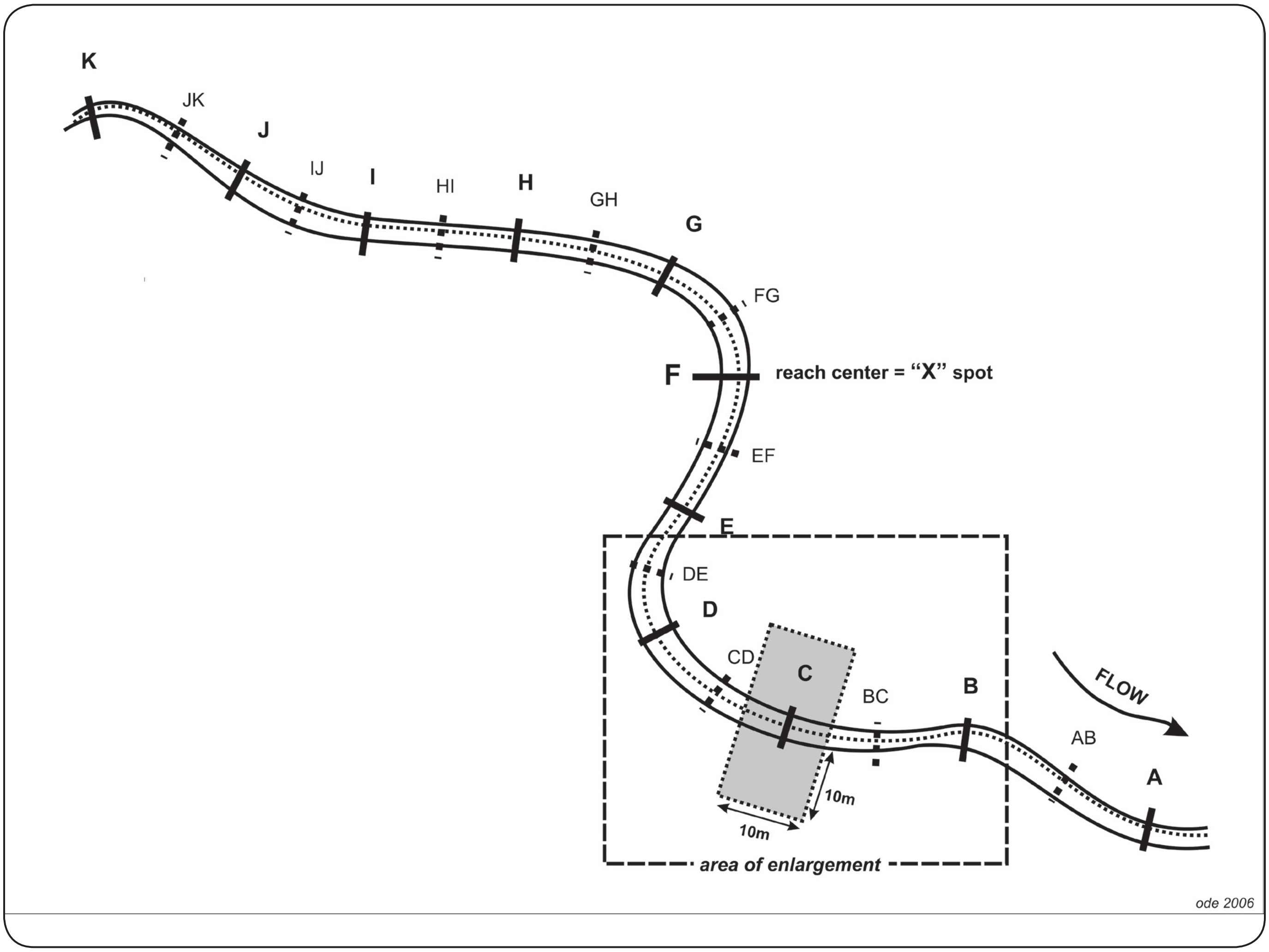

Figure 1. Reach layout geometry for physical habitat and biological sampling showing positions of 11 main transects (A – K) and the 10 supplemental inter-transects (AB- JK). The area highlighted in the figure is expanded in Figure 2. Note: reach length = 150 m for streams ≤ 10-m average wetted width, and reach length = 250 m for streams > 10-m average wetted width.

Step 2. Once a site has been identified, make an initial survey of the reach from the stream banks (being sure to not disturb the instream habitat). If TRC samples will be collected, identify all riffle habitats suitable for sampling (see Section IIIa for suitable habitat types) and note their positions so that a subset can be identified for sampling.

Step 3. Determine if the average wetted width is greater or less than 10 m. If the average wetted width ≤ 10 m, use a 150-m reach length. If the average wetted width > 10 m, use a 250-m reach length.

Step 4. Starting at one end of the reach, establish the position of the 11 main transects (labeled A-K from downstream to upstream) by measuring 15 m (25 m for streams > 10 m wetted width) along the bank from the previous transect. The 10 inter-transects should be established equidistant from the adjacent main transects (i.e., 7.5 m from main transects for 150-m reaches, 12.5 m for 250-m reaches). Since the data collection will start at the downstream end, is often easiest to establish transects starting from the upstream end. For easy setup and breakdown, mark the main transects with easily removable markers (e.g., large washers tied with strips of flagging, surveyor's flags).

Note 1: *While it is usually easiest to establish transect positions from the banks (this also reduces disturbance to the stream channel), this can result in uneven spacing of transects in complex stream reaches. To avoid this, estimate transect positions by projecting from the mid-channel to the banks.*

Note 2: *Flagging of a single bank is recommended to reduce mistakes caused by missed markers.*

Step 5. Measure and record common ambient water chemistry measurements (pH, DO, specific conductance, alkalinity, water temperature) at the downstream end of the reach (near same location as the GPS coordinates were taken). These are typically taken with a handheld water quality meter (e.g., YSI, Hydrolab), but field test kits (e.g., Hach) can provide acceptable information if they are properly calibrated. For appropriate calibration methods and calibration frequency, consult the current SWAMP QAMP (Appendix F), or follow manufacturer's guidelines.

Note 1: *If characteristics of the site prohibit downstream entry, measurements may be taken at other points in the reach. In all cases, ambient chemistry measurements should be taken at the beginning of the reach survey.*

Note 2: *Alkalinity test kits may not perform well in low ionic strength waters. Programs should consider collecting lab samples for these sites (see SWAMP QAMP for guidance on collecting water chemistry samples).*

Step 6. Take a minimum of four (4) photographs of the reach at the following locations: a) Transect A facing upstream, b) Transect F facing upstream, c) Transect F facing downstream, and d) Transect K facing downstream. It may also be desirable to take a photograph at Transect A facing downstream and Transect K facing upstream to document conditions immediately adjacent to the reach. Digital photographs should be used when possible. Record the image numbers on the front page of the field form.

Note 1: *When possible, photograph names should follow SWAMP coding conventions ("StationCode_yyyy_mm_dd_uniquecode"). The unique code should include one of the following codes to indicate direction: RB (right bank), LB (left bank), BB (both banks), US (upstream), DS (downstream). SWAMP suggests using unique codes created by the camera to facilitate file organization. Example: 603WQLB02_2004_03_20_RBDS1253.*

Step 7. Record the dominant land use and land cover in the area surrounding the reach (evaluate land cover within 50 m of either side of the stream reach).

Step 8. At the bottom of the form, record evidence of recent flooding, fire, or other disturbances that might influence bioassessment samples. Especially note if flow conditions have been affected by recent rainfall, which can cause significant under-sampling of BMI diversity (see note in the following section). If you are unaware of recent fire or rainfall events, select the "no" option on the forms.

SECTION 3
COLLECT BENTHIC MACROINVERTEBRATES

MULTIPLE HABITAT AND TARGETED RIFFLE PROTOCOLS

Note 1: *BMI samples intended for ambient bioassessments are generally collected when streams are at or near base flow (i.e., not influenced by surface runoff) as sudden flow increases can dramatically alter local community composition.*

Note 2: *Guidance for choosing among TRC sampling, RWB sampling or both will be provided in a separate document (see Appendix A for current guidance for sampling under SWAMP).*

Once the reach transects have been laid out, the biological samples (BMIs and algae if included) should be collected before any other physical habitat measures so that substrates are not disturbed prior to sampling. Both TRC and RWB methods use 500-μ mesh D-frame nets (see list of BMI sampling equipment in Table 2). The two samples can be collected at the same time by carrying two D-nets and compositing the material from the two samples in their respective nets. If a two person field crew is responsible for both the physical habitat data and benthic invertebrate samples, it is generally best to collect the benthos at each transect, then immediately record the physical habitat data before moving to the next transect. Obviously, this requires especially careful handling of the D-nets during the course of sampling to avoid loss or contamination of the samples. It can be helpful to clearly label the two D nets as RWB and TRC. Larger field crews may choose to split the sampling between biological team and a physical habitat team and have the biological team go through the reach first. The positions of the TRC and RWB subsampling locations are illustrated in Figure 2.

SECTION III A. TARGETED RIFFLE COMPOSITE PROCEDURE

The TRC method is designed for sampling BMIs in wadeable streams that contain fast-water (riffle/run) habitats and is not appropriate for waterbodies without fastwater habitats. The RWB protocol should be used in these situations. Riffles are often used for collecting biological samples (e.g., the old CSBP methods) because they often have the highest BMI diversity in wadeable streams. This method expands the definition to include other fast water habitats, however care should be taken when attempting to apply this method in low gradient streams.

Note: *Since all streams (even low gradient streams) have variation in flow habitats within the channel, this guidance should not be interpreted as including areas within low gradient streams that are only marginally faster than the surrounding habitats. The RWB protocol should be applied in these situations.*

The TRC was developed by the Western Center for Monitoring and Assessment of Freshwater Ecosystems (www.cnr.usu.edu/wmc) in Logan, Utah (Hawkins et al. 2003) and slightly modified by the EPA program (Peck et al. 2004). The TRC has been widely used in California (US Forest Service (USFS), the EMAP Western Pilot, and the California Monitoring and Assessment Program (CMAP)), and in the interest of methodological consistency between state and federal water resource agencies, has been adopted as the standard riffle protocol for bioassessment in California. The version described here is the EMAP modification, which distributes the sampling effort throughout the reach.

