

**San Francisquito Creek
Aquatic Habitat Assessment:
Field Survey Plan and
Phase II Scope of Activities
(Work Product F/G)**

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October 1, 2004

Jones & Stokes. 2004. San Francisquito Creek Aquatic Habitat Assessment:
Field Survey Plan. October. (J&S 04262.04.) San Jose, CA.

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Acronyms and Abbreviations

BMI	benthic macroinvertebrate
DFG	California Department of Fish and Game
GIS	geographic information system
GPS	global positioning system
NHC	Northwest Hydraulic Consultants
RWQCB	Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SCVWD	Santa Clara Valley Water District
SRA	shaded riverine aquatic
TMDL	Total Maximum Daily Load
USGS	U.S. Geological Survey

Introduction

The Aquatic Habitat Assessment and Limiting Factors Analysis is intended to characterize channel and habitat conditions with respect to factors that limit the steelhead population in the San Francisquito Creek watershed. Information for this analysis will come both from direct data collection and analysis and from studies that have already been performed. Data collection and analysis will evaluate stressors that limit (1) aquatic habitat, (2) steelhead (*Oncorhynchus mykiss*), and (3) development of individuals in specific steelhead life history stages within the watershed. Extensive studies have already been conducted within the watershed; these can provide a base for study design, and data from these studies can be incorporated with new data for the current habitat assessment and the limiting factors analysis.

This Field Survey Plan describes the geographic scope of the study, the schedule and methodology for acquiring data, and contextual information on related watershed studies that will help guide this study. The primary purpose of this study is to evaluate the balance between stream sediment supply and transport capability and consequent effects on aquatic habitat attributes (i.e. pool volume and filling, permeability of spawning gravels, stream bed and bank stability, streambed morphology, sediment storage, etc.) and to characterize streamflow, temperature, habitat structure, and water quality as they relate to steelhead life history needs. Key questions to be answered by this study include the following.

- Is it valid to list San Francisquito Creek as impaired for sediment?
- Do any factors other than sediment limit steelhead habitat and productivity in the San Francisquito Creek watershed?
- What is the present status of habitat in the system?
- Where has steelhead habitat been impaired?
- What aspects of the aquatic habitat have changed and what caused those changes?
- What is the relative importance of habitat changes to steelhead?

The fundamental focus of this study is the 303(d) listing of San Francisquito Creek as *impaired for sediment*. The listing is “based primarily on a decline in native fish populations” (San Francisco Bay RWQCB 2004). If this claim is true, steelhead habitat, which is sensitive to the impacts of excess turbidity and sedimentation, will also be impaired, thus leading to a decline in the steelhead population in the watershed. However, there is no historical data available to refute or substantiate this claim.

While significant work has been done on sediment supply and transport within the watershed, no focused assessment of steelhead habitat for indications of biological consequences due to sediment has been completed. The connection between sediment and steelhead habitat is important in defining the basis and

potential extent of sediment impairment in the San Francisquito Creek Watershed.

The Santa Clara Valley Water District is also currently in the early stages of an effort to characterize the geomorphology of all stream channels in the watershed as part of the District's Fine Scale Assessment Project. The purpose of the Fine Scale Assessment is to gather data that can be used to identify, prioritize, and support planned and potential future stewardship projects. The geomorphic component of this project is a field methodology developed by District staff and Dr. Bill Annable of Colorado State University. This assessment protocol addresses the hydraulic geometry of the channel (i.e. longitudinal profile of the channel, identification of head cuts and bankfull elevations, and channel cross sections), but does not characterize factors that affect the life history stages of *O. mykiss*. This geomorphic assessment methodology will likely be used in the future in the San Francisquito Creek Watershed. This habitat based assessment may result in the identification and/or prioritization of specific reaches for the District to survey.

Geographic Scope

The geographic scope of this study includes the lower mainstem of San Francisquito Creek and the Los Trancos Creek subwatershed within Santa Clara County (See Appendix A, Map Sheets). While the field study will only be conducted in this area (due to resource constraints), existing data from the tributaries of the upper San Francisquito Creek watershed and the Bear Creek watershed within San Mateo County will be included and qualitatively assessed in the limiting factors analysis.

Within the geographic scope of the field survey, the habitat assessment will specifically focus on stream segments where steelhead utilization has been recorded or in potential steelhead spawning and rearing reaches. Because steelhead are known to occur throughout the defined geographic scope of this project, a majority of the project area will be surveyed.

The watershed has been extensively studied for the occurrence of steelhead, rainbow trout, and other fishes (Vogel 2002, Launer and Holtgreive 2000, Anderson 1995, DFG 1976). *O. mykiss*, which includes both steelhead and rainbow trout, has been found in the project area from the mainstem of San Francisquito Creek at El Camino Real to upstream of the Felt Lake Diversion on Los Trancos Creek. For this reason, the basic survey area will include the mainstem of San Francisquito Creek from the upstream point of tidal influence (just upstream of Highway 101) to the confluence of San Francisquito Creek and Los Trancos Creek. Los Trancos Creek will be surveyed from the confluence with San Francisquito Creek upstream to the crossing of Arastradero Road.

Additionally, geomorphic stream classification for the San Francisquito Creek watershed (NHC and Jones & Stokes 2004) will be compared to a recent spawning and rearing habitat analysis (NHC et al. 2002) to further refine the

determination of reach breaks in the watershed. These refined reach breaks will facilitate development of a random sampling methodology to identify reaches potentially utilized by steelhead. All of the streams in the watershed were classified from aerial photographs and GIS data by NHC and Jones & Stokes (2004) according to the Montgomery-Buffington (1993) stream classification system. This classification revealed that all of the mainstem reaches of San Francisquito and Los Trancos Creek in the study area are pool riffle reaches with a gradient of 1–2% and thus potential *O. mykiss* habitat suitable for surveying.

Specific selection of reaches for specific data protocols will be selected during the basic stream morphology reconnaissance. Selection criteria will be discussed in further detail under each protocol discussion. Generally, recurring monitoring points will be as close to access points as feasible for project efficiency and survey points, once selected, will not be abandoned or altered without sufficient justification and agreement among all project partners (NHC, Jones & Stokes, SCVWD, JPA, and the San Francisco RWQCB).

Study Objective

The overall objective of the San Francisquito Creek Watershed Habitat Assessment and limiting factors analysis is to place the Sediment Total Maximum Daily Load (TMDL) process in the context of *O. mykiss* habitat within the watershed. The assessment will feed directly into the Limiting Factors analysis for the watershed. Each parameter of the habitat assessment is designed to be qualitatively or quantitatively linked to steelhead mortality during all freshwater life history stages of the population (within the obvious context of the San Francisquito Creek Watershed).

Study Parameters

Each individual assessment protocol used in the Habitat Assessment is designed to address a potential limiting factor within the San Francisquito Creek Watershed and its potential for impact on one or more life history stages of *O. mykiss* (Table 1). The data collected will be qualitatively or quantitatively linked to the survival of *O. mykiss* at the appropriate life history stage(s). The survival of steelhead under each potential limiting factor will be compared to determine the limiting factors with greatest impact on steelhead production in the San Francisquito Creek Watershed.

Initial reconnaissance surveys of stream morphology in the watershed and of specific sites that have been identified for analysis will take place in September and October of 2004. Survey work will begin in the late fall to characterize the geomorphic attributes of over-wintering habitat, the survey of spawning habitat will take place from January through March of 2005, and the final assessment of juvenile outmigration will be conducted from March through early May.

The following paragraphs discuss the methodologies that were considered to assess each potential limiting factor for the Aquatic Habitat Assessment, as well as strategies and assessment methods that would resolve data gaps. Using methodologies consistent with those used in previous analyses (i.e., Napa, Sonoma, and Stevens Creek Limiting Factors Analyses) facilitates consistency within the San Francisco Bay Regional Water Quality Control Board's (RWQCB's) TMDL process and defines the watershed within the context of the greater San Francisco Bay Area.

Several potential protocol and parameters were considered and left out of this plan due to the existing data, irrelevance to the study needs, and/or level of complexity. The following study parameters were omitted from the field plan.

- Some water quality parameters (pH, turbidity, salinity, nutrient load, contaminants) were excluded. These parameters were all considered low priority and of minimal direct consequence within the San Francisquito Creek watershed
- Many large-scale sediment parameters (e.g. slope stability, erosion potential, gross bedload movement, and channel geometry) are adequately covered in previous sediment analysis studies and do not easily translate to biological consequences.
- Surveys of long profile, channel cross section, and longitudinal profile surveys, including development of hydraulic geometry regression relationships will be covered within the scope of the fine scale assessment protocol.

Table 1. Life History stages of *O. mykiss*, Known Data for the San Francisquito Creek Watershed, and Applicable Field Studies

Life Cycle	Potential Limiting Factors	Data Availability	Applicable Field Surveys
Adult Upstream Migration	Attraction flows	No known data	None proposed. Interruption and/or masking of attraction flows is not known to occur
	Migration barriers:(e.g. dams, dewatered reaches, inadequate flows, channel braiding, natural falls, culverts, road crossings, and water temperature)	Smith and Harden (2001), USGS 2004	Juvenile Outmigration Barrier Analysis
	Migration corridor hazards (e.g. bypasses, poaching)	Launer and Holtgreive 1999	None proposed. Surveys will note any additional barriers.
Spawning and Incubation	Spawning gravel quantity/redd superimposition	No known data	Redd Identification, Embeddedness, and Gravel Permeability
	Spawning gravel quality (e.g. intergravel flow, sedimentation, armoring)	No known data	Gravel Permeability, Embeddedness
	Water quality and temperature	Several sources: (SCVWD 2004, City of Palo Alto, Stanford (2004)	Temperature and Dissolved Oxygen Measurements
	Substrate mobility and scouring	NHC et al. 2003	Additional bulk sampling and visual observations
	Redd dewatering	No known data	Flow analysis, modeling, and permeability measurements
Early Rearing	Availability of suitable stream margin habitat for fry rearing	No known data	Visual assessment of banks
	Rearing habitat/spawning area proximity	SCVWD 2004	Sample reach assessment and redd identification
	Water quality (e.g. temperature, toxics)	Several sources: (SCVWD 2004, City of Palo Alto, Stanford (2004)	Temperature and Dissolved Oxygen Measurements
	Predation	No known data	None proposed
	Food availability	Carter and Fend 2000	macroinvertebrate survey
	Stranding by low flows	Metzger 2002	Flow analysis and modeling
	Displacement by high flows	No known data	Flow analysis and modeling
Juvenile Rearing	Availability of summer habitat (e.g.pools, temperature refugia, SRA)	SCVWD 2004	Sample reach assessment and pool filling measurements

Life Cycle	Potential Limiting Factors	Data Availability	Applicable Field Surveys
	Availability of winter habitat (e.g. in-channel LWD, interstitial habitat)	No known data	embeddedness measurements
	Stranding by low flows	Metzger 2002	Flow analysis and modeling
	Displacement by high flows	No known data	Flow analysis and modeling
	Predation	No known data	None proposed
	Food availability	Carter and Fend 2000	macroinvertebrate survey
	Interspecific interactions with native species	Launer and Holtgrieve 2000	None proposed
	Competition with introduced species	Launer and Holtgrieve 2000	None proposed
	Water quality/temperature	Several sources: (SCVWD 2004, City of Palo Alto, Stanford (2004)	Temperature and Dissolved Oxygen Measurements
Smolting and Outmigration	Adequate flows for outmigration	No known data	Flow analysis and modeling
	Water quality and temperature	Several sources: (SCVWD 2004, City of Palo Alto, Stanford (2004)	Temperature and Dissolved Oxygen Measurements
	Predation, poaching	No known data	None proposed

Sources: Carter and Fend 2000, City of Palo Alto, Stanford (2004), Launer and Holtgrieve 1999, Launer and Holtgrieve 2000, Metzger 2002, NHC et al. 2003, SCVWD 2004, Smith and Harden (2001), USGS 2004.

Staff Qualifications

To successfully complete data collection associated with the anadromous fish occurrence and environmental conditions, lead staff conducting the work will have the following minimum qualifications: a related 4-year college degree (e.g., fisheries biology or biology) and a minimum of 2 years' professional experience in fisheries field surveys. Specifically, staff members will have experience with

- use of various fish and fish habitat sampling techniques,
- interpretation of aerial photographs,
- use of aerial photographs as a field mapping base,
- use of global position system (GPS) equipment, and
- design and analysis of biological field studies.

The data collection methods assume that the work will be conducted by a two-person (minimum) monitoring team to facilitate safe and efficient data collection. When monitoring is being conducted, at least one team member will have the minimum qualifications as stated above.

Schedule

The timing of field surveys will be important in both the collection of relevant data and the interpretation of the effects of each potential limiting factor on steelhead life history. (A complete project schedule can be found in Appendix B). Each portion of the field survey period will focus on the time of year appropriate for the life history stage of steelhead that is directly affected (e.g. gravel permeability during the spawning period to determine effects on trout redds). The following is a synopsis of the fieldwork that will be completed within the four field survey periods over the course of the year (September 2004–May 2005).

September-October (Initial Reconnaissance and Rearing Conditions): The initial reconnaissance effort will focus on (1) field verification of the selected survey reaches selected, and (2) recording (using GPS) of the beginning and end of each survey reach. During each reach survey, temperature loggers will be deployed, basic stream morphology will be recorded, and flow measurements will be taken. Photo points will be selected for their ability to show distinct geomorphic features, eroding banks, and refugia, and these locations will be documented with photographs. All photo points will include a stable point of reference and a defined scale to facilitate comparison with future photo points. All identified passage barriers in the surveyed reaches will be verified and re-assessed.

Rearing studies will include a qualitative assessment of refuge features, characterization of available pool habitat, measurements of gravel embeddedness,

and a vegetative cover survey. An assessment of the mainstem from the Los Trancos Creek confluence to San Francisco Bay will be completed for dry reaches and isolated pools. The dry reach assessment will be conducted by vehicle at accessible crossings of the channel and will be recorded in digital photos.

November–December (Over-Wintering Conditions): The over-wintering survey will focus on obtaining embeddedness and pool-filling measurements in all of the survey reaches. Additionally, all of the temperature loggers will be checked for damage and data will be collected, photo points will be revisited to update the photographic record, and additional flow measurements will be taken.

January–March (Adult Migration and Spawning): The spawning period surveys will focus on gravel permeability measurements and redd identification in all survey reaches. All temperature loggers will be checked and additional photographs will be taken. Additional flow and embeddedness measurements will be taken during the spawning period surveys.

March–May (Juvenile Migration): The juvenile survey will focus on embeddedness and pool filling measurements in all of the survey reaches. All identified barriers in the watershed will be reassessed to ensure passage for outmigrating juvenile steelhead. Additionally, all of the temperature loggers will be removed from the field and additional photographs will be taken. Additional flow measurements will also be taken and a second assessment of dry reaches and potential stranding points will be conducted using the assessment methodology conducted during the summer. A macroinvertebrate survey will be completed using a methodology consistent with the previous USGS (Carter and Fend 2000) survey of San Francisquito Creek watershed.

Access

Santa Clara Valley Water District has existing access agreements that provide access along the mainstem of San Francisquito Creek, from Camino Real to the confluence with Los Trancos Creek. Access is available along Los Trancos Creek from the confluence upstream to just above the Felt Lake Diversion. The majority of access is for the diversion area of Los Trancos Creek and is provided through Stanford University, coordinated through Stanford Property Management, Stanford Golf Course, and Stanford Utilities. However, these agreements end in December of 2004 and will likely have to be extended to facilitate any work done in early 2005. Properties accessed will be notified as outlined in each individual access agreement.

Contingencies

All of the activities are timed for the appropriate time of year and conditions appropriate for the specific protocol. However, abnormal climatic factors such as drought or floods can skew the data for that year away from a more “normal”

condition. This is an inherent risk of any single-year study, as the data collected represents a picture of the watershed for a specific period of time. It is important to recognize that the “average year” is as much an abnormality as a year with extreme conditions. The data collected must be considered within the context of the year and any conclusions framed within that context. To prevent an extreme skewing of data survey, work will not be conducted during events in excess of the 5-year flood event, nor when any reach of the survey area is dry.

Due to the later than anticipated start of the project, the rearing habitat surveys will be cancelled if significant (> 1 inch) precipitation occurs during the survey period. Rainfall and the consequent increased streamflow would alter the bedload and channel dynamics for the summer of 2005, potentially rendering the channel morphology not representative of summer 2004 rearing conditions. These surveys would be completed in the early summer (May–June) of 2005 if cancellation were required during the currently scheduled survey period. The initial reconnaissance of basic stream morphology will be completed even in the event of precipitation.

Biology and Species Analysis

Under guidance from the RWQCB, and because of the listing of impairment to cold-water habitat beneficial use, steelhead trout was selected as the primary analysis species. The aquatic habitat assessment will address both habitat condition and the specific needs of steelhead trout throughout life stages. Steelhead trout was selected because of its threatened status and declining population in northern California, and the COLD and SPAWN impairment listings for San Francisquito Creek watershed are the most sensitive beneficial use designations (SCBWMI 2004).

A key element in using a species as an indicator for impairment is the presence of that species. Fish occurrence data from DFG, SCVWD, and Stanford was reviewed to determine the presence or absence of fish and the study locations of each survey. The San Francisco Estuary Institute (SFEI) has already entered the Leidy surveys into a database; this data was mapped directly into a GIS database developed specifically for this assessment. Due to the variable means by which fish surveys were conducted in these various studies, fish occurrence was characterized on a presence/absence basis and, while sufficient to characterize the population, was not found to provide additional value when mapped on the field survey map sheets (Appendix A) and are not included in the final map sheets.

Existing Data and Limitations/Gaps

The studies that best represent the occurrence and extent of steelhead in the watershed are the following.

- Vogel 2002. An extensive snorkel survey of juvenile *O. mykiss* in Los Trancos Creek, funded by Stanford University. The survey covered 2.3 miles of channel downstream and 1.6 miles upstream of the Felt Lake Diversion Dam in the spring of 2002. Fry and yearling trout were identified upstream and downstream of the diversion dam.
- Launer and Holtgreive 2000. A Stanford University study, in the summers of 1998 and 1999, of all fish populations in San Francisquito Creek and Los Trancos Creek. The survey started at the confluence of San Francisquito and Los Trancos creeks, continued upstream to Searsville Dam on San Francisquito Creek, and terminated at the Felt Lake Diversion fish ladder on Los Trancos Creek. A small portion of Bear Creek was also surveyed in 1998. The study found that non-native fishes supported by Searsville Lake were not expanding their range into the rest of the watershed and that “moderate to high” densities of steelhead, including yearling trout, were prevalent in the surveyed reaches.
- Anderson 1995 and California Department of Fish and Game (DFG) 1976. Summer electrofishing surveys of Bear, Los Trancos, and San Francisquito Creeks in 1976 and in 1992–1993. The effort was more extensive in 1992–1993, but steelhead were found in all streams during both surveys. However, more young of year *O. mykiss* were found upstream of the Felt Lake Diversion. Because the survey was conducted before the installation of a fish ladder in 1995, this suggests a self-sustaining rainbow trout population upstream of the diversion. However, it does not confirm a rainbow trout population because the diversion barrier was not a complete barrier to movement.

The long-term, consistent finding of juveniles and evidence of spawning clearly imply a viable steelhead population. However, very little escapement information or data on returning adults and no data on the timing of outmigration and returning adults (although this information can be assumed from juvenile presence studies and spawning data) exists. While some additional outmigrant studies would help in comparisons of outmigration and flow timing, this does not currently appear to be the best utilization of the resources available for the current project.

This study will not include the collection of steelhead biological or population data due to the special status designation of steelhead trout. The District is currently waiting approval on a district-wide application for Endangered Species Act (ESA) Section 10 permit from the National Marine Fisheries Service and may collect additional population data in the future. The incorporation of biology and population information into the limiting factor analysis will be dependent on available biological data for steelhead in the San Francisquito Creek watershed (such as the Stanford University Biodiversity studies). While additional data may be collected in the future, the current extent of data is considered sufficient to characterize the population.

Proposed Fieldwork

Given the extent of existing data on the occurrence and utilization of the watershed by steelhead, we do not see adult and juvenile trout presence as a data gap. Existing studies cover key life history stages of steelhead including spawning (SCVWD 2004) and rearing (Launer and Holtgrieve 2000, Vogel 2002). The long-term, consistent finding of juveniles and evidence of spawning clearly imply the continuous presence of a steelhead population over time. Jones & Stokes Staff will survey benthic macroinvertebrate (BMI) prey species in the spring of 2005.

List of Equipment

In addition to basic field monitoring equipment, the monitoring team will use the following specialized equipment.

- D-shaped kick net (0.5mm mesh).
- Standard Size 35 sieve (0.5mm mesh).
- Wide-mouth 500 ml plastic jars.
- White sorting pan and forceps.
- 95% ethanol.
- California Bioassessment Worksheet (CBW) (in Appendix C).
- Physical/ Habitat Quality form (in Appendix C).
- Chain of Custody form (in Appendix C).
- Random number table (in Appendix C).
- pH, temperature, DO and conductivity meter.
- Stadia rod and hand level/ clinometer.
- Densimeter/Solar Pathfinder.
- GPS unit or watershed topographic map.

In the Field

The California Stream Bioassessment Procedure (CSBP) is a standardized protocol for assessing biological and physical/habitat conditions of wadeable streams in California. The CSBP non-point source sampling design is appropriate for assessing an entire stream or large section of stream. The sampling units in this study will be riffles within a reach of stream. The stream reach must contain at least five riffles within the same stream order and relative gradient. One sample will be collected from the upstream third of three randomly chosen riffles.

1. Randomly choose three of the five riffles within the stream reach using the random number table.
2. Starting with the downstream riffle, place the measuring tape along the bank of the entire riffle while being careful not to walk in the stream. Select one

transect from all possible meter marks along the top third of the riffle using a random number table.

3. Inspect the transect before collecting BMIs by imagining a line going from one bank to the other, perpendicular to the flow. Choose three locations along that line where you will place your net to collect BMIs. If the substrate is fairly similar and there is no structure along the transect, the three locations will be on the side margins and the center of the stream. If there is substrate and structure complexity along the transect, then as much as possible, select the three collections to reflect it.
4. After mentally locating the three areas, collect BMIs by placing the D-shaped kick-net on the substrate and disturbing a 1x2-foot portion of substrate upstream of the kick-net to approximately 4–6 inches in depth. Pick up and scrub large rocks by hand under water in front of the net. Maintain a consistent sampling effort (approximately 1–3 minutes) at each site. Combine the three collections within the kick-net to make one composite sample.
5. Place the contents of the kick-net in a standard size 35 sieve (0.5 mm mesh) or white enameled tray. Remove the larger twigs, leaves, and rocks by hand after carefully inspecting for clinging organisms. If the pan is used, place the material through the sieve to remove the water before placing the material in the jar. Place the sampled material and label in a jar and completely fill with 95% ethanol. Never fill a jar more than two-thirds full with sampled material. Gently agitate jars that contain primarily mud or sand.
6. Proceeding upstream, Repeat Steps 2 through 5 for the next two riffles within the stream reach.

In the Office

1. Retrieve the sample from the sample depository and cross-check the sample number with the bioassessment laboratory number on the COC.
2. Empty the contents of the sample jar into the # 35 sieve (0.5 mm mesh) and thoroughly rinse with water.
3. Once the sample is rinsed, clean and remove debris larger than 2 inches. Remove and discard green leaves, twigs and rocks. Do not remove filamentous algae and skeletonized leaves.
4. After cleaning, place the material into a plastic tray marked with equally sized, numbered grids (approximately 2x2 inches). Do not allow any excess water into the tray. Spread the moist, cleaned debris on the bottom of the tray using as many grids necessary to obtain an approximate thickness of 2 inch. Make an effort to distribute the material as evenly as possible.
5. Remove and count macroinvertebrates from randomly chosen grids until 300 BMIs are removed. Place the BMIs in a clean petri dish containing 70% ethanol and 5% glycerin. Completely count the remaining organisms in the last grid but do not include them with the 300 used for identification. The final count should be recorded on the bench sheet for eventual abundance calculations.

6. The debris from processed grids should be put in a clean remnant jar and the remaining contents of the tray should be placed back into the original sample jar. Both jars should be filled with fresh 70% ethanol, labeled (bioassessment laboratory number and either original or remnant), and returned to the sample depository.
7. Identify the 300 BMIs from each sample to the standardized level recommended by CAMLnet using appropriate taxonomic keys.
8. Place identified BMIs in individual glass vials for each taxon. Each vial should contain a label with taxonomic name, bioassessment laboratory number, stream, county, collection date, and collector's name. This voucher collection should be labeled and returned to the Sample Depository.
9. Record taxonomic information on a Macroinvertebrate Laboratory Bench Sheet. The bench sheet should include the following information: watershed or project name; sampling date; sample ID number; bioassessment laboratory number; date of subsampling; name of subsampler; remnant jar number; taxonomy completion date; name of taxonomist; taxonomic list of organism and enumeration; total number of organisms; total number of taxa; list of unknowns, problem groups, and comments.
10. Maintain a reference collection of representative specimens of all accurately identified BMI taxa.

Limiting Factor Analysis

Without extensive quantitative data from historical and recent surveys, it is very difficult to analyze the extent and size of fish populations. Many studies circumvent this by extrapolating population potential from the historical and current extent of viable habitat in relation to the carrying capacity of each habitat unit. This methodology can prove useful, but given the wide range of habitats and variables that effect steelhead trout throughout their life history, the margin of error in these calculations can be very broad and does not provide accurate population numbers, especially when considered on a watershed scale.

The plasticity of *O. mykiss* life history characteristics further muddies the picture. The wide range in habitat variation for the species and the ability of *O. mykiss* to alter its life cycle from generation to generation can make an accurate assessment of “viable” habitat difficult, if not impossible. Hence, the numerical extent of the steelhead population will not be assessed as part of the limiting factors analysis. A qualitative reference state will be developed to characterize the population and is discussed later in this document.

In order to determine potential prey availability, macroinvertebrate surveys will be qualitatively assessed for richness of taxon and percentage composition of major taxonomic groupings and compared to previous work in the watershed and relevant, recent (i.e. within the last 10 years) from other local watersheds.

Basic Stream Morphology

The purpose of the field survey to assess aquatic habitat is to document existing habitat conditions for *O. mykiss* in the study area. Habitat mapping will document the occurrence and the lengths of riffles, runs, and pools, and the occurrence and linear distance of SRA cover, including undercut banks, overhead vegetation, and in-stream woody material in the study area. A diversity of habitat types provides spawning, resting, and feeding areas for fish. Riffles provide important fish-spawning habitat and food-producing areas, pools provide cover and moderate variability in water temperature, and runs provide habitat values intermediate between those of riffles and pools. SRA cover provides fish with escape cover from predators and shade from overwater vegetation helps to moderate water temperatures.

Existing Data and Limitations/Gaps

The only basic habitat information that has been collecting in the study area consists of survey data collected in the spring of 2003 (SCVWD 2004) during preliminary field studies for the AHALFA studies. Habitat units in Los Trancos Creek consisted largely of riffle (49%) and run (47%), with a few pools (4%). Habitat units recorded within the surveyed reach of San Francisquito Creek consisted largely of run (59%), with some riffles (21%) and deep pools (20%). Substrates observed in both creeks consisted largely of sand and gravel with cobble and boulders also present in moderate quantities.

Proposed Fieldwork

Below is a list that *summarizes* key field methods that the monitoring team will perform to map habitat. These steps are described in detail below.

To conduct habitat mapping, the monitoring team will:

- field-measure stream flow at three locations;
- map channel types and SRA cover on laminated aerial photographs, printed at a scale of 1 inch = 300 feet;
- measure channel gradient;
- measure mean bankfull and wetted width of each habitat unit;
- identify and measure structural and erosional features of the habitat unit;
- photograph each habitat unit; and
- record habitat unit and feature measurements on data collection form HABITAT-01.