Sampling Locations – Acceptable Habitat Types

Riffles are the preferred habitat for TRC sampling, but other fast water habitats are acceptable for sampling if riffles are sparse. Common flow-defined habitat types are listed in Table 3 in decreasing order of energy. Most streams contain some or all of the following fast water habitat types: 1) cascades/falls, 2) rapids, 3) riffles, 4) runs. All of these are acceptable for TRC sampling if riffles are not available.

Note: *Because the common habitat types are arranged on a continuum between high to low energy environments, the categories grade into each other continuously and are not discrete. Thus, determination of habitat types requires somewhat subjective decision-making.*

Table 3. Common habitat types in stream channels, arranged in decreasing order of energy

Flow Habitat Type	Description
Cascades	Short, high gradient drop in stream bed elevation often accompanied by boulders and considerable turbulence
Falls	High gradient drop in elevation of the stream bed associated with an abrupt change in the bedrock
Rapids	Sections of stream with swiftly flowing water and considerable surface turbulence. Rapids tend to have larger substrate sizes than riffles
Riffles	Shallow sections where the water flows over coarse stream bed particles that create mild to moderate surface turbulence; (< 0.5 m deep, > 0.3 m/s)
Step-Runs	A series of runs that are separated by short riffles or flow obstructions that cause discontinuous breaks in slope
Runs	Long, relatively straight, low-gradient sections without flow obstructions. The stream bed is typically even and the water flows faster than it does in a pool; (> 0.5 m deep, > 0.3 m/s)
Glides	A section of stream with little or no turbulence, but faster velocity than pools; (< 0.5 m deep, < 0.3 m/s)
Pools	A reach of stream that is characterized by deep, low-velocity water and a smooth surface ; (> 0.5 m deep, < 0.3 m/s)

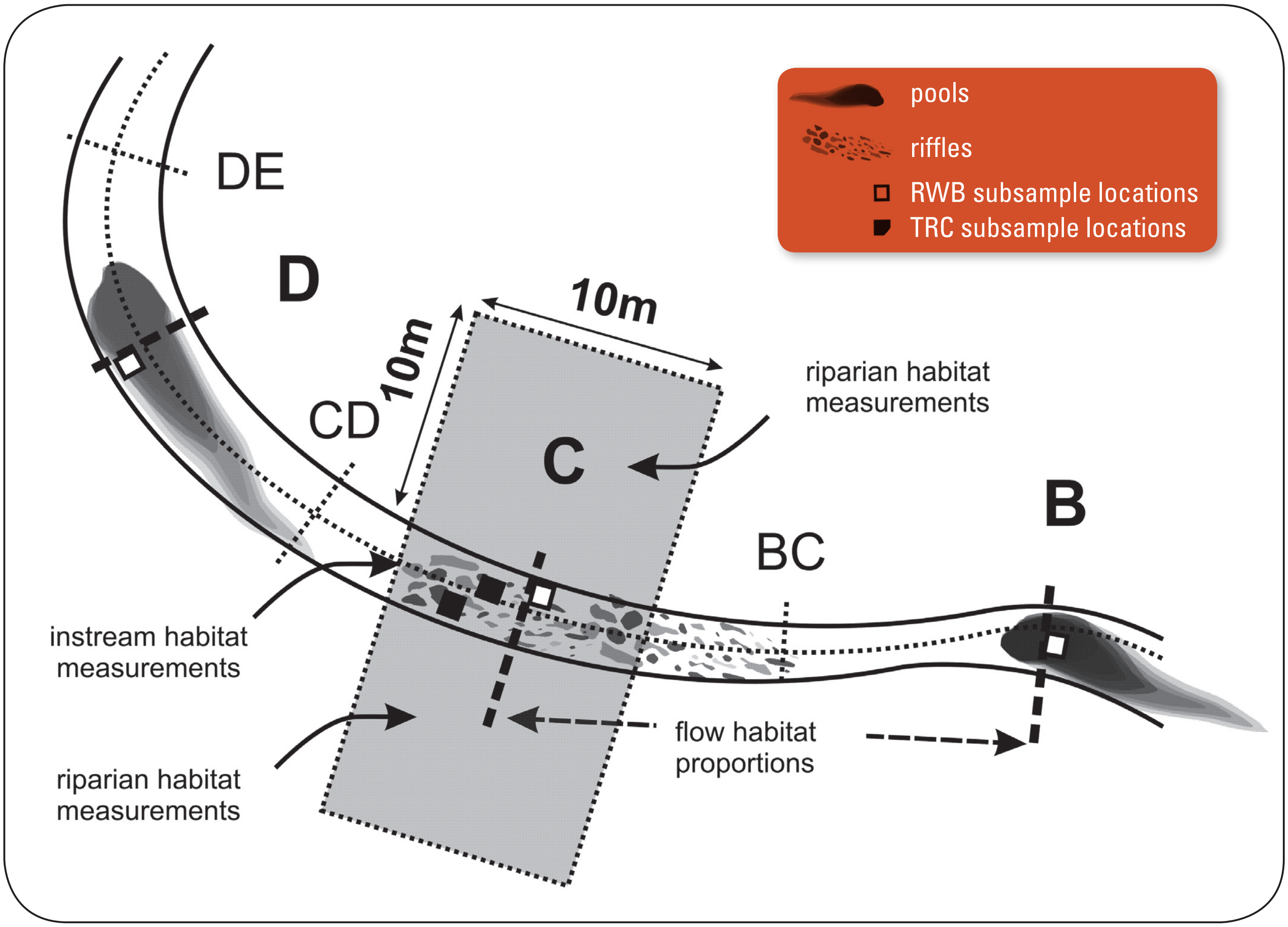

Figure 2. Section of the standard reach expanded from Figure 1 showing the appropriate positions for collecting benthic macroinvertebrate samples, instream and riparian habitat measurements and flow habitat proportion measurements.

Sampling Locations – Selecting Habitat Units

A TRC sample is a composite of eight individual kick samples of 1 ft^2 (0.09 m^2) of substrate each. During your initial layout of the reach, take a mental note of the number and position of the main riffles in a reach (and other fast water habitats if needed). Randomly distribute the eight sub-samples among the fast water habitats in the reach, giving preference to riffles where possible. Unless you are sampling in small streams, try to avoid very small riffle units (i.e., < 5 ft^2). If fewer than eight riffles are present in a reach, more than one sample may be taken from a single riffle, especially if the riffles are large.

Sampling Procedure

Begin sampling at the downstream end of the reach at the first randomly selected riffle and work your way upstream.

TRC-Step 1. Determine net placement within each habitat unit by generating a pair of random numbers between 0 and 9. Examples of convenient random number generators include the hundredths place on the stopwatch feature of a digital watch, a 10 sided die and a random number chart. The first number in each pair (multiplied by 10) represents the percent upstream along the habitat unit's length. The second number in each pair represents the percent of the riffle width from right bank. For example, if the two generated random numbers are 4 and 7, you will walk upstream 40% of the distance of the riffle and then go 70% of the distance across the riffle (see Figure 3). This position is the center of the 1 ft^2 (0.09 m^2) sampling quadrat for that riffle. If you are unable to sample this location because it is too deep or it is occupied by a large boulder, select a new pair of random numbers and pick a new spot.

TRC-Step 2. Position a 500-µ D-net (with the net opening perpendicular to the flow and facing upstream) quickly and securely on the stream bottom to eliminate gaps under the frame. Avoid, and if necessary remove, large rocks that prevent the sampler from seating properly on the stream bottom.

TRC-Step 3. Holding the net in position on the substrate, visually define a square quadrat that is one net width wide and one net width long upstream of the net opening. Since D-nets are 12 inches wide, the area within this quadrat is 1ft^2 (0.09 m^2). Restrict your sampling to within that area. If desired, a wire frame of the correct dimensions can be placed in front of the net to help delineate the quadrat to be sampled, but it is often sufficient to use the net dimensions to keep the sampling area consistent.

TRC-Step 4. Working backward from the upstream edge of the sampling plot, check the quadrat for heavy organisms such as mussels, snails, and stone-cased caddisflies. Remove these organisms from the substrate by hand and place them into the net. Carefully pick up and rub stones directly in front of the net to remove attached animals. Remove and clean all of the rocks larger than a golf ball (~3 cm) within your sampling quadrat such that all the organisms attached to them are washed downstream into your net. Set these rocks outside your sampling quadrat after you have cleaned them. If the substrate is consolidated or comprised of large, heavy rocks, use your feet to kick and dislodge the substrate to displace BMIs into the net. If you cannot remove a rock from the stream bottom, rub it (concentrating on cracks or indentations) thereby loosening any attached insects. As you are disturbing the plot, let the water current carry all loosened material into the net.

***Note 1:** Brushes are sometimes used in other bioassessment protocols to help loosen organisms, but in the interest of standardizing collections, do not use a brush when following this protocol.*

***Note 2:** In sandy-bottomed streams, kicking within run habitats can quickly fill the sampling net with sand. In these situations, follow the standard procedures but use care to disturb the substrate gently and avoid kicking.*

TRC-Step 5. Once the coarser substrates have been removed from the quadrat, dig your fingers through the remaining underlying material to a depth of about 10 cm (this material is often comprised of gravels and finer particles). Thoroughly manipulate the substrates in the quadrat.

Note: *The sampler may spend as much time as necessary to inspect and clean larger substrates, but should take a standard time of 30 seconds to perform Step 5.*

TRC-Step 6. Let the water run clear of any insects or organic material before carefully lifting the net. Immerse the net in the stream several times to remove fine sediments and to concentrate organisms at the end of the net, but be careful to avoid having any water or foreign material enter the mouth of the net during this operation.