List of Equipment

In addition to basic field monitoring equipment, the monitoring team will use the following specialized equipment:

- aerial photographs, printed at a scale of 1 inch = 300 feet (for mapping habitat features);
- 100-foot measuring tape;
- 12-foot minimum diameter tape;
- clinometer;
- high-resolution digital camera;
- chest waders (for each team member);
- stadia rod or other instrument for measuring stream depth;
- wading staff (for stability and identifying deep water); and
- data collection forms HABITAT-01.

In the Field

To map channel types and SRA cover in the field, the monitoring team will undertake the following activities.

1. Walk upstream in the stream channel or along the bank.
2. Map the location of each habitat unit (riffle, run, or pool) on the aerial photograph by marking the upstream and downstream extent of the habitat. The following alphanumeric naming convention will be used to label each habitat unit: water year, four-letter abbreviation for habitat unit (e.g., RIFF, RUNN, POOL), and a three-digit consecutive number for each habitat unit, beginning with 001. For example, the first habitat unit for water year 2004 will be labeled 04-RUNN-001 if the habitat unit is a run. Subsequent habitats encountered will be numbered sequentially but with their respective abbreviation for habitat unit. For example, if the first five habitats encountered are a riffle, a run, a riffle, a run, and a pool, they will be designated 04-RIFF-001, 04-RUNN-002, 04-RIFF-003, 04-RUNN-004, and 04-POOL-005. Within each habitat unit, measurements will be taken of the mean bankfull width and mean wetted width of the channel.

Note: Every part of the creek will fit into one of the habitat types (i.e., no part of the creek will be left unmapped or mapped as “other”).

3. Measure channel gradient at the beginning of each survey day and at any point when the stream gradient changes noticeably. The measurement should be taken in an open segment of the channel across one complete pool-riffle sequence. Use the clinometer to measure stream slope. If possible, take one reading from the top to the bottom of the selected channel length. Both surveyors should stand at water's edge at opposite ends of the segment to be measured. Estimate percent slope by aligning the cross hair of the clinometer with a point on your partner equal in height to your eye (or equalize to a

standard 1.5 meters) and reading the right-hand scale on the clinometer. If the stream characteristics make a top to bottom reading impossible, break the study site into two or more equal length sections and take separate readings. Average these readings to characterize the entire study site. Record the clinometer reading in the field data form to the nearest 0.5%.

4. Map the location of undercut banks, overhead vegetation, and in-stream woody material on the aerial photograph by marking the upstream and downstream extent of these cover features with different colored marking pens. Indicate the type of woody material, length of material, and DBH (diameter breast height) on the data collection form (e.g., rootwads, branches, tree trunk, etc.). DBH is measured at 54 inches from the base of the tree. If the DBH of the tree is greater than 30 cm (12 inches), it will be classified as large woody debris (LWD) All other trees will simple be classified as woody debris.

In the Office

- Download digital images from the digital camera.
- Download GPS data.

Schedule and Timing

Habitat mapping will be conducted once in September 2004.

Location and Access

Basic stream morphology will be characterized in San Francisquito Creek (from 500 feet upstream of Highway 101 to the confluence with Los Trancos Creek) and in Los Trancos Creek (from the San Francisquito Creek confluence to 500 feet upstream of Arastadero Road).

Access to these areas requires coordination with private property owners, Stanford University Land Management, Stanford Golf Course, and Stanford Facilities Management.

Limiting Factor Analysis

Habitat mapping will be rolled into several of the limiting factors analyses. The survey parameters include SRA canopy cover, which will enable further qualitative analysis of temperature. The surveys will note over-wintering and rearing refugia such as boulders, LWD, and unique channel features that could provide juvenile refuge. The surveys will also annotate the length, depth and character of eroding and/or undercut banks that relate to bedload mobility within the watershed. All of these factors will provide additional qualitative analysis and support of the quantitative analyses in the limiting factors analysis.

Physical Barriers

Physical barriers (dams, improperly sized weirs, etc.) can isolate returning adult steelhead from spawning reaches and can prevent juvenile trout from outmigrating into San Francisco Bay.

Existing Data and Limitations/Gaps

Significant rigorous studies have been completed throughout the watershed to identify potential barriers to migration (Smith and Harden 2001, NHC et al. 2002, NHC and Jones & Stokes 2004, USGS 2004).

However, barrier analysis within the watershed has been limited to upstream passage for adults, not for outmigrating juveniles. As part of the outmigration analysis, we propose to monitor known existing barriers downstream of spawning reaches to determine the extent of passability for juveniles during the period of outmigration (March–May). Reaches of the system that are dry in the summer months will also be visually assessed during this period. Flow measurements will also be collected in order to help determine the extent of passability at various potential barriers.

Proposed Fieldwork

The purpose of monitoring fish passage (with a focus on steelhead passage) is to provide documentation of the number and location of passage barriers to *O. mykiss* caused by shallow water depth, high water velocity, and/or excessive height.

The following list summarizes key field methods that the monitoring team will perform to monitor fish passage conditions based on water depth and velocity, and vertical height. These steps are described in detail below.

To monitor fish passage conditions based on water depth and velocity, and vertical drop, the monitoring team will

- field measure stream flow at three locations;
- identify artificial and natural barriers, including channel constrictions (velocity greater than 5 fps) and shallow riffles (depth less than 1 foot);
- measure stream depth;
- measure stream velocity;
- map potential depth, velocity, and vertical barriers on laminated aerial photographs, printed at a scale of 1 inch = 100 feet and by using GPS;
- photograph potential depth, velocity, and vertical barriers with a digital camera;

- record depth, velocity, and vertical barrier data on data collection forms HABITAT-02 and HABITAT-03;
- assess overall passage conditions at each potential depth, velocity, and/or vertical barrier; and
- determine whether depth, velocity, and/or height is a barrier to fish passage.

List of Equipment

In addition to basic field monitoring equipment, the monitoring team will use the following specialized equipment:

- aerial photographs, at a scale of 1 inch = 300 feet;
- depth rod (with divisions to 0.1 foot, for measuring water depth);
- velocity meter (attached to depth rod and accurate to 0.1 foot per second);
- 100-foot measuring tape;
- chaining pins and spring clamps (at least two of each);
- high-resolution digital camera;
- chest waders and life jackets (for each team member);
- wading staff (for stability and identifying deep water); and
- data collection forms WATER-01, HABITAT-02, and HABITAT-03 (in Appendix C).

In the Field

To map and document potential and actual fish passage barriers in the study area, the monitoring team will undertake the following actions.

1. Measure stream flow concurrently with Steps 2–10 below. Measure stream flow at locations (to be determined) on San Francisquito Creek and Los Trancos Creek and record all measurements on data collection form WATER-01. Flow measurement data will be collected using the following procedure.
 - An area of uniform flow, such as a run or a pool tail out, but not a pool or riffle, will be selected. Ideally, the cross section will not have large rocks, logs, or other obstacles, and the depth rod will not sink into soft substrate. A cross section perpendicular to the stream flow in the selected area will be established and will encompass the total wetted channel width at the cross section.
 - A measuring tape will be secured across the width of the channel using the chaining pins.
 - Stream depth and flow velocity along the cross section at intervals of 1 foot will be measured if the wetted channel width is greater than or equal to 25 feet or at intervals of 6 inches to 1 foot if the wetted channel width is less than 25 feet. There will be at least 25-30 intervals per cross

section. If the intervals are not evenly spaced, the greater spacing will occur in the slower moving water.

- ❑ Water depth will be measured using a depth rod with attached velocity meter at each interval of the cross section. Depth measurements will be recorded (in feet) to the nearest 0.1 foot on the data collection form.
 - ❑ If depth is less than or equal to 2.5 feet, water velocity will be measured at 0.6 of the stream depth. Velocity measurements will be recorded to the nearest 0.01 fps on the data collection form.
 - ❑ If depth is greater than 2.5 feet, water velocity will be measured at 0.2 and 0.8 of the stream depth, and recorded on the data collection form.
 - ❑ The data collection form will include comments about water observed to be entering (e.g., through an outfall) or leaving (e.g., through a diversion) the river.
 - ❑ Stream flow measurement locations will be mapped on aerial photographs and by using GPS.
2. Walk the stream reaches identified above under “Adult Migration and Spawning” to identify artificial and natural barriers, including channel constrictions (velocity greater than 5 fps), shallow riffles (depth less than 1 foot), and vertical drops (height in excess of 0.5 foot).
 3. Map the potential depth, velocity, and vertical barriers on the aerial photographs and record the potential barrier identification number on the data collection. The following alphanumeric naming convention will be used to label each potential barrier: water year, four-letter abbreviation potential barrier, and a three-digit consecutive number for each potential barrier, beginning with 001. For example, the first potential barrier for water year 2004 would be labeled 04-BARR-001.
 4. Record the GPS coordinates for the potential fish passage barrier on the appropriate data collection form.

For potential depth barriers, the monitoring team will undertake the following actions.

11. Measure water depth where depth may be a potential barrier. All measurements will be recorded on data collection form HABITAT-02 to the nearest 0.1 foot.
 - ❑ A cross section will be established with the measuring tape set perpendicular to the stream flow and across the shallowest portion of the wetted channel. The cross section will span the total width of the wetted channel, with the 0 end of the measuring tape on the right bank.

Note: Right and left banks are relative to a person facing downstream.

- ❑ The distance on the measuring tape where the left water’s edge (LWE) and right water’s edge (RWE) intersect the cross section will be recorded to calculate the wetted channel width to the nearest 0.1 foot.

- ❑ Water depth will be measured at 2-foot intervals along the cross section, using a depth rod.

Note: If the cross section is less than 5 feet wide, only one measurement at the deepest point along the cross section will be recorded.

- ❑ If water depth is less than 1 foot for any cross-section interval, the upstream and downstream extent of this shallow (i.e., less than 1 foot) depth will be determined for each cross-section interval where depth is less than 1 foot.

12. Complete the assessment portion of the data collection form.

For potential velocity barriers, the monitoring team will undertake the following actions.

1. Measure water velocity where velocity may be a potential barrier. All measurements will be recorded on data collection form HABITAT-03 to the nearest 0.1 foot per second.
 - ❑ A cross section will be established with the measuring tape set perpendicular to the stream flow and across the highest velocity portion of the wetted channel. The cross section will span the total width of the wetted channel, with the 0 end of the measuring tape on the right bank.
 - ❑ The distance on the measuring tape where the LWE and RWE intersect the cross section will be recorded to calculate the wetted channel width to the nearest 0.1 foot.
 - ❑ Water velocity will be measured, in feet per second, at 2-foot intervals along the cross section, using a velocity meter. Water velocity will be measured at 0.6 of the stream depth.

Note: If the cross section is less than 5 feet, only one measurement will be taken at the highest velocity point along the cross section.

- ❑ If water velocity exceeds 5 fps for any cross section interval, the upstream and downstream extent of this fast (i.e., greater than 5 fps) velocity will be determined for each cross section interval where velocity exceeds 5 fps and recorded on the data collection form.

2. Complete the assessment portion of the data collection form.

For potential vertical barriers, the monitoring team will undertake the following actions.

1. Identify areas where the vertical height of a drop is greater than 0.5 foot.

Note: Vertical heights of 3.0 feet or greater are considered a barrier to fish passage regardless of the values of other parameters. Vertical heights of less than 0.5 foot are not considered to be passage barriers to migrating

salmonids. Structures with intermediate vertical heights (0.5–3.0 feet) are potential vertical barriers, depending on the values of other measured parameters (e.g., staging pool depth and horizontal jumping distance).

2. Measure the height, staging pool depth, and horizontal jumping distance of the potential vertical barrier following the steps below. All measurements will be recorded on data collection form HABITAT-03 to the nearest 0.1 foot.
 - The height of the potential vertical barrier will be measured. This will be accomplished by measuring the vertical distance from the water surface to the highest point of the barrier on the downstream side of the potential vertical barrier.
 - The depth of the staging pool at the point where the water plunges into the pool will be measured using the depth rod.
 - The horizontal jumping distance will be measured. The horizontal distance is the length of stream channel fish must cover from the point where water plunges into the staging pool to a suitable landing point upstream of the barrier.
3. Determine whether the potential vertical barrier is a barrier to fish passage. The potential barrier will be considered a barrier to fish passage if:
 - barrier is more than 3.0 feet high,
 - horizontal jumping distance is greater than 5.4 feet, or
 - staging pool depth is less than 1.25 times the height of the potential barrier.
4. Photograph each potential depth, velocity, and vertical barrier from both upstream and downstream views, as necessary, to document conditions at the potential barrier at the observed flows. The digital image number for each barrier will be recorded on the appropriate data collection forms.
5. Sketch a diagram (plan view) of the potential barrier on the data collection form, showing relative locations of depth, velocity, and vertical barrier measurements. In addition, indicate the type of barrier on the data collection form (e.g., woody debris jam, shallow water, bridge culvert, weir, etc.).

In the Office

- Download digital images from the digital camera.
- Download GPS data.

Schedule and Timing

The barrier analysis work will be initially conducted during the basic stream morphology surveys in September. Flow related barriers will be reassessed during following field survey events in the late fall, winter and spring to determine the extent of flow related barrier formation throughout the year.

Location and Access

Depth, velocity, and vertical barrier data will be collected in San Francisquito Creek (from 500 feet upstream of Highway 101 to the confluence with Los Trancos Creek) and in Los Trancos Creek (from the San Francisquito Creek confluence to 500 feet upstream of Arastadero Road). Existing mapped barriers at the following locations will be reassessed:

- weir approximately 2,700 feet upstream of 101;
- two notched weirs upstream of Sunset Magazine building;
- bonde weir at El Camino Real;
- concrete apron 600 feet downstream of Alpine Road;
- weir 800 feet upstream of Alpine Road;
- four weirs between Alpine Road and Interstate 280;
- weir under Interstate-280; and
- Felt Lake Diversion structure.

Access to these areas requires coordination with private property owners, Stanford University Land Management, Stanford Golf Course, and Stanford Facilities Management.

Limiting Factor Analysis

Barriers will be qualitatively assessed in terms of accessible habitat during various times of the year. Genetic analysis of *O. mykiss* conducted in Los Trancos Creek confirms the presence of steelhead trout, which confirms the lack of complete barriers within the lower watershed. Thus, barriers will be studied to determine at what times during the year barriers are a limiting factor, and which life history stages the barriers limit. Flow analyses will be incorporated into the limiting factors analysis in order to model and predict the flow elevations at which channel flows create barriers for adult and juvenile salmonids.

Hydrology/Flow

Flow can affect the ability of adult steelhead to access natal streams during spawning. Flow can also hamper the ability of juvenile trout to outmigrate during low flows or flush them out of the system before they are ready to outmigrate during flood flows. High flows can also scour out redds, greatly reducing spawning success.

Existing Data and Limitations/Gaps

Fairly extensive data is available on flow characteristics of the watershed (Sokol 1964, Army Corps of Engineers 1972, Metzger 2002, NHC et al. 2002).

The majority of focused flow information exists for spring flows, low summer flows, and winter peak flood events, but USGS data exists year-round for San Francisquito Creek. This allows for an assessment of flow in relation to *all* critical life history stages within the watershed. However, the majority of this data has not been looked at rigorously in terms of juvenile outmigration or the ability of returning adults to access spawning reaches. This will be assessed in the limiting factors analysis. Additional flow measurements will be taken as part of the temperature modeling effort and be added to the dataset.

Water diversions identified during survey efforts will be recorded and verified, but a comprehensive diversion assessment will not be conducted. As water diversions can be undocumented and/or illegal, a comprehensive survey of diversions would require a team in the field every day throughout the summer and could place field survey crews in a position of unnecessary risk. Hence, while of value, such surveys are considered beyond the scope of the project.

Proposed Fieldwork

To monitor channel flow conditions, the monitoring team will

- field measure stream flow at two locations in addition to flow measurements at barrier locations;
- measure stream depth and wetted width;
- measure stream velocity; and
- record depth, wetted width, and velocity data on data collection form Water-01.

List of Equipment

In addition to basic field monitoring equipment, the monitoring team will use the following specialized equipment:

- aerial photographs, at a scale of 1 inch = 300 feet;
- depth rod (with divisions to 0.1 foot, for measuring water depth);
- velocity meter (attached to depth rod and accurate to 0.1 foot per second);
- 100-foot measuring tape;
- chaining pins and spring clamps (at least two of each);
- high-resolution digital camera;
- chest waders and life jackets (for each team member);

- wading staff (for stability and identifying deep water); and
- data collection form WATER-01.

In the Field

To record stream flow in the study area, the monitoring team will undertake the following activities.

1. An area of uniform flow, such as a run or a pool tail out, but not a pool or riffle, will be selected. Ideally, the cross section will not have large rocks, logs, or other obstacles, and the depth rod will not sink into soft substrate. A cross section perpendicular to the stream flow in the selected area will be established and will encompass the total wetted channel width at the cross section.
2. A measuring tape will be secured across the width of the channel using the chaining pins.
3. Stream depth and flow velocity along the cross section at intervals of 1 foot will be measured if the wetted channel width is greater than or equal to 25 feet or at intervals of 6 inches to 1 foot if the wetted channel width is less than 25 feet. There will be at least 25–30 intervals per cross section. If the intervals are not evenly spaced, the greater spacing will occur in the slower moving water.
4. Water depth will be measured using a depth rod with attached velocity meter at each interval of the cross section. Depth measurements will be recorded (in feet) to the nearest 0.1 foot on the data collection form.
5. If depth is less than or equal to 2.5 feet, water velocity will be measured at 0.6 of the stream depth. Velocity measurements will be recorded to the nearest 0.01 fps on the data collection form.
6. If depth is greater than 2.5 feet, water velocity will be measured at 0.2 and 0.8 of the stream depth, and recorded on the data collection form.
7. The data collection form will include comments about water observed to be entering (e.g., through an outfall) or leaving (e.g., through a diversion) the river.
8. Stream flow measurement locations will be mapped on aerial photographs and by using GPS.

In the Office

- Download digital images from the digital camera.
- Download GPS data.

Schedule and Timing

The barrier analysis work will be initially conducted during the basic stream morphology surveys in September. Flow related barriers will be reassessed

during following field survey events in the late fall, winter and spring to determine the extent of flow related barrier formation throughout the year.

Location and Access

Stream flow data will be collected in San Francisquito Creek at the following locations:

- Downstream of the inlet from Felt Lake into Los Trancos Creek.
- Oak Court Apartments access point across from the tennis courts.

Additionally, flow may be measured at the following barrier locations based on the results of the initial barrier survey:

- weir approximately 2,700 feet upstream of 101'
- two notched weirs upstream of Sunset Magazine building;
- bonde weir at El Camino Real;
- concrete apron 600 feet downstream of Alpine Road;
- weir 800 feet upstream of Alpine Road;
- four weirs between Alpine Road and Interstate 280;
- weir under Interstate-280; and
- Felt Lake Diversion structure.

Access to these areas requires coordination with private property owners, Stanford University Land Management, Stanford Golf Course, and Stanford Facilities Management.

Limiting Factor Analysis

Flow will be analyzed in a quantitative model that will predict the flows required to meet downstream passage requirements for outmigrating juvenile steelhead. This will be qualitatively compared to actual average flow conditions to determine the extent of impairment and potential for flow to limit the success of outmigration.

Water Quality

Temperatures in excess of 24°C (75°F) can cause direct physiological impacts to *O. mykiss* and create a barrier to the movement of steelhead in and out of the watershed. Even when acclimation temperatures are high, temperatures of 24-27°C (75-80°F) are invariably lethal to trout, except for very short exposures (Moyle 2002). As temperatures increase, more food is required for steelhead to

maintain physiological functions. Additionally, studies have shown that optimal temperatures for trout growth are in the range of 15-18°C (59-64°F) (Baltz et al. 1987).

Dissolved oxygen is critical to the development of eggs and juveniles and is obviously necessary for any life history stage of steelhead. However, optimal dissolved oxygen levels for egg development and alevin growth is at or close to saturation (9.0-12.0 mg/L) (Moyle 2002). Changes in water temperature may also have substantial indirect effects on fish by altering the physical properties of the water on which the fish depend. For coldwater fish such as steelhead, reduced dissolved oxygen associated with high water temperatures is frequently a serious problem (the dissolved oxygen capacity of water is inversely related to temperature). Other indirect temperature-related issues include temperature-dependent changes in the biological activity of a pollutant and changes in behavior or physiology that affect the competitive balance among species and hence may result in a shift in fish species composition or relative abundance.

Existing Data and Limitations/Gaps

Temperature data has been collected throughout the watershed in conjunction with a variety of studies. Both the City of Palo Alto and Stanford University maintain temperature gages on San Francisquito Creek, Matadero Creek, Adobe Creek, Bear Creek, Los Trancos Creek, and Corte Madera Creek. Temperature is a simple factor to record, but can be difficult to analyze and place within the larger context of the watershed and the various factors that influence temperature. Stowaway temperature loggers will be installed for the study period to augment the existing data collection efforts. Additionally, a Shaded Riverine Aquatic (SRA) Cover analysis and flow measurements will be completed in order to develop a simple model of temperature in San Francisquito Creek. The temperature modeling would likely focus on summer habitat of juveniles upstream of the confluence of San Francisquito and Los Trancos Creeks.

Proposed Fieldwork

The purpose of this monitoring is to provide additional documentation of existing water temperature conditions for steelhead in the study area. The data will be used to evaluate existing water temperature conditions in relation to the spawning, egg incubation, and rearing needs of steelhead.

Below is a list that summarizes key steps for monitoring stream water temperature. These steps are described in detail later in this section.

To monitor water temperature and dissolved oxygen, the monitoring team will

- check the performance of the water temperature loggers and hand-held field thermometer;
- launch or activate water temperature loggers;

- place water temperature loggers at six specified monitoring locations;
- record the monitoring location for each water temperature logger;
- photograph the location of the water temperature logger;
- download water temperature logger data to a shuttle or laptop computer at the beginning of each month;
- record water temperature using a hand field thermometer during placement and retrieval of water temperature loggers and when downloading data from the loggers (for quality assurance);
- retrieve data from the temperature loggers monthly and record dissolved oxygen levels during logger data transfers; and
- retrieve water temperature loggers on or after April 30, 2004 (during the spring survey period).

List of Equipment

In addition to basic field monitoring equipment, the monitoring team will use the following specialized equipment:

- computer with software for the water temperature loggers (may be a laptop computer for field use or a desktop computer for office use);
- high-resolution digital camera;
- hand-held water temperature thermometer for field use to verify water temperatures at times of deployment of water temperature loggers and downloading of data in the field;
- hand-held dissolved oxygen meter;
- chest waders and life jackets (for each team member);
- Onset StowAway[®] water temperature loggers (or comparable water temperature loggers) (four total);
- Onset StowAway[®] water temperature logger shuttle (one);
- submersible water temperature logger cases with cable and U-bolts to protect and secure water temperature loggers in the field (one for each water temperature logger); and
- data collection form WATER-02.

In the Field

To monitor water temperature, the monitoring team will prepare temperature loggers as follows:

1. Check the accuracy of the loggers before the water temperature loggers are deployed. Accuracy of the loggers and the hand-held field thermometer measurements will be compared to each other in crushed ice and at room temperature. If a logger or the hand-held thermometer has more than a 0.5°C difference from the other loggers, it will not be used.

2. Program the water temperature loggers to record a temperature every hour.
3. Record the six-digit identification number (i.e., serial number) of each water temperature logger on data collection form WATER-02.

In the field, select suitable sites for the water temperature logger placement. Suitable sites include deep points of the stream cross section through riffles, runs, or pool tail outs where water temperature loggers will remain submerged in the stream during the data collection period and where loggers will be out of view of the public so as to minimize vandalism and theft.

4. Record the water temperature logger location on the data collection form, and place the water temperature logger in a submersible case.
5. Secure the water temperature case with cable and a U-bolt to metal stake that is driven into the creek bed or bank.
6. Record the location of the water temperature logger on the aerial photographs and by using GPS.
7. Take a water temperature reading using a hand-held thermometer and record the reading on data collection form WATER-02.
8. Photograph the location of the water temperature logger, including significant and recognizable landmarks, to aid in the retrieval of data and the logger. The digital image number will be recorded on the data collection form.
9. Download water temperature logger data to a shuttle or laptop computer at the beginning of each month starting in September 2004 and ending in May 2005. Record dissolved oxygen levels at the logger location and record the reading on data collection form WATER-02.

In the Office

- Download the digital images.
- Download temperature data.
- Download GPS data.

Schedule and Timing

Measured water temperatures will be recorded continuously (i.e., hourly) from February through December 2004. Dissolved oxygen will be collected monthly during the download of data from temperature loggers at the beginning of any day that survey crews are in the field.

Location and Access

Measured water temperature data will be collected at four locations in the San Francisquito Creek watershed in addition to the existing temperature gauges. Temperature loggers will be located at

- San Francisquito Creek at Newell Road;
- Oak Court Apartments access point across from the tennis courts;
- Downstream of the inlet from Felt Lake into Los Trancos Creek; and
- Los Trancos Creek at Arastadero Road.

Access to these areas requires coordination with private property owners, Stanford University Land Management, Stanford Golf Course, and Stanford Facilities Management.

Limiting Factor Analysis

In addition to the temperature and SRA analysis, an additional cover analysis will be completed using high-resolution aerial photographs of the entire study area. All of these collected data will be entered into the JSATemp model in order to evaluate temperatures in San Francisquito and Los Trancos Creeks. Temperature modeling will be qualitatively compared to known temperature criteria for steelhead and used to determine the potential for mortality due to high temperatures and the consequent loss of habitat created in areas of high stream temperatures.

Sediment

Sediment can have a variety of effects on steelhead during all life history stages, including turbidity, gravel permeability, embeddedness, pool filling, and bed mobility. Turbid water can impact *O. mykiss* by “clogging” or damaging the gills. The accumulation of fine sediment in gravels used for spawning can reduce gravel permeability and the ability of dissolved oxygen to reach redds. The filling of interstices of stream gravels (embeddedness) and the filling of pools which provide refuge for young of year and yearling trout, can reduce the availability and/or quality of rearing habitat. Bed mobility, a function of flow regime and erosion potential, can result in the scouring of redds, as discussed in the flow section.

Gravel quality for spawning and rearing is largely a function of gravel permeability and embeddedness. Neither of these habitat characteristics has been extensively studied within the San Francisquito Creek Watershed.

Turbidity

High turbidity and suspended sediment concentrations can have detrimental effects on aquatic biota in river systems (e.g. Cordone and Kelley 1961, Sigler et al. 1984, Newcombe and MacDonald 1991, Shaw and Richardson 2001). While very high turbidity levels may cause acute physiological stress and tissue damage to some aquatic organisms during peak flows, fish tend to survive high turbidity levels over short periods of time. Lower levels of turbidity over longer time

periods can be more harmful to fish than higher intensity short-duration events (Shaw and Richardson 2001). Therefore, chronic sediment sources that continue to supply sediment to channels after peak flow events can be particularly harmful to juvenile steelhead.

Existing Data and Limitations/Gaps

Suspended sediment has been extensively studied throughout the watershed (Owens et al. 2003, NHC and Jones & Stokes 2003). Additional data gathering will not occur as part of the proposed field survey program.

Proposed Fieldwork

At the beginning of any day during which surveys are being conducted in the San Francisquito Creek watershed or temperature data is being collected, turbidity will be measured using a secchi tube.

Schedule and Timing

Turbidity measurements will be taken monthly when temperature readings are collected from temperature loggers and at the beginning of any day that survey crews are in the field.

Location and Access

Access will be consistent with the methodology for the surveys on which this collection will piggyback.

Limiting Factor Analysis

Turbidity will be discussed in the limiting factors report but will not be quantitatively analyzed as a potential limiting factor.

Permeability

The key factor determining survival of salmonids during egg incubation through fry emergence is the presence of sufficient flow of cool, clean water through the spawning gravels to ensure delivery of dissolved oxygen and elimination of metabolic wastes. When a high percentage of fine sediment is deposited in or on the streambed, gravel permeability (or flow rate of water through the gravels) can be substantially reduced. Reduction of gravel permeability results in progressively less oxygen and greater concentrations of metabolic wastes around

incubating eggs and alevins (newly hatched fish larvae or sac-fry) as they develop in the pore spaces between gravels, resulting in higher mortality (Platts et al. 1979, Barnard and McBain 1994). At the time permeability measurements are taken, a field measurement of dissolved oxygen will also be taken.