TRC-Step 7. Move upstream to the next randomly selected habitat unit and repeat steps one through six, taking care to keep the net wet but uncontaminated by foreign material when moving the net from riffle to riffle. Sometimes, the net will become so full of material from the streambed that it is no longer effective at capturing BMIs. In these cases, the net should be emptied into sample jars as frequently as necessary, following guidelines described below in the "Preparation of BMI Sample Jars" section. Continue until you have sampled eight $1ft^2$ ($0.09\ m^2$) of benthos.

TRC-Step 8. PROCEED to Section IIIc. Filling and Labeling BMI Sample Jars.

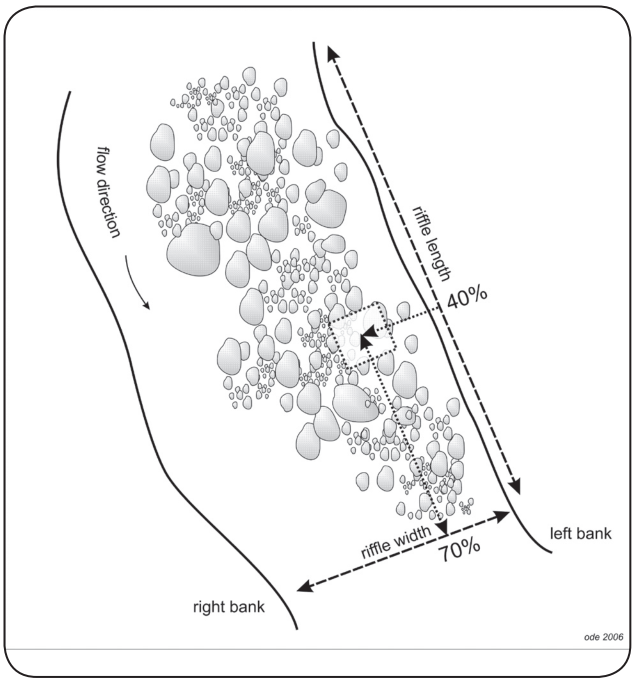

Figure 3. Example showing the method for selecting a subsampling position within a selected riffle under the TRC method. In this example, the random numbers 4 and 7 were selected

SECTION III B. REACHWIDE BENTHOS (MULTIHABITAT) PROCEDURE

The RWB procedure employs an objective method for selecting subsampling locations that is built upon the 11 transects used for physical habitat measurements. The RWB procedure can be used to sample any wadeable stream reach since it does not target specific habitats. Because sampling locations are defined by the transect layout, the position of individual sub-samples may fall in a variety of erosional or depositional habitats.

Note: *Sampling locations should be displaced one meter downstream of the transects to avoid disturbing substrates for subsequent physical habitat assessments.*

RWB -Step 1. The sampling position within each transect is alternated between the left, center and right positions along a transect (25%, 50% and 75% of wetted width, respectively) as you move upstream from transect to transect. Starting with the downstream transect (Transect

A), identify a point that is 25% of the stream width from the right bank (note that the right bank will be on your left as you face upstream). If you cannot collect a sample at the designated point because of deep water obstacles or unsafe conditions, relocate the point as close as possible to the designated position.

Note: *A modification to this procedure is currently being investigated by SWAMP. This "margin-center-margin" (MCM) modification replaces the samples at 25% and 75% of wetted width with samples of the marginal habitats (including emergent and submergent vegetation).*

RWB -Step 2. Place a 500-µ D-net in the water so the mouth of the net is perpendicular to and facing into the flow of the water. If there is sufficient current in the area at the sampling point to fully extend the net, use the normal D-net collection technique to collect the sub-sample (TRC-Step 3 through TRC-Step 6 above). If flow volume and velocity is not sufficient to use the normal collection technique, use the sampling procedure for "slack water" habitats (RWB-Step 3 through RWB-Step 7 below).

RWB -Step 3. Visually define a 1 ft^2 (0.09 m^2) quadrat that is one net-width wide and one net-width long at the sampling point.

RWB -Step 4. Working backward from the upstream edge of the sampling plot, check the quadrat for heavy organisms such as mussels and snails. Remove these organisms from the substrate by hand and place them into the net. Carefully pick up and rub stones directly in front of the net to remove attached animals. Remove and clean all of the rocks larger than a golf ball within your sampling quadrat such that all the organisms attached to them are washed downstream into your net. Set these rocks outside your sampling quadrat after you have cleaned them. Large rocks that are less than halfway into the sampling area should be pushed aside. If the substrate is consolidated or comprised of large, heavy rocks, use your feet to kick and dislodge the substrate to displace BMIs into the net. If you cannot remove a rock from the stream bottom, rub it (concentrating on cracks or indentations) thereby loosening any attached insects.

RWB -Step 5. Vigorously kick the remaining finer substrate within the quadrat with your feet while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net all the time so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds. For vegetation-choked sampling points, sweep the net through the vegetation within a 1ft^2 (0.09 m^2) quadrat for 30 seconds.

Note: *If flow volume is insufficient to use a D- net, spend 30 seconds hand picking a sample from 1ft^2 of substrate at the sampling point, then stir up the substrate with your gloved hands and use a sieve with 500-µ mesh size to collect the organisms from the water in the same way the net is used in larger pools.*

RWB -Step 6. After 30 seconds, remove the net from the water with a quick upstream motion to wash the organisms to the bottom of the net.

RWB -Step 7. PROCEED to Section IIIc: Filling and Labeling BMI Sample Jars

SECTION III C. FILLING AND LABELING BENTHIC MACROINVERTEBRATE SAMPLE JARS

Step 1. Once all sub-samples (eight for TRC, 11 for RWB) have been collected, transfer benthos to a 500-mL or 1000-mL wide-mouth plastic sample jar using one of the following methods.

Note: *Field elutriation should only be used by well-trained field crews who are proficient at removing all benthic organisms from the discarded inorganic material. Training in the recognition of aquatic invertebrates is highly recommended.*

Step 1a. Complete Transfer of all Sampled Material – Invert the contents of the kick net into the sample jar. Perform this operation over a white enameled tray to avoid loss of any sampled material and make recovery of spilled organisms easier. If possible, remove the larger twigs and rocks by hand after carefully inspecting for clinging organisms, but be sure not to lose any organisms. Use forceps to remove any organisms clinging to the net and place these in the sample jar.

Step 1b. Field Elutriation of Samples – Empty the contents of the net into a large plastic bucket (10-20 L is sufficient). Use forceps to remove any organisms clinging to the net and place these in the bucket. Add stream water to the bucket and gently swirl the contents of the bucket in order to suspend the organic material (being certain to not introduce entrained organisms from the source water). Pour the organic matter from the bucket through a 500-µ sieve (or use the 500-µ net). Repeat this process until no additional material can be elutriated (i.e., only inorganic material is left in the bucket). If possible, remove the larger twigs and rocks by hand after carefully inspecting for clinging organisms, but be sure not to lose any organisms. Transfer all of the material in the sieve (invertebrates and organic matter) into the sample jar. Carefully inspect the gravel and debris remaining in the bottom of the bucket for any cased caddisflies, clams, snails, or other dense animals that might remain. Remove any remaining animals by hand and place them in the sample jar.

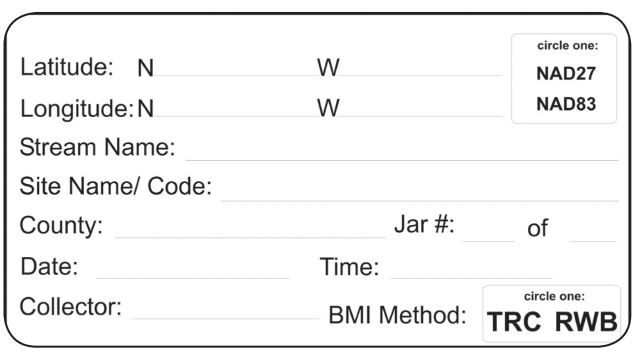
Latitude: N W
Longitude: N W
circle one: NAD27 NAD83
Stream Name:
Site Name/ Code:
County: Jar #: of
Date: Time:
Collector: BMI Method: circle one: TRC RWB

Figure 4. Example date - locality label for all BMI samples.

Step 2. Place a completed date/locality label (see Figure 4) on the inside of the jar (use pencil only as most "permanent" inks dissolve in ethanol) and completely fill with 95% ethanol. Place a second label on the outside of the jar. Note that the target concentration of ethanol is 70%, but 95% ethanol is used in the field to account for dilution from water in the sample. If organic and inorganic material does not accumulate in the net quickly, it may be possible to transfer all the material in the net into one jar. Otherwise, divide the material evenly among several jars (being careful to clearly label them as part of a set). To ensure proper preservation of benthic macroinvertebrates it is critical that the ethanol is in contact with the BMIs in the sample jar. Never fill a jar more than 2/3 full with sampled material, and gently rotate jars that contain mostly mud or sand to ensure that the ethanol is well distributed. If jars will be stored for longer than a month prior to processing, jars should not contain more than 50% sample material.

SECTION 4
MAIN CROSS-SECTIONAL TRANSECT MEASURES

SECTION IVA. PHYSICAL MEASURES

The majority of physical habitat measurements in this protocol are made relative to the main cross-sectional transects (Figure 5). All the measures taken relative to each transect are recorded on forms specific to that transect. Start with the downstream transect (Transect A) and repeat steps 6-15 for all 11 main transects.

Module A. Transect Dimensions: Wetted Width and Bankfull Dimensions

Wetted Width – The wetted channel is the zone that is inundated with water and the wetted width is the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water. Measure the wetted stream width and record this in the box at the top of the transect form.

Bankfull Width and Depth – The bankfull channel is the zone of maximum water inundation in a normal flow year (one to two year flood events). Since most channel formation processes are believed to act when flows are within this zone (Mount 1995), bankfull dimensions provide a valuable indication of relative size of the waterbody.