To determine the quality of streambed gravels, substrate permeability will be measured using a modified Mark IV standpipe (Terhune 1958, Barnard and McBain 1994). The recharge rate (the rate at which water moves through the substrate) derived from these measurements will be converted to permeability using a rating table with a temperature and viscosity correction from Barnard and McBain (1994).

Existing Data and Limitations/Gaps

Gravel permeability studies have never been undertaken within the San Francisquito Creek Watershed.

Proposed Fieldwork

The permeability selected spawning gravel beds can be measured equally well by pumping water either into or out of the gravel via a piezometer. A piezometer is a small diameter well with a section of screened or otherwise perforated tube at one end to allow movement of subsurface water into and out of the well.

Intragravel permeability is estimated from the rate of flow into the piezometer (inflow rate) by pumping water out of the substrate through a piezometer built following the original design by Terhune (1958), except that a 3.8 cm diameter stainless steel tube is used in place of Terhune's less durable 3.2 cm aluminum tube (Barnard and McBain 1994). The stainless steel piezometer is closed at one end by a stainless steel driving point, and immediately above the driving point, the tube is perforated all around with evenly spaced rows of small holes to allow the free movement of water into the tube from anywhere in the adjacent water column (Terhune 1958). Piezometers of this design are intended for repeat point-in-time sampling of substrate permeability in the hyporheic zone in general and spawning habitat specifically.

The piezometer is driven into the gravel by hand, and the intragravel water enters the tube through the holes. At each sample site, the piezometer is driven into the gravel substrate until the holes in the piezometer reach the desired sampling depth. The rate of water flow out of the substrate and into the piezometer at each habitat site is measured at depths of 15 cm, 30 cm, and 46 cm. At each sample depth, the water is pumped out of the piezometer to remove water from the surface or from previously sampled depths and to allow intragravel water to refill the piezometer from the desired sample depth.

A battery-operated suction pump is used to maintain a 2.5 cm pressure head to cause water to flow out of the gravel and into (inflow) the piezometer. By maintaining the pressure head, the suction apparatus allows evacuation of water

from the piezometer equal to the rate water flows into the piezometer from the surrounding gravel. The water is collected in a 1 liter graduated cylinder so that the volume per unit time (*i.e.*, inflow rate) can be measured.

Sample permeability is estimated by a comparison of empirical permeability and correct inflow, based on a corrected inflow calibration curve adapted from Terhune (1958) and recalibrated by Barnard and McBain (1994) for the modified piezometer. Empirical permeability is determined by averaging the inflow rate from three sample depths, standardizing the value to a temperature of 10 C, and correcting for viscosity.

Schedule and Timing

Permeability measurement will be taken by a crew staffed by one person from Northwest Hydraulic Consultants and one from Jones & Stokes associates. Surveys will be conducted once during the spring survey period (April-May).

Location and Access

During the basic stream morphology reconnaissance, the sites of spawnable gravels will be recorded. A random (or possibly complete) selection of those sample sites will be surveyed for permeability.

Access to these areas requires coordination with private property owners, Stanford University Land Management, Stanford Golf Course, and Stanford Facilities Management.

Limiting Factor Analysis

The relationships between survival-to-emergence and permeability will be calculated from two data sets (McCuddin 1977, Taggart 1976), consistent with the methods used in previous limiting factors analyses. The following simple linear regression will be used on the combined data sets to estimate survival based on permeability measurements taken in the field:

$$\blacksquare \text{ Survival} = 0.1488 * \ln(\text{Permeability}) - 0.8253 \quad (1)$$

where permeability is in units of cm/hr and

$$\blacksquare \text{ Mortality Index} = (1 - \text{Survival}) * 100 \quad (2)$$

Embeddedness

The degree to which fine sediments surround interstices of stream gravels and coarse substrates on the surface of a streambed is referred to as embeddedness.

Although the term and its measurement were initially developed to address habitat space for juvenile steelhead trout, embeddedness measures have been used to assess fish spawning and macroinvertebrate habitat, as well as substrate mobility. The methodology to be used will be the Burns Method (Burns 1984) with some modifications proposed by Skille and King (1989). The technique requires sampling measuring the depth of embeddedness and total particle depth of all substrate between 4.5 and 30 cm (fines are defined as particles less than 6.35 mm). Sample substrates are selected by the random tossing of a 60 cm hoop within the selected habitat unit until at least 100 particles have been measured.

Existing Data and Limitations/Gaps

Embeddedness measurements have not been taken within the San Francisquito Creek Watershed.

Proposed Fieldwork

Below is a list that summarizes key field methods that the monitoring team will perform to map habitat. These steps are described in detail below.

To conduct embeddedness measurements, the monitoring team will

- identify suitable spawning gravel beds and record location on aerial photographs and by using GPS;
- visually estimate the elevation of the gravel bed relative to the current water surface elevation to determine whether the gravel will be inundated during anadromous fish spawning periods;
- measure average gravel bed length and width;
- measure gravel bed depth;
- measure gravel size;
- excavate gravel samples at least 6 inches in diameter by 6 inches deep at the deepest point of the gravel bed;
- numerically categorize the gravel by quality category;
- photograph each quality sample; and
- record spawning gravel abundance and quality data on data collection forms HABITAT-04 and HABITAT-05.

List of Equipment

In addition to basic field monitoring equipment, the monitoring team will use the following specialized equipment:

- aerial photographs, printed at a scale of 1 inch = 300 feet (for mapping habitat features);

- 100-foot measuring tape;
- high-resolution digital camera;
- chest waders (for each team member);
- stadia rod or other instrument for measuring stream depth;
- ruler in metric units (to assist in estimating gravel size);
- plastic bucket (12-inch diameter);
- shovel;
- sampling grid (a clear plastic sheet with 9 squares in each row and each column that forms eighty-one 5-centimeter squares and has lines intersecting at 100 points);
- plastic tarp (to lay gravel samples on);
- wading staff (for stability and identifying deep water); and
- data collection forms HABITAT-04 and HABITAT-05.

In the Field

1. Identify all suitable spawning gravel beds to be monitored. Suitable spawning gravel beds conform to the following characteristics:
 - have a minimum area of 10 square feet and are at least 6 inches deep (depth refers to thickness of gravel layer);
 - are not armored with cobbles or rocks greater than 6 inches in diameter; and
 - contain gravel sizes ranging from 0.25 to 4.0 inches in diameter and average 2.0 inches in diameter.
2. Record the location of the gravel bed on the aerial photographs and provide a location description and GPS coordinates of the gravel bed on data collection form HABITAT-04 under “Comments/Location (Narrative)” column.
3. Use the following alphanumeric naming convention to label each gravel bed: water year, four-letter abbreviation for gravel bed, and a consecutive number for each gravel bed beginning with 001. For example, the first gravel bed for water year 2004 will be labeled 04-GRAV-001.
4. Visually estimate the percentage of gravel within each foot of contour elevation (elevational unit).

Note: An elevational unit is used to determine what portion of a gravel bed will be inundated during anadromous fish spawning periods.

- Establish a cross section through the gravel bed by stretching a measuring tape across the gravel bed, making sure that the cross section generally encompasses all elevations of the gravel bed.
- Measure the average length and width of the gravel bed in feet and record on the data collection form.

- ❑ Determine the lowest point of the cross section relative to the stream surface by walking along the cross section and measuring water depth at regular intervals with a depth rod.
- ❑ Beginning at the lowest point along the cross section, visually estimate the percentage of gravel (to the nearest whole percent) in each elevational unit and record on the data collection form. Elevational units are relative to the stream water surface and describe the elevation of the gravel in 1-foot increments. Negative numbers designate elevational units below the water surface, positive numbers designate elevational units above the water surface, and 0 is the water surface. For example, elevational unit -3 to -2 is between 2 and 3 feet below the water surface, and elevational unit 0 to +1 is between 0 and 1 foot above the water surface. The percentages in the elevational units are not cumulative, that is, they are not added to the percentage in the adjacent elevational unit.
- ❑ Measure the depth (i.e., thickness) of the gravel bed.
- ❑ Dig a 6-inch diameter hole or larger in what appears to be the deepest (i.e., thickest) part of the gravel bed and place the gravel excavated from the hole in a bucket. The depth of the hole should be at least 6 inches or, if less, excavated to a point at which the gravel becomes too embedded to remove.
- ❑ Measure the depth of the hole (gravel bed depth) to the nearest 0.1 foot and record on the data collection form.

Note: Gravel excavated for this survey will be set aside for use in the spawning gravel quality monitoring.

- ❑ Visually estimate the average size of gravel found within the gravel bed. Record on the data collection form the corresponding gravel class, as listed in Table 2.

Table 2. Classification of Gravel by Average Size

Gravel Class	Average Size [millimeters (inches)]
Fine gravel	6–25 (0.25–1)
Medium gravel	26–50 (1.1–2.0)
Coarse gravel	51–75 (2.1–3.0)
Small cobble	76–102 (3.1–4.0)

5. Spread the material excavated for estimating spawning gravel bed depth evenly over the tarp.
6. Photograph the sample with the ruler placed in the frame to give a scale perspective, and record the digital image number on data collection form HABITAT-05.

7. Overlay the gravel sample that is spread on the tarp with the sampling grid.
8. Record the category for the size of each particle (Table 3) that lies under each point of line intersection on the grid. A tally of the number of particles in each size category will be recorded, and the total number of particles within each size category will be summed on data collection form HABITAT-05. A minimum of 85 particle measurements will be recorded.

Table 3. Numeric Categories of Substrate Particle Size for Steelhead Spawning Habitat

Particle Size		
Inches	Millimeters	Category
<0.08	<2	1
0.08–0.2	2–5	2
0.3–1.0	6–25	3
1.1–4.0	26–102	4
4.1–6.0	103–150	5

Modified from Crouse et al. 1981.

9. Backfill the excavated hole with the original material.

In the Office

- Download digital images from the digital camera.
- Download GPS data.

Schedule and Timing

Embeddedness measurements will be taken during the summer and winter survey periods.

Location and Access

During the basic stream morphology reconnaissance, the sites of spawnable gravels will be recorded. A random (or possibly complete) selection of those sample sites will be surveyed for permeability.

Access to these areas requires coordination with private property owners, Stanford University Land Management, Stanford Golf Course, and Stanford Facilities Management.

Limiting Factor Analysis

Embedded reaches will be quantitatively grouped by embeddedness class and will be qualitatively assessed for loss of over-wintering habitat. From this information, mortality curves will be calculated, from which determinations will be made about the potential for loss of over-wintering habitat to limit the San Francisquito Creek *O. mykiss* population.

Pool Filling

If the total and/or fine sediment load is high relative to transport capacity of a channel, large deposits of fine bed material may accumulate in pools. Reduction in pool volume caused by fine sediment deposition is biologically important because it has the potential to reduce the amount of juvenile rearing habitat for salmonids and other native fish and aquatic wildlife. To determine the impact of pool filling by fine sediment in the study reaches, the V^* technique developed by Hilton and Lisle (1993) will be used. The technique estimates the proportion of the residual pool filled by fine sediment, where “residual pool” is defined as the scoured volume of the pool lying below the downstream grade control. V^* (“the fraction of pool volume filled with fine sediment” [Hilton and Lisle 1993]) is estimated in a study reach within a stream channel by measuring the water and fine sediment volume in the residual pool in all of the pools in that reach and then calculating the weighted average value of V^* for the reach.

Existing Data and Limitations/Gaps

Pool filling surveys have not been conducted within the San Francisquito Creek Watershed.

Proposed Fieldwork

Volumes of water and fine sediment in the residual pool are calculated from measurements of water and fine-sediment depth along a series of cross sections in the pool. The basic technique is essentially a systematic sample, with cross sections spaced evenly along the length of the pool. Zero area cross sections are assumed at the ends of the pool. Depth-measurement points are spaced evenly across each cross section and at either end. The locations of both the cross sections and the depth-measurement points are determined from a random starting location.

List of Equipment

In addition to basic field monitoring equipment, the monitoring team will use the following specialized equipment:

- two measuring tapes;

- chaining pins;
- a graduated rod (The rod must be long enough to measure water depth plus fines depth in the deepest part of the pool. A rod made of 0.5-inch diameter stainless steel probes fine sediment deposits well without bending);
- a calculator with a random number generator or a random number table;
- wading staff (for stability and identifying deep water); and
- data collection notebook.

In the Field

The basic systematic sample will be described first, followed by examples of modifications for specific situations.

1. Stretch a tape along the length of the pool, from the upstream end to the furthest point on the riffle crest or along the longest dimension of the pool. This tape must be straight, because bends will distort the volume calculations. If the pool is so irregular that a bend cannot be avoided, divide the pool into sections and measure each separately.
2. Draw a sketch map of the pool, showing locations of the upstream end of the pool, riffle crest, areas of fine-sediment deposition, and major features of the pool, such as logs and outcrops.
3. Decide on the number of cross sections and the distance between depth-measurement points. The appropriate sampling intensity depends on the complexity of the pool and on the accuracy required. Four to 10 cross sections should be taken in each pool. Set the distance between depth locations to provide 7 to 16 points across the widest cross section.
4. Determine the locations of cross sections and depth-measurement points. Divide the total length of the pool by the number of cross sections to find the distance between sections. Choose a random number between zero and this distance to locate the first cross section, and add the chosen spacing to locate the remaining sections. Choose random numbers between zero and the distance between depth-measurement points to locate the first point in from the edge of each cross section.
5. Run a tape perpendicular to the lengthwise tape at each cross-section location. Measure water depth and the thickness of any fine sediment present at each measurement point with a graduated rod. Fine sediment depth is determined by probing with the rod until a change in resistance is felt as it strikes coarser material. A small sledge may be useful for probing deep deposits. The cross section begins at the edge of the scoured residual pool, where water depth plus fines depth becomes greater than riffle-crest depth. Record total water depth and fines depth at both edges of the pool and at regular intervals across the pool as determined in Step 4. If a fine deposit deep enough to be included in the scoured pool extends above the water surface, record height above the water surface as a negative water depth.

Schedule and Timing

V* measurements will be taken once in the fall as part of the survey program.

Location and Access

During the basic stream morphology reconnaissance, all pools will be identified and recorded. A random (or possibly complete) selection of those pools will be surveyed.

Access to these areas requires coordination with private property owners, Stanford University Land Management, Stanford Golf Course, and Stanford Facilities Management.

Limiting Factor Analysis

Loss of pool habitat equates to the loss of rearing and over-wintering refuge for juvenile steelhead. Mortality associated with the loss of rearing habitat in pools will be calculated in terms of loss of habitat and will be compared to other potential limiting factors.

Bed Mobility

Successful hatching and emergence require stable gravels in and around the egg pocket. Scouring of redd gravels can alter redd hydraulics and cause abrasion or displacement of eggs, resulting in reduced survival rates or direct egg mortality. Therefore, steelhead spawning success requires that deep scour of the bed does not occur during the time the eggs are incubating in gravel deposits (or redds). Seasonal bed mobility, on the other hand, enhances food production and reduces the accumulation of fines in the bed. Relative bed mobility varies naturally among gravel bedded rivers and it is typically higher where the gravel supply is higher.

Existing Data and Limitations/Gaps

Based on applying sediment rating curves to simulated flows, bed load transport in Bear Creek is just over one-third of that in Los Trancos, and suspended sediment transport is about 3.5 times greater than from Los Trancos Creek (NHC et al 2002). On this basis, bed load transport from 1995 to 2000 is estimated to be 3,300 yd³; suspended load transport is estimated to be 30,000 yd³. Average annual load is then 6,700 yd³. Assuming that the bedload is sand and gravel and that the suspended load is one-third sand and two-thirds silt and clay, the total load from 1995 to 2000 consisted of 13,300 yd³ of coarse sediment and 20,000

yd³ of fine sediment. The above estimates are not exact, but they are adequate for evaluating estimated erosion.

Long-term sediment transport (1964 to 2002) calculated by applying the suspended sediment rating curve to simulated flows and from bed material transport calculated from the calibrated HEC-6 model (NHC et al 2002) is about 46% of that from 1995 to 2000, or about 3,100 yd³. Coarse sediment is assumed to be only a small portion of the long-term annual load. Combined long-term annual transport from Bear and Los Trancos amounts to a little more than half of the long-term annual load estimated for the gage on San Francisquito Creek, suggesting the long-term estimates for the individual tributaries are too low.

As part of the reconnaissance-level geomorphic surveys, data will be collected that can provide a qualitative assessment of bed mobility in the basin. The surveys will note slope, grain size, condition of the bed and banks, and other geomorphic characteristics that can affect bed mobility during this survey. Seasonal flow data will also be incorporated into this analysis. Bulk samples from the bottom of Searsville Lake, currently housed at the Jasper Ridge Biological Preserve, will also be assessed to determine the bedload composition of materials transported out of Corte Madera Creek.

Proposed Fieldwork

See field methodologies, schedule, timing, and access restraints for “Basic Stream Morphology” and “Embeddedness.” Both surveys will provide data that will be used to assess bed mobility in the limiting factors analysis.

Additionally, a redd survey will be conducted from San Francisquito Creek at El Camino Real upstream to the confluence with Los Trancos Creek and upstream on Los Trancos Creek to Arastadero Road. Redds identified during spring surveys will be marked using GPS and photographed. Redds will not be physically disturbed. The redd survey will be conducted once during the spring survey period. The redds will be qualitatively assessed for the effects of scour.

Limiting Factor Analysis

Loss of redds due to scour can be a catastrophic limiting factor in terms of egg mortality. Mortality associated with the loss of redds will be calculated and compared to mortality regressions for other potential limiting factors. Loss of redds will be qualitatively assessed based on the morphology of redds. Watershed level bedload will be qualitatively characterized in support of the limiting factors analysis.

Reference State Model

Develop a reference state conceptual model that describes watershed processes (i.e. precipitation, erosion and sedimentation, channel form and function, etc.) and conditions controlling spatial and temporal variations in stream habitat quality (i.e. gravel embeddedness and decrease in spawning, pool siltation and decrease in rearing, stream flow diversions and base flow reductions, dams and migration barriers, decrease in riparian vegetation and increases in temperature, availability of large woody debris, predators and increased competition, increase in nutrients and toxicity, etc.). Qualitative historic and existing condition conceptual models will be developed to identify broad scale spatial and temporal aquatic habitat changes and impacts, and to identify factors causing these impacts. The conceptual model will be based on existing historical data and/or anecdotal records.

Due to the severe hydromodification and urbanization of the watershed that extends back earlier than most written records, the reference state cannot be inferred from existing watershed processes or reasonably extrapolated from best professional judgment. The extreme statistical error inherent in assumptions of the historical reference state could result in the potential for misinterpretation of the conclusions by stakeholders.

Limiting Factors Analysis Technical Report

The limiting factor analyses for aquatic habitat will be conducted in order to interpret the biological significance for steelhead of any alteration of habitat that is identified in existing studies and the currently proposed surveys. This analysis incorporates geomorphology, habitat and biological requirements, and population dynamics into the modeling of the abundance and distribution of the analysis species (steelhead). The reference state model and field data—collected to describe the quality and quantity of habitat currently available in the watershed—will be used in the limiting factors analysis. All habitat factors will be analyzed in terms of current mortality (i.e., to determine the source of steelhead mortality limiting the population to the greatest extent during the survey period).

A wide range of factors may limit the size and growth potential of *O. mykiss*. While each of these factors may serve as the primary limiting factor under specific circumstances, the goal of the limiting factors analysis is to identify the factor or factors that appeared to be limiting the population under current conditions in San Francisquito Creek and its tributaries. The primary aim of the limiting factors analysis is to combine knowledge of various potential limiting factors with focused studies to elucidate (1) the cause-and-effect relationships between land and water use activities in the watershed and (2) their effects on the analysis species and general aquatic ecosystem health. This will yield a more quantitative understanding of the viability of potential restoration and management strategies and actions that are available to restore analysis species. As noted in the discussion of field survey activities, the analysis of potential

limiting factors is more efficient when organized by life history stages. I agree, please note anywhere you find such uses and I will eliminate]

Ancillary Activities

The project team will present information to San Francisquito Creek watershed stakeholders at two technical workshops and provide and present technical materials.

Workshop #1 will follow at the completion of the project and will present key findings of this study to watershed stakeholders and decision makers. Stakeholder workshop to include presentations on draft findings, review methods, maps, photographs, data, figures and tables. Tentatively scheduled for May 20, 2005.

Workshop #2 will present the final Limiting Factors Analysis and discuss future activities and recommendations for the San Francisquito Creek Watershed. Tentatively scheduled for June 3, 2005

Deliverables

1. Technical Memorandum Reference state and baseline conditions.
2. Technical Memorandum Habitat Survey and field data.
3. Technical Memorandum In-Stream Aquatic Habitat Assessment. Graphical presentation of conceptual model.
4. GIS mapping of habitat survey data, habitat availability, aquatic habitat impairment, and fisheries degradation.
5. Technical Memorandum habitat availability.
6. Draft and final reports on potential stressors and limiting factor(s) effecting quantity and quality of steelhead, including assumptions, field and other data sources, analytical approach, and limitations of method.
7. Summary of Stakeholder workshop presentations.

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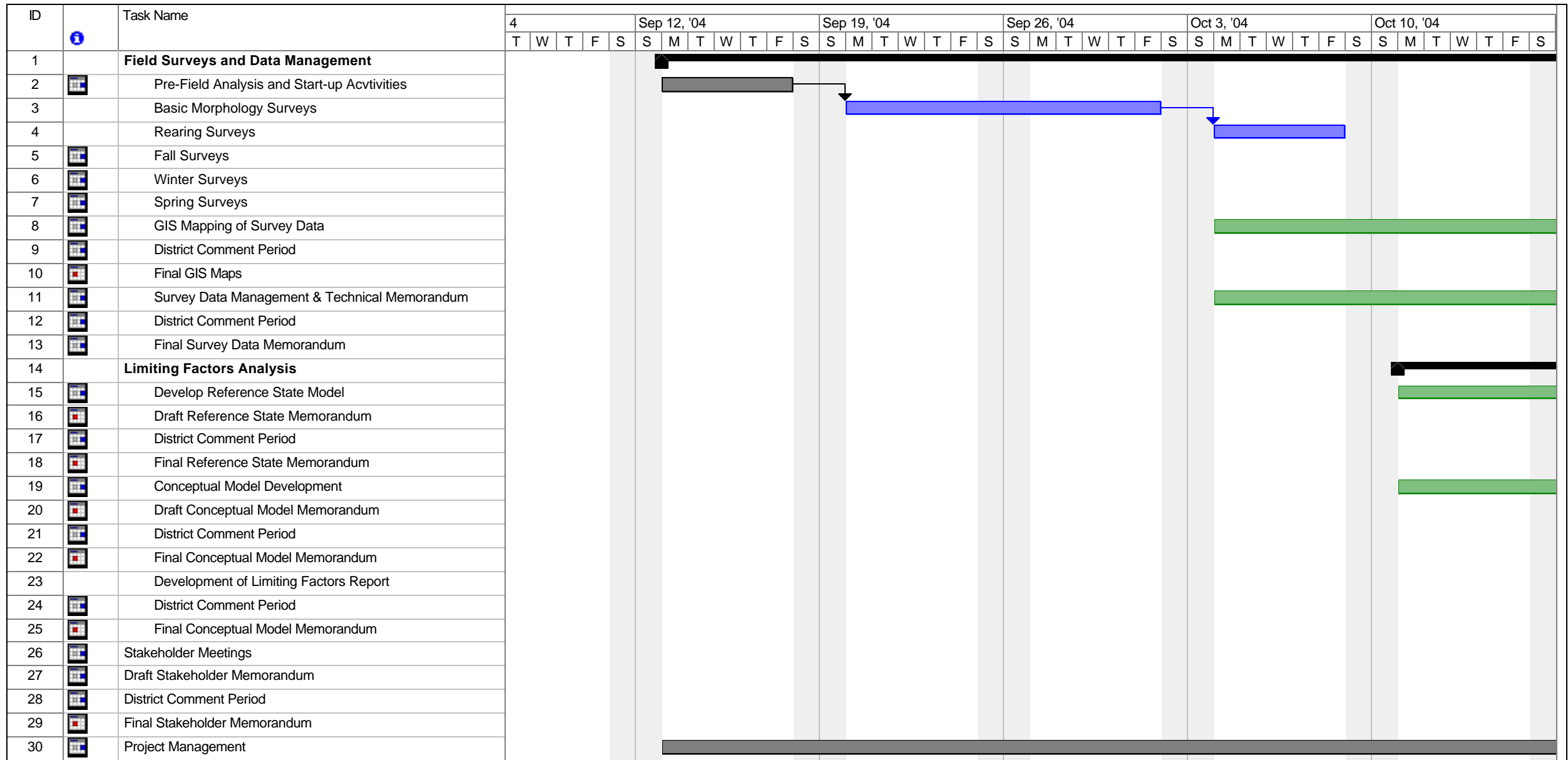
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Appendix A

Map Sheets










Appendix B

Schedule



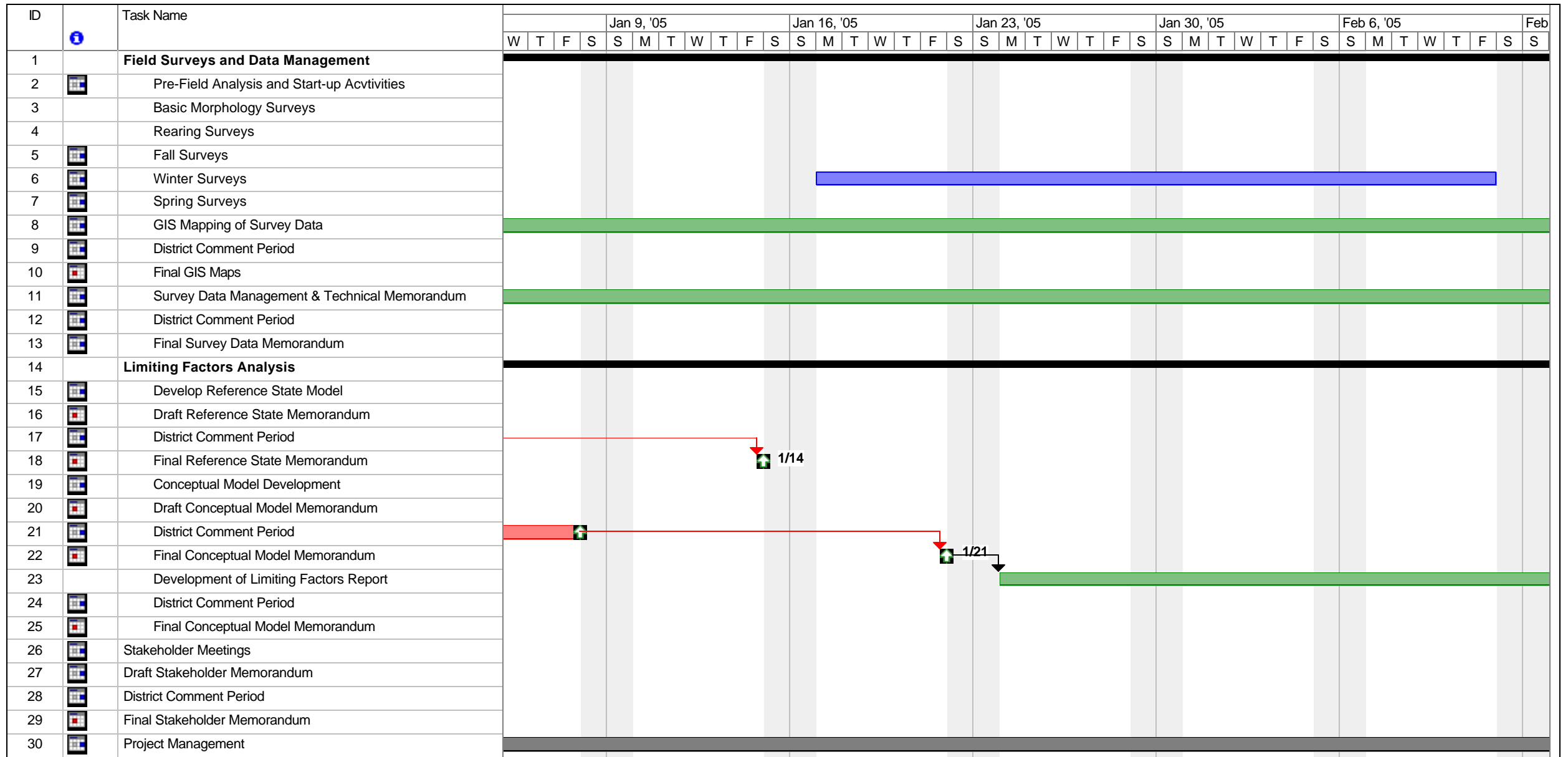
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	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	