Note: *Bankfull dimensions are notoriously difficult to assess, even by experienced field crews (see Heil and Johnson 1995). It is often useful to discuss the interpretation of bankfull locations among the field crew members to reach a consensus. The USFS Stream Team provides a good set of instructional videos for improving consistency in accurate bankfull measurements (http://www.stream.fs.fed.us/publications/videos.html).*

Step 1. Scout along the stream margins to identify the location of the bankfull margins on either bank by looking for evidence of annual or semi-annual flood events. Examples of useful evidence includes topographic, vegetative, or geologic cues (changes in bank slope, changes from annual to perennial vegetation, changes in the size distribution of surface sediments). While the position of drift material caught in vegetation may be a helpful aid, this can lead to very misleading measurements.

Note: *The exact nature of this evidence varies widely across a range of stream types and geomorphic characteristics. It is helpful to investigate the entire reach when attempting to interpret this evidence because the true bankfull margin may be obscured at various points along the reach. Often the bankfull position is easier to interpret from one bank than the other; in these cases, it is easiest to infer the opposite bank position by projecting across the channel. Additionally, height can be verified by measuring the height from both edges of the wetted channel to the bankfull height (these heights should be equal).*

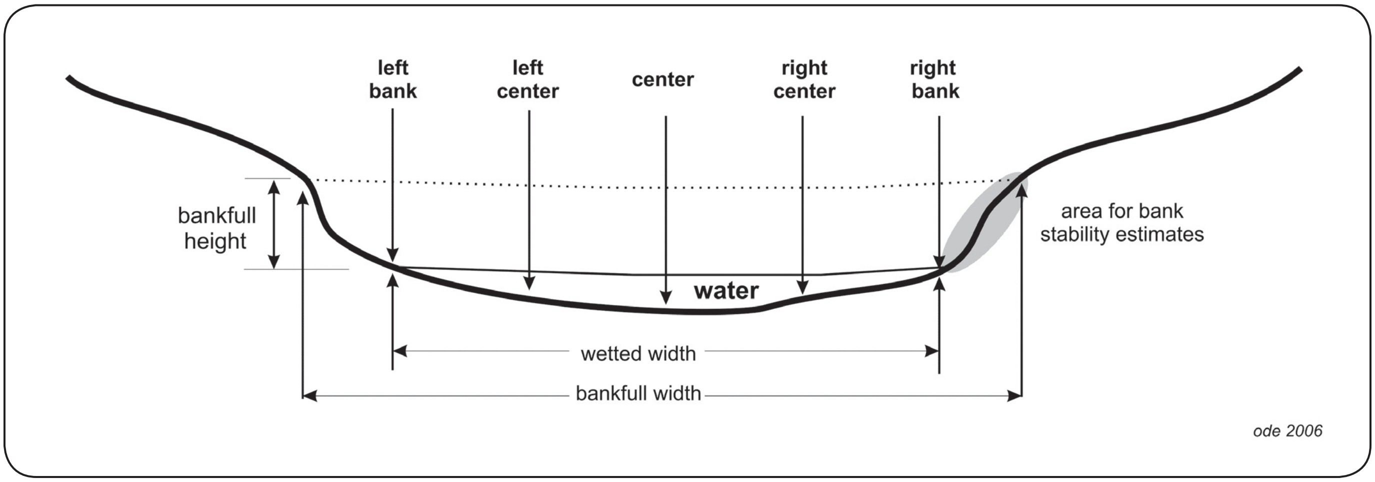

Figure 5. Cross sectional diagram of a typical stream channel showing locations of substrate measurements, wetted and bankfull width measurements, and bank stability visual estimates.

Step 2. Stretch a tape from bank to bank at the bankfull position. Measure the width of the bankfull channel from bank to bank at bankfull height and perpendicular to the direction of stream flow.

Step 3. Measure bankfull height (the vertical distance between the water height of the water and the height of the bank, Figure 5) and record.

Module B. Transect Substrate Measurements

Particle size frequency distributions often provide valuable information about instream habitat conditions that affect BMI distributions. The Wolman pebble count technique (Wolman 1954) is a widely used and cost-effective method for estimating the particle size distribution and produces data that correlates with costly, but more quantitative bulk sediment samples. The method described here follows the EMAP protocol, which records sizes of 105 particles in a reach (five particles from each of 11 main transects and 10 inter-transects).

Note: *The size cutoff for the finest particle sizes in the EMAP protocol (< 0.06 mm) differs from that used by the Sierra Nevada Aquatic Research Laboratory (SNARL) program (0.25 mm), although the narrative description for this cutoff is the same (the point at which fine particles rubbed between one's fingers no longer feel gritty).*

Coarse particulate organic matter (CPOM, particles of decaying organic material such as leaves that are greater than 1.0 mm in diameter) is a general indicator of the amount of allochthonous organic matter available at a site, and its measurement can provide valuable information about the basis of the food web in a stream reach. The presence of CPOM associated with each particle is quantified at the same time that particles are measured for the pebble counts.

Step 1. Transect substrate measurements are taken at five equidistant points along each transect (Figure 5). Divide the wetted stream width by four to get the distance between the five points (Left Bank, Left Center, Center, Right Center and Right Bank) and use a measuring device to locate the positions of these points (a stadia rod is especially helpful here). Once the positions are identified, lower a graduated rod (e.g., a marked ski pole) though the water column perpendicular to both the flow and the transect to objectively select the particle located at the tip of the rod.

Step 2. Measure the depth from the water surface to the top of the particle with the graduated rod and record to the nearest cm.

Step 3. Record the presence or absence of CPOM >1mm within 1 cm of the particle.

Step 4. If the particle is cobble-sized (64-250 mm), record the percent of the cobble that is embedded by fine particles (<2 mm) to the nearest 5% (see cobble embeddedness text below).

Step 5. Remove the particle from the streambed, then measure and record the length of its intermediate axis to the nearest mm (see Figure 6). Alternatively, assign the particle to one of the size classes listed in the bottom of the transect form. Particle sizes classes can be estimated visually or with a quantitative measuring device (e.g., pass/ no-pass template, "gravelometer"). Regardless of the method, all particles less than 0.06 mm should be recorded as fines, all particles between 0.06mm and 2.0 mm recorded as sand. Field crews may want to carry vials containing sediment particles with these size ranges until they are familiar with these particles.

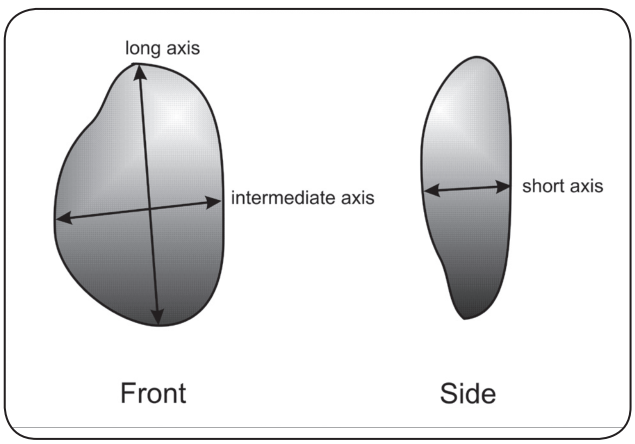

Figure 6. Diagram of three major perpendicular axes of substrate particles. The intermediate axis is recorded for pebble counts.

Module C. Cobble Embeddedness

The quantification of substrate embeddedness has long been a challenge to stream geomorphologists and ecologists (Klamt 1976, Kelley and Dettman 1980). It is generally agreed that the degree to which fine particles fill interstitial spaces has a significant impact on the ecology of benthic organisms and fish, but techniques for measuring this impact vary greatly (this is summarized well by Sylte and Fischenich 2002, http://stream.fs.fed.us/news/streamnt/pdf/StreamOCT4.pdf). Here we define embeddedness as the volume of cobble-sized particles (64-250 mm) that is buried by fine particles (<2.0 mm diameter).

Note: *This method differs from the EMAP method for measuring embeddedness, which measures embeddedness of all particles larger than 2 mm.*

Table 4. Size class codes and definitions for particle size measurements

Size Class Code	Size Class Description	Common Size Reference	Size Class Range
RS	bedrock, smooth	larger than a car	> 4 m
RR	bedrock, rough	larger than a car	> 4 m
XB	boulder, large	meter stick to car	1 - 4 m
SB	boulder, small	basketball to meter stick	25 cm - 1.0 m
CB	cobble	tennis ball to basketball	64 - 250 mm
GC	gravel, coarse	marble to tennis ball	16 - 64 mm
GF	gravel, fine	ladybug to marble	2 – 16 mm
SA	sand	gritty to ladybug	0.06 – 2 mm
FN	fines	not gritty	< 0.06 mm
HP	hardpan (consolidated fines)		< 0.06 mm
WD	wood		
RC	concrete/ asphalt		
OT	other		

Step 1. Every time a cobble-sized particle is encountered during the pebble count, remove the cobble from the stream bed and visually estimate the percentage of the cobble's volume that has been buried by fine particles. Since visual estimates of volume and surface area are subject to large amounts of observer error, field crews should routinely calibrate their estimates with each other and with other field crews.

Step 2. In the spaces to the right of the pebble count data, record the embeddedness of all cobble-sized particles encountered during the pebble count.

Note: *The cobble embeddedness scores do not correspond with the specific particles in the pebble count cells to the left, but are merely a convenient place to record the data.*

Step 3. If 25 cobbles are not encountered during the pebble count, supplement the cobbles by conducting a "random walk" through the reach. Starting at a random point in the reach, follow a transect from one bank to the other at a randomly chosen angle. Once at the other bank reverse the process with a new randomly chosen angle. Record embeddedness of cobble-sized particles in the cobble embeddedness boxes on the transect forms until you reach 25 cobbles. If 25 cobble-sized particles are not present in the entire reach, then record the values for cobbles that are present.

Module D. Canopy Cover

This method uses the Strickler (1959) modification of a convex spherical densiometer to correct for over-estimation of canopy density that occurs with unmodified readings. Read the densiometer by counting the number of line intersections that are obscured by overhanging vegetation (see Figure 7). Taping off the lower left and right portions of the mirror emphasizes overhead vegetation over foreground vegetation (the main source of bias in canopy density measurements). All densiometer readings should be taken with the bubble leveled and 0.3 m (1 ft) above the water surface.

Step 1. Using a modified convex spherical densitometer, take and record four 17-point readings all taken from the center of each transect: a) facing upstream, b) facing downstream, c) facing the left bank, d) facing the right bank.

Note: *This method deviates slightly from that of EMAP (in which two additional readings are taken at the left and right wetted edges to increase representation of bank vegetation).*

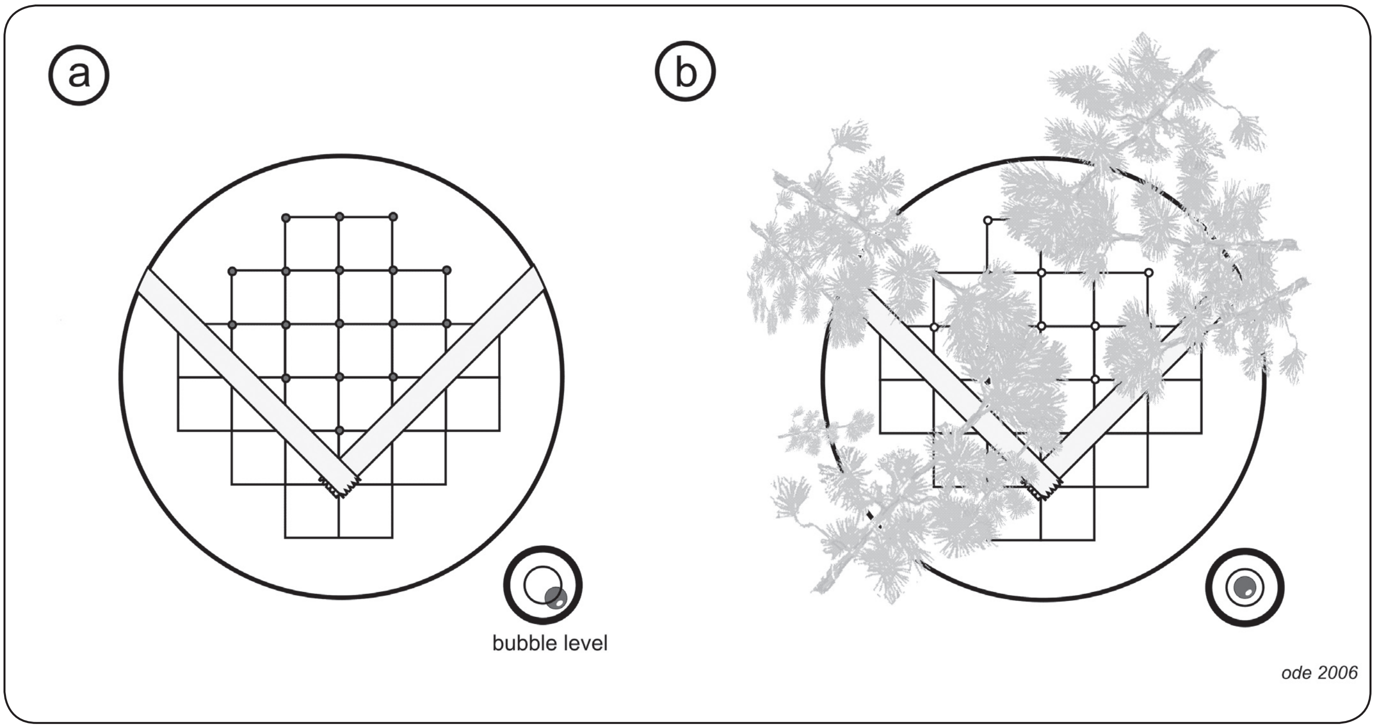

Figure 7. Representation of the mirrored surface of a convex spherical densiometer showing the position for taping the mirror and the intersection points used for the densiometer reading. The score for the hypothetical condition in (b) is 10 covered intersection points out of 17 possible. Note the position of the bubble level in (b) when the densiometer is leveled.

Module E. Gradient and Sinuosity

The gradient of a stream reach is one of the major stream classification variables, giving an indication of potential water velocities and stream power, which are in turn important controls on aquatic habitat and sediment transport within the reach. The gradient (slope) of a stream reach is often strongly correlated with many BMI metrics and other physical habitat measures and is therefore very useful when interpreting BMI data.

The "full" physical habitat method uses 10 transect to transect measurements to calculate the average slope through a reach. Although this is a little more time intensive than the reach-scale transect measures used in the "basic" protocol, it results in more precise slope determination and the ability to quantify slope variability within a reach. Sinuosity (calculated as the ratio of the length of the flow path between the ends of the reach and the straight line distance between the ends of the reach, Kaufmann et al. 1999) is measured at the same time as slope. These two measurements work best with two people, one taking the readings at the upstream transect ("backsighting") and the other holding a stadia rod at the downstream transect. If you cannot see the mid point of the next transect from the starting point, use the supplemental sections (indicating the proportion of the total length represented by each section). Otherwise, leave these blank.

Note 1: *An auto level should be used for reaches with a percent slope of less than or equal to 1%. All methods (clinometer, hand level, or auto level) may be used for reaches with a percent slope of greater than 1%. The following description is for clinometer-based slope measurements, but the same principles apply to use of an auto or hand level.*

Note 2: *In reaches that are close to 1%, you will not know whether you are above or below the 1% slope cutoff before taking readings. In these cases, default to use of an autolevel.*

Step 1. Beginning with the upper transect (Transect K), one person (the measurer) should stand at the water margin with a clinometer held at eye level. A second person should stand at the margin of the next downstream transect (Transect J) with a stadia rod flagged at the eye level of the person taking the clinometer readings. Be sure you mark your eye level while standing on level ground! Adjust for water depth by measuring from the same height above the water surface at both transects. This is most easily accomplished by holding the base of the pole at water level.

Note: *An alternative technique is to use two stadia rods pre-flagged at the eye-height of the person taking the readings.*

Step 2. Use a clinometer to measure the percent slope of the water surface (not the streambed) between the upstream transect and the downstream transect by sighting to the flagged position on the stadia rod. The clinometer reads both percent slope and degree of the slope. Be careful to read and record percent slope rather than degrees slope (these measurements differ by a factor of ~2.2). Percent slope is the scale on the right hand side as you look through most clinometers (e.g., Suunto models).

Note: *If an auto level or hand level is used, record the elevation difference (rise) between transects and the segment length (run) instead of the percent slope.*

Step 3. If the stream reach geometry makes it difficult to sight a line between transects, divide the distance into two or three sections and record the slope and the proportion of the total segment length between transects for each of these sections in the appropriate boxes on the slope form (supplemental segments).

Note: *Never measure slope across dry land (e.g., across a meander bend).*

Step 4. Take a compass reading from the center of each main transect to the center of the next main transect downstream and record this bearing to the nearest degree on the slope and bearing section of the form. Bearing measurements should always be taken from the upstream to downstream transect.

Step 5. Proceed downstream to the next transect pair (I-J) and continue to record slope and bearing between each pair of transects until measurements have been recorded for all transects.

SECTION IVB. VISUAL ESTIMATES OF HUMAN INFLUENCE, INSTREAM HABITAT, AND RIPARIAN VEGETATION

The transect-based approach used here permits semi-quantitative calculations from visual estimates even though most are categorical data (i.e., either presence/ absence or size classes) because we can calculate the percentage of transects that fall into different categories. These modules are adapted directly from EMAP protocols with some modifications as noted.

Module F. Human Influence

The influence of human activities on stream biota is of critical concern in bioassessment analyses. Quantification of human activities for these analyses is often performed with GIS techniques, which are very useful but are not capable of accounting for human activities occurring at the reach scale. Reach scale observations are often critical for explaining results that might seem anomalous on the basis of only remote mapping tools.

Step 1. For the left and right banks, estimate a 10 x 10 m riparian area centered on the edges of the transect (see Figure 2). Record the presence of 11 human influence categories in three spatial zones relative to this 10 x 10 m square (between the wetted edge and bankfull margin, between the bankfull margin and 10 m from the stream, and between 10 m and 50 m beyond the stream margins): 1) walls/rip-rap/dams, 2) buildings, 3) pavement/cleared lots, 4) roads/railroads, 5) pipes (inlets or outlets), 6) landfills or trash, 7) parks or lawns (e.g., golf courses), 8) row crops, 9) pasture/ rangelands, 10) logging/ timber harvest activities, 11) mining activities, 12) vegetative management (herbicides, brush removal, mowing), 13) bridges/ abutments, 14) orchards or vineyards. Circle all combinations of impacts and locations that apply, but be careful to not double-count any human influence observations.

Step 2. Record the presence of any of the 11 human influence categories in the stream channel within a zone 5 m upstream and 5 m downstream of the transect.

Module G. Riparian Vegetation

Riparian vegetation (vegetation in the region beyond the bankfull margins) has a strong influence on the composition of stream communities through its direct and indirect roles in controlling the food base, moderating sediment inputs and acting as a buffer between the stream channel and the surrounding environment. These methods provide a cursory survey of the condition of the riparian corridor. Observations are made in the same 10 x 10 m riparian area used for assessing human influence (see Figure 2).

Note: *Riparian vegetation measurements should only include living or recently dead vegetation.*

The riparian vegetation categories used here were condensed from the EMAP version, which further breaks the canopy classes into different components. However, because we have consolidated EMAP categories into fewer categories rather than creating new categories, existing EMAP data can be easily converted to this format simply by combining the appropriate categories.

Step 1. Divide the riparian zone into three elevation zones: 1) ground cover (<0.5 m), 2) lower canopy (0.5 m - 5 m), and 3) upper canopy (>5 m). Record the density of the following riparian classes: 1) Upper Canopy–Trees and Saplings, 2) Lower Canopy–Woody Shrubs and Saplings, 3) Woody Ground Cover–Shrubs, Saplings, 4) Herbaceous Ground Cover–Herbs and Grasses, and 5) Ground Cover–Barren, Bare Soil and Duff. Artificial banks (e.g., rip-rap, concrete, asphalt) should be recorded as barren.