ID	Task Name	Oct 17, '04					Oct 24, '04					Oct 31, '04					Nov 7, '04					Nov 14, '04					Nov 21, '04												
		S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T
1	Field Surveys and Data Management																																						
2	Pre-Field Analysis and Start-up Acvtivities																																						
3	Basic Morphology Surveys																																						
4	Rearing Surveys																																						
5	Fall Surveys																																						
6	Winter Surveys																																						
7	Spring Surveys																																						
8	GIS Mapping of Survey Data																																						
9	District Comment Period																																						
10	Final GIS Maps																																						
11	Survey Data Management & Technical Memorandum																																						
12	District Comment Period																																						
13	Final Survey Data Memorandum																																						
14	Limiting Factors Analysis																																						
15	Develop Reference State Model																																						
16	Draft Reference State Memorandum																																						
17	District Comment Period																																						
18	Final Reference State Memorandum																																						
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20	Draft Conceptual Model Memorandum																																						
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22	Final Conceptual Model Memorandum																																						
23	Development of Limiting Factors Report																																						
24	District Comment Period																																						
25	Final Conceptual Model Memorandum																																						
26	Stakeholder Meetings																																						
27	Draft Stakeholder Memorandum																																						
28	District Comment Period																																						
29	Final Stakeholder Memorandum																																						
30	Project Management																																						

Project: AHALFA_timeline Date: Thu 9/9/04	Task		Milestone		External Tasks	
	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	










ID	Task Name	Nov 28, '04				Dec 5, '04				Dec 12, '04				Dec 19, '04				Dec 26, '04				Jan 2, '05										
		F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
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9	District Comment Period																															
10	Final GIS Maps																															
11	Survey Data Management & Technical Memorandum																															
12	District Comment Period																															
13	Final Survey Data Memorandum																															
14	Limiting Factors Analysis																															
15	Develop Reference State Model																															
16	Draft Reference State Memorandum																															
17	District Comment Period																															
18	Final Reference State Memorandum																															
19	Conceptual Model Development																															
20	Draft Conceptual Model Memorandum																															
21	District Comment Period																															
22	Final Conceptual Model Memorandum																															
23	Development of Limiting Factors Report																															
24	District Comment Period																															
25	Final Conceptual Model Memorandum																															
26	Stakeholder Meetings																															
27	Draft Stakeholder Memorandum																															
28	District Comment Period																															
29	Final Stakeholder Memorandum																															
30	Project Management																															

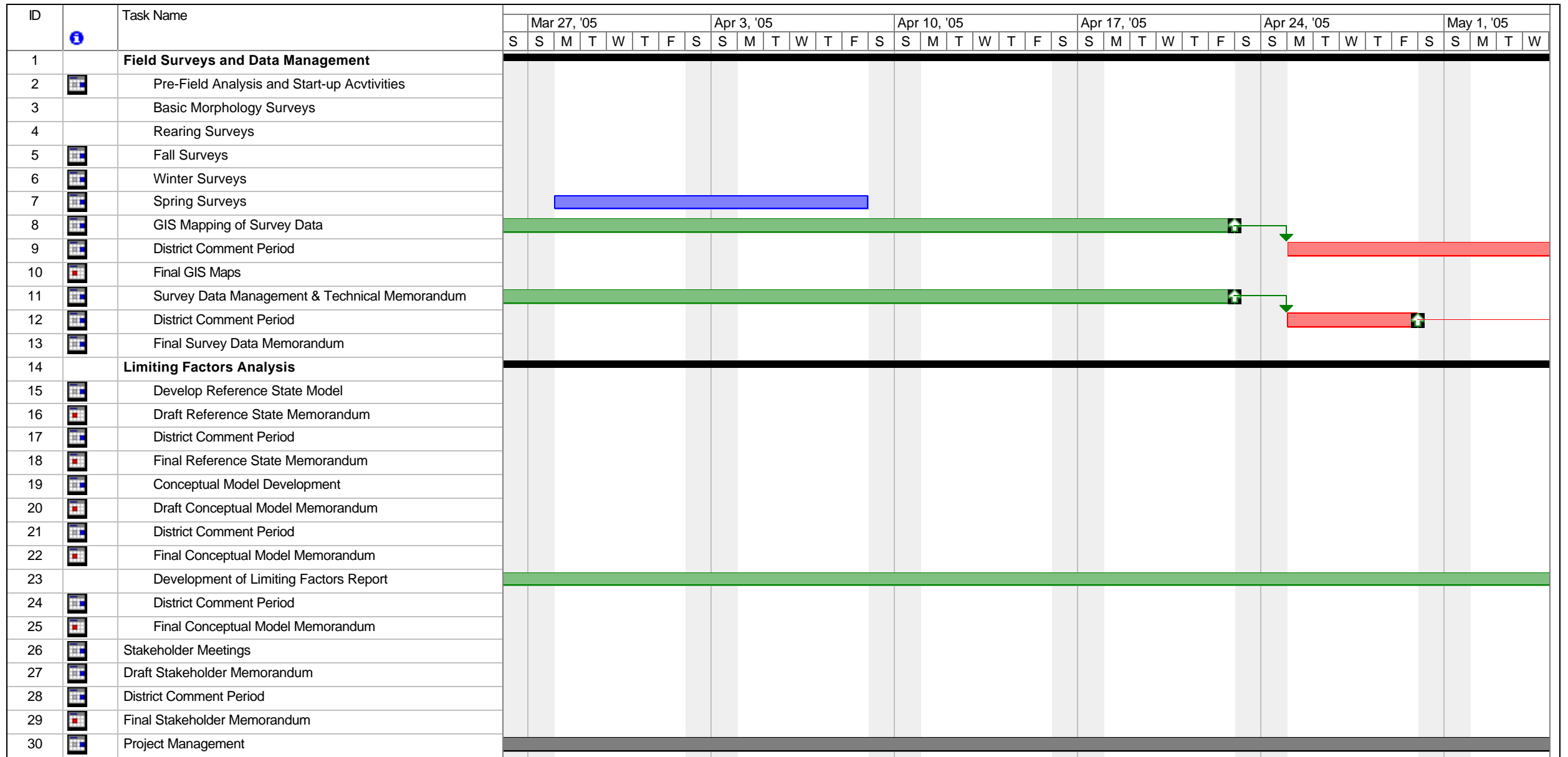
Project: AHALFA_timeline Date: Thu 9/9/04	Task		Milestone		External Tasks	
	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	



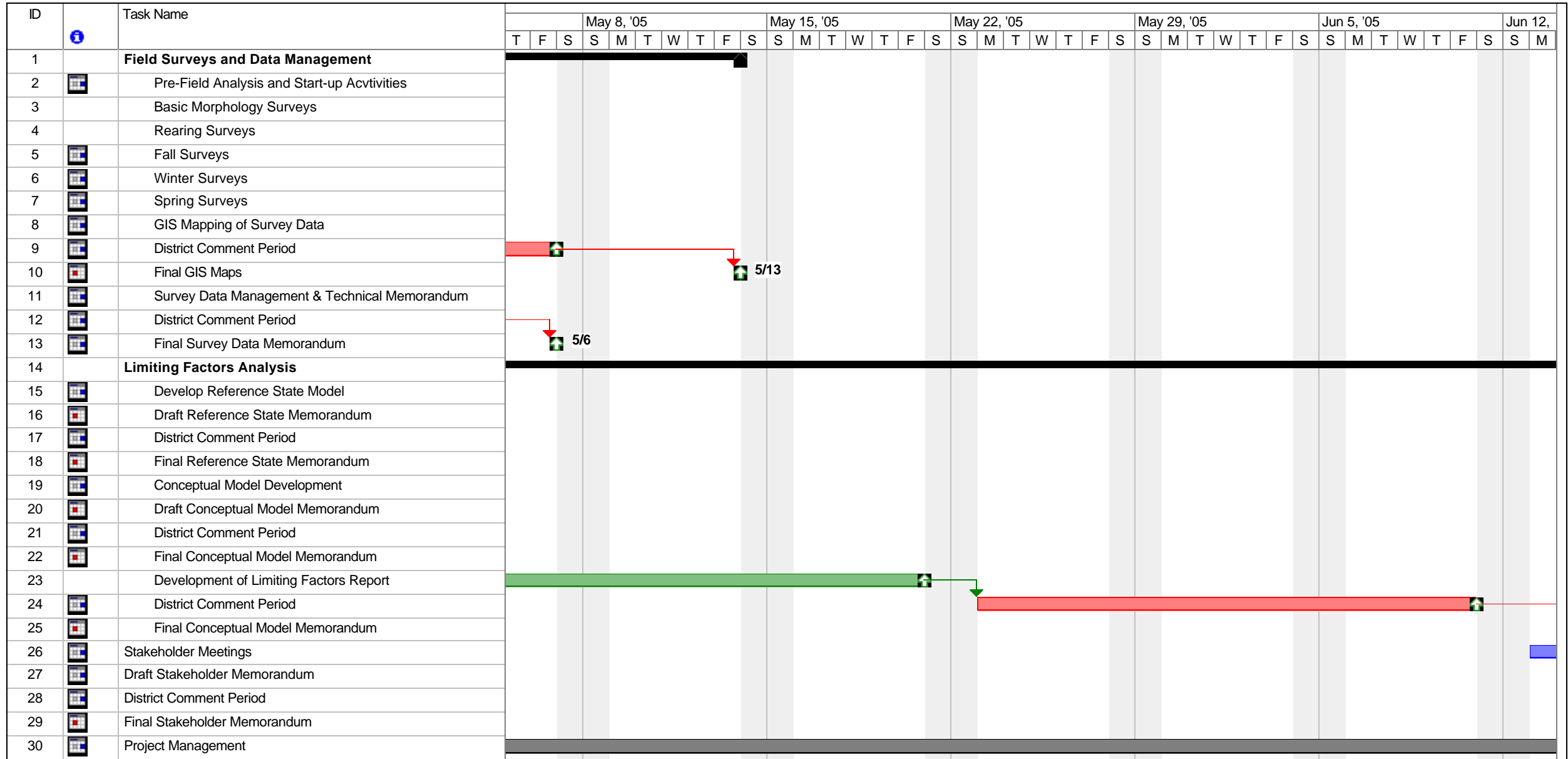
Project: AHALFA_timeline Date: Thu 9/9/04	Task		Milestone		External Tasks	
	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	

ID	Task Name	13, '05					Feb 20, '05					Feb 27, '05					Mar 6, '05					Mar 13, '05					Mar 20, '05						
		M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T
1	Field Surveys and Data Management																																
2	Pre-Field Analysis and Start-up Acvtivities																																
3	Basic Morphology Surveys																																
4	Rearing Surveys																																
5	Fall Surveys																																
6	Winter Surveys																																
7	Spring Surveys																																
8	GIS Mapping of Survey Data																																
9	District Comment Period																																
10	Final GIS Maps																																
11	Survey Data Management & Technical Memorandum																																
12	District Comment Period																																
13	Final Survey Data Memorandum																																
14	Limiting Factors Analysis																																
15	Develop Reference State Model																																
16	Draft Reference State Memorandum																																
17	District Comment Period																																
18	Final Reference State Memorandum																																
19	Conceptual Model Development																																
20	Draft Conceptual Model Memorandum																																
21	District Comment Period																																
22	Final Conceptual Model Memorandum																																
23	Development of Limiting Factors Report																																
24	District Comment Period																																
25	Final Conceptual Model Memorandum																																
26	Stakeholder Meetings																																
27	Draft Stakeholder Memorandum																																
28	District Comment Period																																
29	Final Stakeholder Memorandum																																
30	Project Management																																

Project: AHALFA_timeline Date: Thu 9/9/04	Task		Milestone		External Tasks	
	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	



Project: AHALFA_timeline Date: Thu 9/9/04	Task		Milestone		External Tasks	
	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	












Project: AHALFA_timeline Date: Thu 9/9/04	Task		Milestone		External Tasks	
	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	

ID	Task Name	05					Jun 19, '05					Jun 26, '05					Jul 3, '05					Jul 10, '05					Jul 17, '05							
		T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
1	Field Surveys and Data Management																																	
2	Pre-Field Analysis and Start-up Acvtivities																																	
3	Basic Morphology Surveys																																	
4	Rearing Surveys																																	
5	Fall Surveys																																	
6	Winter Surveys																																	
7	Spring Surveys																																	
8	GIS Mapping of Survey Data																																	
9	District Comment Period																																	
10	Final GIS Maps																																	
11	Survey Data Management & Technical Memorandum																																	
12	District Comment Period																																	
13	Final Survey Data Memorandum																																	
14	Limiting Factors Analysis	[Summary bar spanning all columns]																																
15	Develop Reference State Model																																	
16	Draft Reference State Memorandum																																	
17	District Comment Period																																	
18	Final Reference State Memorandum																																	
19	Conceptual Model Development																																	
20	Draft Conceptual Model Memorandum																																	
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29	Final Stakeholder Memorandum																																	
30	Project Management																																	

Project: AHALFA_timeline Date: Thu 9/9/04	Task		Milestone		External Tasks	
	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	

ID	Task Name	Jul 24, '05							Jul 31, '05							Aug 7, '05							Aug 14, '05							Aug 21, '05							Aug 28, '05						
		S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T		
1	Field Surveys and Data Management																																										
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30	Project Management																																										