Step 2. Indicate the areal cover (i.e., shading) by each riparian vegetative class as either: 1) absent, 2) sparse (<10%), 3) moderate (10-40%), 4) heavy (40-75%), or 5) very heavy (>75%).

Module H. Instream Habitat Complexity

Instream habitat complexity was developed by the EMAP program to quantify fish concealment features in the stream channel, but it also provides good information about the general condition and complexity of the stream channel. Estimates should include features within the banks and outside the wetted margins of the stream.

Step 1. Record the amount of nine different channel features within a zone 5m upstream and 5m downstream of the transect (see Figure 2): 1) filamentous algae (long-stranded algal forms that are large enough to see with the naked eye), 2) aquatic macrophytes (include mosses and vascular plants), 3) boulders (>25 cm), 4 and 5) woody debris (break into two classes- larger and smaller than 30 cm diameter), 6) undercut banks, 7) overhanging vegetation, 8) live tree roots and 9) artificial structures (includes any anthropogenic objects including large trash objects like tires and shopping carts). Indicate the areal cover of each feature as either: 1) absent, 2) sparse (<10%), 3) moderate (10-40%), 4) heavy (40-75%), or 5) very heavy (>75%).

SECTION 5
INTER-TRANSECT MEASURES

While most measures are taken at or relative to the main transects, a few measures are recorded at transects located at the midpoint between main transects. These are called “inter-transects”.

Module B (Part 2) Pebble Counts (same as for transects, but no cobble embeddedness measures)

Step 1. Divide the wetted stream width by four to get the distance between the five points (Left Bank, Left Center, Center, Right Center and Right Bank) and use a measuring device to locate the positions of these points (a stadia rod is especially helpful here, see Figure 5). Once the positions are identified, lower a graduated rod through the water column perpendicular to both the flow and the transect to objectively select the particle located at its tip.

Step 2. With the graduated rod, measure the depth from the water surface to the top of the particle and record to the nearest cm.

Step 3. Remove the particle from the streambed, then measure and record the length of its intermediate axis to the nearest mm (see Figure 6). Alternatively, assign the particle to one of the size classes listed in the bottom of the transect form (see Table 3 for a list of size classes). Particle size classes may be estimated visually or with a quantitative measuring device (e.g., pass/ no-pass template, gravelometer). Regardless of the method, all particles less than 0.06 mm should be recorded as fines, while all particles between 0.06 mm and 2.0 mm should be recorded as sand. Field crews may want to carry vials containing sediment particles with these size ranges until they are familiar with these particle size classes.

Step 4. Record the presence (P) or absence (A) of any CPOM within 1 cm of each particle.

Module J. Flow Habitats

Because many benthic macroinvertebrates prefer specific flow and substrate microhabitats, the proportional representation of these habitats in a reach is often of interest in bioassessments. There are many different ways to quantify the proportions of different flow habitats (for example, see text on EMAP’s “thalweg profile” below). Like the riparian and instream measures listed above, this procedure produces a semi-quantitative measure consisting of 10 transect-based visual estimates.

Note: *The categories used here are based on those used in the EMAP protocol, with pools combined into one class and cascades and falls combined into another class.*

Step 1. At each inter-transect, identify the proportion of six different habitat types in the region between the upstream transect and downstream transect: 1) cascades/falls, 2) rapids, 3) riffles, 4) runs, 5) glides, 6) pools, 7) dry areas. Record percentages to the nearest 5% — the total percentage of surface area for each section must total 100%.

SECTION 6 DISCHARGE

Stream discharge is the volume of water that moves past a point in a given amount of time and is generally reported as either cubic meters per second (cms) or cubic feet per second (cfs). Because discharge is directly related to water volume, discharge affects the concentration of nutrients, fine sediments and pollutants; and discharge measurements are critical for understanding impacts of disturbances such as impoundments, water withdrawals and water augmentation. Discharge is also closely related to many habitat characteristics including temperature regimes, physical habitat diversity, and habitat connectivity. As a direct result of these relationships, stream discharge is often also a strong predictor of biotic community composition. Since stream volume can vary significantly on many different temporal scales (diurnal, seasonal, inter-annually), it can also be very useful for understanding variation in stream condition.

This procedure (modified from the EMAP protocol) provides for two different methods for calculating discharge. It is preferable to take discharge measurements in sections where flow velocities are greater than 0.15 m/s and most depths are greater than 15 cm, but slower velocities and shallower depths can be used. If flow volume is sufficient for a transect-based "velocity-area" discharge calculation, this is by far the preferred method. If flow volume is too low to permit this procedure or if your flow meter fails, use the "neutrally buoyant object/ timed flow" method.

Note: *Programs that sample fixed sites repeatedly may want to consider installing permanent discharge estimation structures (e.g., stage gauges, wiers).*

Module K. Discharge: Velocity Area Method

The layout for discharge measurements under the velocity-area (VA) method is illustrated in Figure 8. Flow velocity should be measured with either a Swoffer Instruments propeller-type flow meter or a Marsh-McBirney inductive probe flow meter. Refer to the manufacturers' instrument manuals for calibration procedures.

VA-Step 1. Select the best location in the reach for measuring discharge. To maximize the repeatability of the discharge measurement, choose a transect with the most uniform flow (select hydraulically smooth flow whenever possible) and simplest cross-sectional geometry. It is acceptable to move substrates or other obstacles to create a more uniform cross-section before beginning the discharge measurements.

VA-Step 2. Measure the wetted width of the discharge transect and divide this into 10 to 20 equal segments. The use of more segments gives a better discharge calculation, but is impractical in small channels. A minimum of 10 intervals should be used when stream width permits, but interval width should not be less than 15 cm.

VA-Step 3. Record the distance from the bank to the end of the first interval. Using the top-setting rod that comes with the flow velocity meter, measure the median depth of the first interval.

VA-Step 4. Standing downstream of the transect to avoid interfering with the flow, use the top-setting rod to set the probe of the flow meter (either the propeller or the electromagnetic probe) at the midpoint of each interval, at 0.6 of the interval depth (this position generally approximates average velocity in the water column), and at right angles to the transect (facing upstream). See Figure 8 for positioning detail.

VA-Step 5. Allow the flow velocity meter to equilibrate for 10-20 seconds then record velocity to the nearest m/s. If the option is available, use the flow averaging setting on the flow meter.

Note: *Under very low flow conditions, flow velocity meters may register readings of zero even when there is noticeable flow. In these situations, record a velocity of 0.5x the minimum flow detection capabilities of the instrument.*

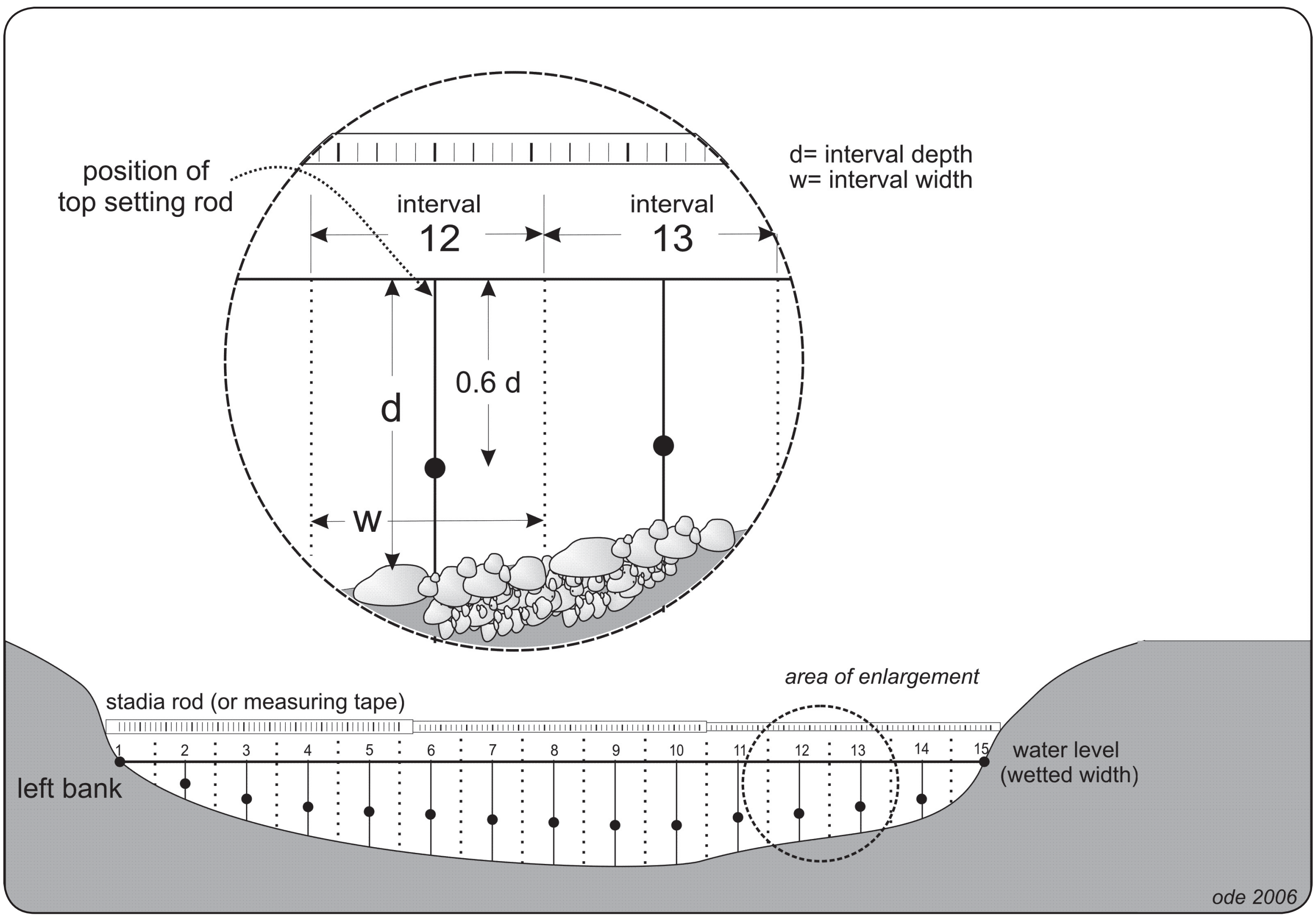

Figure 8. Diagram of layout for discharge measurements under the velocity-area method showing proper positions for velocity probe (black dots).

VA-Step 6. Complete Steps 3 through 5 on the remaining intervals.

Note: *The first and last intervals usually have depths and velocities of zero.*

Module L. Discharge: Neutrally Buoyant Object Method

If streams are too shallow to use a flow velocity meter, the neutrally buoyant object (NBO) method should be used to measure flow velocity. However, since this method is less precise than the flow velocity meter it should only be used if absolutely necessary. A neutrally buoyant object (one whose density allows it to just balance between sinking and floating) will act as if it were nearly weightless, thus it's movement will approximate that of the water it floats in better than a light object. To estimate the flow velocity through a reach, three transects are used to measure the cross-sectional areas within the test section sub-reach and three flow velocity estimates are used to measure average velocity through the test reach. To improve precision in velocity measurements, the reach segment should be long enough for the float time to last at least 10-15 seconds.

NBO-Step 1. The position of the discharge sub-reach is not as critical as it is for the velocity-area method, but the same criteria for selection of a discharge reach apply to the neutrally buoyant object method. Identify a section that has relatively uniform flow and a uniform cross sectional shape.

NBO-Step 2. The cross sectional area is estimated in a manner that is similar but less precise than that used in the velocity area method. Measure the cross sectional area in one to three places in the section designated for the discharge measurement (three evenly-spaced cross sections are preferred, but one may be used if the cross section through the reach is very uniform). Record the width once for each cross section and measure depth at five equally-spaced positions along each transect.

NBO-Step 3. Record the length of the discharge reach.

NBO-Step 4. Place a neutrally buoyant object (e.g., orange, rubber ball, heavy piece of wood, etc.) in the water upstream of the discharge reach and record the length of time in seconds that it takes for the object to pass between the upstream and downstream boundaries of the reach. Repeat this timed float three times.

SECTION 7 POST-SAMPLING OBSERVATIONS

Module M. Rapid Bioassessment Procedures Visual Assessment Scores (for Basic Physical Habitat, or optional supplement)

EPA's Rapid Bioassessment Procedures (RBPs, Barbour et al. 1999) include a set of 10 visual criteria for assessing instream and riparian habitat. The RBP has been used in the CSBP since its first edition (1995) and thus, this information is often valuable for comparison to legacy datasets. The criteria also have a useful didactic role since they help force the user to quantify key features of the physical environment where bioassessment samples are collected.

Module N. Additional Habitat Characterization (Full Physical Habitat only)

The RBP stream habitat visual estimates described in Step 1 are not included in the Full Physical Habitat version because they are generally replaced by more quantitative measurements of similar variables. However, we have found that three of the RBP measures are reasonably repeatable and include them in the reachwide assessment portion of the Full Physical Habitat version.

Note: *This is the only case in which a measurement included in the basic procedure is not included in the full.*

Module O. Reach Slope (for Basic Physical Habitat only)

Reach slope should be recorded as percent slope as opposed to degrees slope to avoid confusion. Slope measurements work best with two people, one taking the readings at the upstream transect and the other holding a stadia rod at the downstream transect. If you cannot see the mid point of the next transect from the starting point, use the supplemental sections (indicating the proportion of the total length represented by each section).

An auto level (with a tripod) should be used for reaches with a percent slope of less than or equal to 1%. All methods (clinometer, hand level, or auto level) may be used for reaches with a percent slope of greater than 1%. In reaches that are close to 1%, you will not know whether you are above or below the 1% slope cutoff. In these cases, default to use of an autolevel.

Step 1. Divide the reach into multiple segments such that stadia rod markings can be easily read with the measuring device to be employed (this is especially a factor for clinometer and hand level readings).

Step 2. Use a clinometer, hand level, or auto level to measure the percent slope of the water surface (not the streambed) between the top and bottom of each segment. Be sure to adjust for water depth by measuring from the same height above the water surface at both transects. Also be sure to record percent slope, not degrees slope. Record the segment length for each of these sections in the appropriate boxes on the BASIC slope form.

SECTION 8
OPTIONAL EXCESS SEDIMENT MEASURES

Future editions of these protocols will include supplemental modules, including a full discussion of the measurements used for calculating the excess sediment index (sometimes referred to as log relative bed stability, LRBS). However, since several of the measurements in EMAP's physical habitat protocols are interwoven into the layout of this protocol, a brief overview of the additional measurements collected for the LRBS calculations is included here for information purposes only. For detailed explanations of these measurements, consult Peck et al. 2004.

Woody Debris Tallies

Large woody debris (logs, snags, branches, etc.) that is capable of obstructing flow when the channel is at bankfull condition (just short of flood stage) contributes to the "roughness" of a channel. The effect of this variable is to reduce water velocity and thereby reduce the stream's competence to move substrate particles. The EMAP protocol tallies all woody debris with a diameter greater than 10 cm (~4") into one of 12 size classes based on the length and width of each object. Tallies are conducted in the zone between the main transects.

Thalweg Measurements

A stream's thalweg is a longitudinal profile that connects the deepest points of successive cross-sections of the stream. The thalweg defines the primary path of water flow through the reach. Thalweg measurements perform many functions in the EMAP protocols, producing measurements for the excess sediment calculations (residual pool volume, stream size, channel complexity) and flow habitat variability.

SECTION 9
OPTIONAL PERIPHYTON QUANTIFICATION

Periphyton Quantification

Characterization of periphyton has a dual role in bioassessments, as periphyton is both a food and habitat resource for benthic macroinvertebrates and fish and an effective bioindicator on its own. Quantification of periphytic resources will be covered under a separate SWAMP bioassessment protocol, but will include procedures for qualitative characterization of diatom assemblages, documentation of filamentous algal growth, and biomass quantification (e.g., ash-free dry mass and chlorophyll a).

SECTION 10
QUALITY ASSURANCE & CONTROL PROCEDURES

The SWAMP bioassessment group is currently developing guidelines for quality assurance and quality control for bioassessment procedures. Future revisions to this document will include guidance covering personnel qualifications, training and field audit procedures, procedures for field calibration, procedures for chain of custody documentation, requirements for measurement precision, health and safety warnings, cautions (actions that would result in instrument damage or compromised samples), and interferences (consequences of not following the standard operating procedure, SOP).

REFERENCES R

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. Revision to rapid bioassessment protocols for use in stream and rivers: periphyton, BMIs and fish. EPA 841-D-97-002. U.S. Environmental Protection Agency. Washington DC.

Burns, D.C. 1984. An inventory of cobble embeddedness of salmonid habitat in the South Fork Salmon River drainage. Payette and Boise National Forests. EPA841-F-93-002.

Harrington, J.M. 1995. California stream bioassessment procedures. California Department of Fish and Game, Water Pollution Control Laboratory. Rancho Cordova, CA.

Harrington, J.M. 1999. California stream bioassessment procedures. California Department of Fish and Game, Water Pollution Control Laboratory. Rancho Cordova, CA.

Harrington, J.M. 2002. California stream bioassessment procedures. California Department of Fish and Game, Water Pollution Control Laboratory. Rancho Cordova, CA.

Hawkins, C.P., J. Ostermiller, M. Vinson, R.J. Stevenson, and J. Olsen. 2003. Stream algae, invertebrate, and environmental sampling associated with biological water quality assessments: field protocols. Western Center for Monitoring and Assessment of Freshwater Ecosystems (www.cnr.usu.edu/wmc), Utah State University, Logan, UT 84322-5210, USA.

Heil, T.M. and P.A. Johnson. 1995. Uncertainty of bankfull discharge estimations. 3rd International Symposium on Uncertainty Modeling and Analysis. ISUMA 3: 340-345.

Kaufmann, P.R., P. Levine, E.G. Robison, C. Seeliger and D.V. Peck. 1999. Quantifying physical habitat in wadeable streams. EPA 620/R-99/003. Environmental Monitoring and Assessment Program, U.S. Environmental Protection Agency, Corvallis, OR.

Mount, J. F. 1995. California Rivers and Streams: Conflict Between Fluvial Processes and Landuse. University of California Press. Berkeley, CA. 376 p.

Peck, D.V., J.M. Lazorchak, and D.J. Klemm (editors). 2004. Environmental Monitoring and Assessment Program -Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, D.C.

Strickler, Gerald S., 1959. Use of the densiometer to estimate density of forest canopy on permanent sample plots. USDA Forest Service, Pacific Northwest Forest and Range Exp. Sta. Research Note 180, Portland, Oregon, 5 pp.

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

DEFINITIONS OF TERMS USED IN SOP D

Terms & Definitions

TERM	DEFINITION
ABL	California Department of Fish and Game's Aquatic Bioassessment Laboratory
Allocthonous	Derived from a source external to the stream channel (e.g., riparian vegetation) as opposed to autochthonous, which indicates a source inside the stream channel (e.g., periphyton).
Ambient Bioassessment	Biological monitoring that is intended to describe general biotic condition as opposed to a diagnosis of sources of impairment
Bankfull	The bankfull channel is the zone of maximum water inundation in a normal flow year (one to two year flood events)
BMI	Benthic macroinvertebrates: bottom-dwelling invertebrates large enough to be seen with the unaided eye
Cobble Embeddedness	The volume of cobble-sized particles (64-250 mm) that is buried by fine particles (<2.0 mm diameter)
CPOM	Coarse particulate organic matter (CPOM, particles of decaying organic material such as leaves that are greater than 1.0 mm in diameter)
CSBP	California State Bioassessment Procedures
DFG	California Department of Fish and Game
EMAP	The U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program
EPA	The U.S. Environmental Protection Agency
Fines	Substrate particles less than 0.06 mm diameter (not gritty to touch)
Inter-transects	Transects established at points equidistant between the main transects
MCM	Margin-Center-Margin alternative procedure for sampling low gradient habitats
ORD	EPA's Office of Research and Development
QAMP	Quality assurance management plan
RBP	EPA's Rapid Bioassessment Procedures
Reach	A segment of the stream channel
Riparian	An area of land and vegetation adjacent to a stream that has a direct effect on the stream.
RWB	Reach-wide benthos composite sampling method for benthic macroinvertebrates, also referred to as multi-habitat method
SCCWRP	Southern Coastal California Water Research Project
SNARL	Sierra Nevada Aquatic Research Laboratory
Substrate	The composition of a streambed, including both inorganic and organic particles
SWAMP	The State Water Resources Control Board's Surface Water Ambient Monitoring Program
Thalweg	A longitudinal profile that connects the deepest points at successive cross-sections of the stream. The thalweg defines the primary path of water flow through the reach

TERM	DEFINITION
Transects	Lines drawn perpendicular to the path of flow used for standardizing sampling locations
TRC	Targeted riffle composite sampling method for benthic macroinvertebrates
USFS	The United States Forest Service
Wadeable Streams	Streams that can be sampled by field crews wearing chest waders (generally less that 0.5 m - 1.0 meters deep)

APPENDIX A

FACTORS TO CONSIDER WHEN RECOMMENDING/ CHANGING BIOASSESSMENT METHODS

Beyond the primary considerations of precision and accuracy, there are at least five other key issues that SWAMP has considered and should consider in the future, when recommending or changing its official methods for bioassessment. These issues include:

1. Costs of Collecting Samples via Multiple Protocols – Collecting, processing, and interpreting samples using more than one method for each indicator (e.g., algae, macroinvertebrates, fish) per site adds significant costs to bioassessment monitoring programs. SWAMP should strive to identify the minimum set of protocols necessary for each indicator. However, this should not come at the expense of sound monitoring. If more than one method is needed to interpret the biological response, then this decision should be based on a cost-benefit assessment.

2. Costs of Maintaining Multiple SWAMP Protocols – While multiple methods for monitoring a given indicator may provide additional accuracy in specific habitats, there are significant costs to maintaining multiple protocols:

- **a.** Need to maintain method-specific infrastructure (e.g., separate reference samples, separate indices of biotic integrity (IBIs), separate O/E models, etc.).
- **b.** May lose or impair ability to compare across sites if different methods are used (see Issue 5 below).
- **c.** Guidance on when to use methods becomes more complex. For example, we need to define very specifically which methods to use at each water body type; and thus, which tools can be used to interpret them.

Recommendation: *SWAMP should maintain as few protocols as necessary. If we elect to add new or modified protocols it should be because we have determined that the added value is worth all of the costs listed above.*

3. Separating Physical Impairment from Water Quality Impairment – One of the original reasons for adding a multihabitat component to SWAMP bioassessment programs was the potential for distinguishing physical and water quality impairment sources (see recommendations in Barbour and Hill 2002). In regards to macroinvertebrate indicators, the conventional wisdom has been that reachwide (RW, sometimes referred to as multihabitat or MH) samples should be relatively more responsive to physical habitat alteration (i.e., fine sediment inputs) than targeted-riffle (TR) samples because it is believed that erosional habitats take longer to respond to sediment stresses, and because pockets of riffle habitat are thought to act as refugia from habitat loss. To the extent that this is true, RW and TR samples may offer complementary information that allows us to separate these sources of impairment.

While very few studies have addressed this conventional wisdom directly, recent studies suggest that this may not be as much a factor as previously believed. In a recent comparison of TR and RW samples at nearly 200 sites statewide, the ABL found at most weak evidence to support this notion (Rehn et al. 2007). Gerth and Herlihy (2006) came to the same conclusion in their analysis of ~500 sites in the eastern and western United States. However, this issue is far from resolved and SWAMP scientists currently are not in agreement regarding this issue. Since the majority of bioassessment programs in California have emphasized targeted riffle sampling, SWAMP will undoubtedly want to evaluate this question further before making any policy decision to discontinue TR sampling.

Recommendation: *Until this issue can be evaluated further and resolved to SWAMP's satisfaction, ambient macroinvertebrate sampling should include collection of both RW samples and richest targeted habitat (TR or MCM) samples at every site. (The TR method should be used where sufficient riffles are present, and the MCM method should be used at low-gradient sites where sufficient riffle habitat is not available.)*

4. Compatibility with Previous Data – To address this issue, at least three sets of macroinvertebrate sampling method comparisons have been conducted in California.

a. **Targeted Riffle Methods –** Comparisons are complete. Samples collected under the current TR protocols are considered interchangeable with both CSBP and SNARL samples (Ode et al. 2005, Herbst and Silldorff 2006).
b. **Low Gradient Sand-Dominated Streams –** Collaborative studies are currently underway between Water Board Regions 3 and 5, the Southern California Coastal Water Research Project (SCCWRP), and ABL to compare the performance of: (1) the "low-gradient" CSBP; (2) RW samples; and (3) a modification of the RW method designed to emphasize habitats along stream margins (MCM). The results of these low-gradient methods comparisons are not yet available.
c. **Targeted Riffle vs. Reachwide Methods –** A recent comparison of RW and TR samples collected from nearly 200 EMAP/ CMAP sites is in peer review press (Rehn et al. 2007). Results demonstrate remarkably similar performance of the methods across a wide range of habitats. Gerth and Herlihy (2006) recently published a similar analysis with the same conclusions. However, the bioassessment committee has yet to carefully review and discuss these analyses and their implications for SWAMP biomonitoring.

5. Comparability Among Sites – The ability to compare biological condition across sites is a common requirement of most ambient bioassessment programs. This type of analysis is confounded if different methods are used at these sites. One of the big advantages of reachwide (i.e., multihabitat) methods is that they can be applied anywhere because they don't require a specific habitat for sampling. Statewide bioassessments and most regional programs will require the ability to compare their bioassessment results among multiple sites (e.g., within a watershed, within a region, statewide).

INTERIM RECOMMENDATIONS FOR MACROINVERTEBRATE SAMPLING (UPDATED DECEMBER 2006):

1. Until we can reach consensus on the outstanding issues (i.e., whether a single method for macroinvertebrate sampling will meet our needs, and the outcome of RW vs. MCM comparison studies for low-gradient wadeable streams/rivers), SWAMP recommends collecting both a reachwide (i.e., multihabitat) and a targeted habitat sample at each site. In high gradient streams, this means using both the RW and TR methods. In low-gradient streams, we recommend collecting both RW and MCM samples until the results are available from the low-gradient ("non-riffle") comparison. In rare cases where monitoring objectives cannot be met following these recommendations, the SWAMP Bioassessment Coordinator may authorize deviations. For example, where project-specific objectives differ from ambient monitoring, the SWAMP Bioassessment Coordinator may authorize alternate methods. In rare cases where funding is extremely limited and the cost of following the above recommendations would be prohibitive, the SWAMP Bioassessment Coordinator may authorize cost-saving options such as collecting both samples, but archiving one of the samples for later lab analysis.

2. SWAMP should develop guidance specifying when and where different methods should be used. For example, at "low gradient" sites, what is the slope cut-off (or other channel feature criteria to use) when deciding whether to apply TR or MCM? In addition, while SWAMP may eventually choose to adopt a single method (such as RW) at most sites, some regions may determine that the value of targeted habitat sampling merits continued sampling with supplemental protocols. In the latter case, or if SWAMP determines that distinct methods are needed for different habitat types, the guidance should specify the types of waterbodies or classes of waterbodies that require different methods.

REFERENCES

Barbour, M.T., and C. Hill. 2003. The Status and Future of Biological Assessment for California Streams. Prepared by Tetra Tech, Inc., for the California State Water Resources Control Board. January 2003. Available on the Internet at: http://www.swrcb.ca.gov/swamp/reports.html

Gerth, W. J., and A. T. Herlihy. 2006. The effect of sampling different habitat types in regional macroinvertebrate bioassessment surveys. Journal of the North American Benthological Society 25:501–512.

Herbst, D.B., and E.L. Silldorff. 2006. Comparison of the performance of different bioassessment methods: similar evaluations of biotic integrity from separate programs and procedures. Journal of the North American Benthological Society 25(2):513-530. Available on the Internet at: http://www.waterboards.ca.gov/swamp/docs/herbst_silldorff.pdf

Ode, P.R., A.C. Rehn, and J.T. May. 2005. A Quantitative Tool for Assessing the Integrity of Southern Coastal California Streams. Environmental Management 35(4):493-504.

Rehn, A.C., P.R. Ode and C.P. Hawkins. 2007. Comparisons of targeted-riffle and reach-wide benthic macroinvertebrate samples: implications for data sharing in stream-condition assessments. Journal of the North American Benthological Society 26(2):000–000 (in press).

SWAMP
Surface Water Ambient Monitoring Program

For more information, please contact:

Peter R. Ode
Aquatic Bioassessment Laboratory
Water Pollution Control Lab
California Department of Fish and Game
2005 Nimbus Road
Rancho Cordova, CA 95670
pode@ospr.dfg.ca.gov

California Water Boards

www.waterboards.ca.gov/swamp

APPENDIX 3

ABL Chain of Custody (COC) Form

CHAIN OF CUSTODY RECORD

CDFG Aquatic Bioassessment Laboratory

Sampling Agency : ________________

Date/Time : ______________________

Address/Phone of Project Supervisor:

____

____

____

____

Project Name: _______________

County: _____________________

Address/Phone of Crew Member:

____

Sample #: ***ABL #:***	***Date Collected: Waterbody:***	***Site Description:*** ***# of Jars:***

Relinquished By: (Sign and Date)	***Received By: (Sign and Date)***	***Sample Location***