Project: AHALFA_timeline
Date: Thu 9/9/04

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	

Appendix C

Data Sheets

**Basic Stream Morphology
Data Collection Form HABITAT-01**

Date: _____

Monitoring Team Member Names:^a _____

Stream:^b _____

Starting Bankfull Width: _____

General Description of Measurement Site

(stream characteristics and location): _____

Notes on Upstream Changes in Flow and Gradient

(i.e., water observed entering or leaving the river): _____

Habitat Unit	Average Bankfull Width (feet)	Average Wetted Width (feet)	Average Depth (feet)	Length of Unit	Percent Canopy Cover	Gradient	Comments

**Basic Stream Morphology
Data Collection Form HABITAT-01**

Date: _____

Monitoring Team Member Names: _____

Location (Habitat Unit)	Habitat Feature	Length of Feature	Photo ID #'s	Diameter of feature (LWD) Height of Feature (eroded bank)	GPS Coordinates and Comments

Depth and Velocity Data Collection Form HABITAT-02

Date: _____

GPS Coordinates: _____

Monitoring Team Member Names:^a _____

Wetted Channel Width (feet): LWE^d _____ – RWE^d _____ = _____

Stream:^b _____

Measured Flow^e (cfs):^f _____

Site Description: _____

Time Measured: _____

Location of Field Measured Flow: _____

Potential Barrier Identification Number:^c _____

Depth (feet) and Velocity (fps)^g Measurements at 2-Foot Intervals along Cross Section^h

		2 ⁱ	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	
Potential Depth Barrier	Depth (to nearest 0.1 foot)																					
	Stream length of depth <1.0 foot ^j (to nearest 0.1 foot)																					
Potential Velocity Barrier	Velocity (to nearest 0.1 foot per second)																					
	Stream length of velocity >5.0 feet per second ^j (to nearest 0.1 foot)																					
Assessment	Depth <i>and</i> velocity criteria met? (Y/N) ^k																					
	Comments:											Field Calculations Worksheet A = passage corridor width = largest number of continuous intervals where depth and/or velocity criteria are met _____ x 2 = _____ B = reference number = 4 or wetted channel width _____ x 0.10 = _____ (whichever is greater) ^l Is A < B? <input type="checkbox"/> No (no barrier, go to next line) <input type="checkbox"/> Yes (indicate type of barrier: <input type="checkbox"/> depth <input type="checkbox"/> velocity <input type="checkbox"/> both)										
	Ground-Level Digital Image Numbers:											Is potential barrier a notched weir? <input type="checkbox"/> Yes (conduct a vertical barrier assessment) <input type="checkbox"/> No										
Professional Judgement:																						

Depth and Velocity Data Collection Form HABITAT-02

- ^a List first initial and last name of each member of the monitoring team.
- ^b Indicate San Francisquito Creek or Los Trancos Creek.
- ^c Number potential fish passage barriers sequentially for each water year using the following naming conventions: "WY-BARR-Barrier #", where "WY" is the last 2 digits of the water year (e.g., "04" for 2004) and "Barrier #" is a 3-digit barrier number (e.g., "001" for first potential fish barrier and "002" for second). For example, the first potential fish barrier in water year 2004 would be 04-BARR-001.
- ^d LWE = left water edge; RWE = right water edge. Left and right banks are relative to a person facing downstream.
- ^e Field measured stream flow (from data collection form WATER-01)
- ^f Cubic feet per second.
- ^g Feet per second.
- ^h If the cross section is less than 5 feet wide, take only 1 measurement at the center of the cross section.
- ⁱ Stream length, perpendicular to the cross section and within the specified cross-section interval, upstream and downstream from the cross section of depth less than 1 foot.
- ^j Stream length, perpendicular to the cross section and within the specified cross-section interval, upstream and downstream from the cross section of velocity greater than 5 feet per second.
- ^k Y = interval **meets** both minimum depth and maximum velocity criteria (i.e., depth greater than 1 foot or depth less than 1 foot extending for less than 6 feet of channel length and velocity less than or equal to 5 fps or velocity greater than 5 fps extending for less than 6 feet of channel length).
- N = interval **does not meet** both minimum depth and maximum velocity criteria (i.e., depth less than or equal to 1 foot extends for more than 6 feet of channel length and/or velocity greater than 5 fps extends for more than 6 feet of channel length).
- ^l If stream width times 0.10 is greater than 4, use this number as reference number, otherwise use 4 as reference number.

Diagram of Site

Vertical Barrier Data Collection Form HABITAT-03

Date: _____

Start Point for the Day:^c _____

Monitoring Team Member Names:^a _____

End Point for the Day:^d _____

Stream:^b _____

Measured Flow^e (cfs):^f _____

Time Measured: _____

Potential Barrier Identification Number ^g	Barrier Height (feet) ^h	Staging Pool Depth (feet) ⁱ	Horizontal Distance ^j	Barrier ^k (Y/N)	Comments/Ground-Level Digital Image Numbers/Location (narrative) and GPS Coordinates

^a List first initial and last name of each member of the monitoring team.

^b Indicate San Francisquito Creek or Los Trancos Creek.

^c Geographic location of start point for data entered on this form.

^d Geographic location of end point for data entered on this form.

^e Field measured stream flow (from data collection form WATER-01)

^f cfs=cubic feet per second.

^g Number potential fish passage barriers sequentially for each water year using the following naming conventions: "WY-BARR-Barrier #", where "WY" is the last 2 digits of the water year (e.g., 01 for 2001) and "Barrier #" is a 3-digit barrier number (e.g., "001" for first potential fish barrier and "002" for second). For example, the first potential fish barrier in water 2004 would be 04-BARR-001.

^h Measure vertical distance (to the nearest 0.1 foot) from the water surface to the lowest point of the potential barrier.

ⁱ Measure depth (to the nearest 0.1 foot) at location where fish are expected to initiate leaps from staging pool.

^j Distance from staging pool below potential barrier to location where depth upstream of the barrier first reaches 1 foot; measured to the nearest 0.1 foot.

^k The potential barrier is a barrier to fish passage if barrier is more than 3.0 feet high, horizontal distance is greater than 5.4 feet, OR staging pool depth is less than 1.25 times the height of the potential barrier.

Spawning Gravel Abundance Data Collection Form HABITAT-04

Date: _____

Start Point for the Day:^c _____

Monitoring Team Member Names:^a _____

End Point for the Day:^d _____

Measured Flow^e(cfs):^f _____

Stream:^b _____

Time Measured: _____

Classification of Gravel by Average Size

Gravel Class	Average Size [millimeters (inches)]
Fine gravel	6–25 (0.25–1.0)
Medium gravel	26–50 (1.1–2.0)
Coarse gravel	51–75 (2.1–3.0)
Small cobble	76–102 (3.1–4.0)

Gravel Bed Identification Number ^g	Gravel Bed Average Length (feet)	Gravel Bed Average Width (feet)	Percentage of Gravel Area in Each Elevational Unit ^h						Gravel Bed Depth (nearest 0.1 foot)	Gravel Class Based on Average Size ⁱ	Comments/Location (Narrative)
			-3 to -2 (feet)	-2 to -1 (feet)	-1 to 0 (feet)	0 to +1 (feet)	+1 to +2 (feet)	+2 to +3 (feet)			

^a List first initial and last name of each member of the monitoring team.

^b Indicate an Francisquito Creek or Los Trancos Creek.

^c Geographic location of start point for data entered on this form.

^d Geographic location of end point for data entered on this form.

^e Field measured stream flow (from data collection form WATER-01)

^f cfs=cubic feet per second..

^g Number gravel beds sequentially for each water year using the following naming convention: “WY-GRAV-Bed#”, where “WY” is the last 2 digits of the water year (e.g., 01 for 2001) and “Bed#” is a 3-digit bed number (e.g., 001 for first location and 002 for second location). For example, the first gravel bed in water year 2001 would be 01-GRAV-001.

^h Elevational units are relative to the water surface and describe the depth of the water covering the spawning gravel in 1-foot increments. Negative numbers designate elevational units below the water surface, positive numbers designate elevational units above the water surface, and 0 is the water surface.

ⁱ Gravel class: see table at top right corner.

Spawning Gravel Quality Data Collection Form HABITAT-05

Date: _____

Monitoring Team Member Names:^a _____

Stream:^b _____

Start and End Points for the Day:^c _____

Numeric Categories of Substrate Particle Size

Category	Average Size [millimeter (inches)]
1	<2 (<0.08)
2	2–5 (0.08–0.2)
3	6–25 (0.3–1.0)
4	26–102 (1.1–4.0)
5	103–152 (4.1–6.0)

Modified from Crouse et al. 1981.

Gravel Bed Identification Number ^d		Particle Size ^e (millimeters)					Comments/Ground-Level Digital Image Number
		Category 1 <2	Category 2 2–5	Category 3 6–25	Category 4 26–102	Category 5 103–150	
	Tally ^f						
	Sum ^g						
	Tally ^f						
	Sum ^g						
	Tally ^f						
	Sum ^g						
	Tally ^f						
	Sum ^g						

^a List first initial and last name of each member of the monitoring team.

^b Indicate San Francisquito Creek or Los Trancos Creek.

^c Geographic location of start and end points for data entered on this form.

^d Use gravel bed identification number from the Spawning Gravel Abundance Data Collection Form HABITAT-04.

^e Particle size: see table at top right corner..

^f Keep a tally for each category and then sum the totals.

^g Total of particles within category.

Stream Flow Measurements Data Collection Form WATER-01

Date: _____

General Description of Measurement Site
(stream characteristics and location): _____

Monitoring Team Member Names:^a _____

Stream:^b _____

Channel Width: _____

Notes on Upstream Changes in Flow
(i.e., water observed entering or leaving the river): _____

Vertical Number	Tape Distance (feet) ^c	Depth (feet)	Velocity (feet per second) ^d			Comments
			0.2 * depth	0.8 * depth	0.6 * depth	
RWE						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

RWE = Right Water Edge

^a List first initial and last name of each member of the monitoring team.

^b Indicate San Francisquito Creek or Los Trancos Creek.

^c The 0 should be at the right water's edge. Right is relative to a person facing downstream.

^d If depth is greater than 2.5 feet, measure velocity at 0.2 and 0.8 of the total depth. Otherwise, measure velocity at 0.6 of the total depth.

Measured Water Temperature Data Collection Form WATER-02

Date: _____

Monitoring Team Member Names:^a _____

Logger ID Number ^b	Logger Location (narrative)	Placement, Retrieval, or Data Download	Time	Water Temperature (°F) ^c	Dissolved Oxygen	Water Temperature Data Filename	GPS Coordinates and Comments

^a List first initial and last name of each member of the monitoring team.
^b The 6-digit serial number on the water temperature logger.
^c Measured using a hand-held water temperature thermometer.

CALIFORNIA BIOASSESSMENT WORKSHEET

WATERSHED/ STREAM: _____

DATE/ TIME: _____

COMPANY/ AGENCY: _____

SAMPLE ID #: _____

SITE DESCRIPTION: _____

SAMPLING CREW	
_____	_____
_____	_____
_____	_____

SITE INFORMATION	
GPS Coordinates	
Latitude:	_____
Longitude:	_____
Elevation:	_____
Ecoregion:	_____
COMMENTS:	_____
_____	_____
_____	_____
_____	_____
_____	_____

CHEMICAL CHARACTERISTICS	
Water Temperature:	_____
Specific Conductance:	_____
pH:	_____
Dissolved Oxygen:	_____

Bioassessment Laboratory Information:

SEND A COPY OF THIS FORM TO:
DFG/ WPCL
2005 Nimbus Road
Rancho Cordova, CA 95670
(916) 358-2858
website: www.dfg.ca.gov/cabw/cabwhome.html

RIFFLE/ REACH CHARACTERISTICS			
Point Source Sampling Design			
Riffle Length:	_____	_____	_____
Transect 1:	_____	_____	_____
Transect 2:	_____	_____	_____
Transect 3:	_____	_____	_____
<i>(record Physical/ Habitat Characteristics in Riffle 1 column)</i>			
Non-Point Source Sampling Design			
Reach Length:	_____	_____	_____
Physical Habitat Quality Score:	_____	_____	_____
Physical/ Habitat Characteristics			
	<u>Riffle 1</u>	<u>Riffle 2</u>	<u>Riffle 3</u>
Riffle Length:	_____	_____	_____
Transect Location:	_____	_____	_____
Avg. Riffle Width:	_____	_____	_____
Avg. Riffle Depth:	_____	_____	_____
Riffle Velocity:	_____	_____	_____
% Canopy Cover:	_____	_____	_____
Substrate Complexity:	_____	_____	_____
Embeddedness:	_____	_____	_____
Substrate Composition:	_____	_____	_____
Fines (<0.1”):	_____	_____	_____
Gravel (0.1-2”):	_____	_____	_____
Cobble (2-10”):	_____	_____	_____
Boulder (>10”):	_____	_____	_____
Bedrock (solid):	_____	_____	_____
Substrate Consolidation:	_____	_____	_____
Percent Gradient:	_____	_____	_____

**PHYSICAL HABITAT QUALITY
(California Stream Bioassessment Procedure)**

WATERSHED/ STREAM: _____

DATE/ TIME: _____

COMPANY/ AGENCY: _____

SAMPLE ID NUMBER: _____

SITE DESCRIPTION: _____

Circle the appropriate score for all 20 habitat parameters. Record the total score on the front page of the CBW.

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
1. Epifaunal Substrate/ Available Cover	Greater than 70% (50% for low gradient streams) of substrate favorable for epifaunal colonization and fish cover; most favorable is a mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% (30-50% for low gradient streams) mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% (10-30% for low gradient streams) mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% (10% for low gradient streams) stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/ Depth Regimes <i>(deep < 0.5 m, slow < 0.3 m/s)</i>	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameters to be evaluated within the sampling reach

HABITAT PARAMETER	CONDITION CATEGORY			
	OPTIMAL	SUBOPTIMAL	MARGINAL	POOR
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left of right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zones covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
	Left Bank 10 9	8 7 6	5 4 3	2 1 0
	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Parameters to be evaluated in an area longer than the sampling reach

CALIFORNIA STREAM BIOASSESSMENT PROCEDURE CHAIN OF CUSTODY (COC) RECORD

Project Name: _____
 Watershed Name: _____

Date/ Time: _____
 Bioassessment Lab: _____

Sample Number	Lab Number	Sample Date	Sample Description

Sampled by: _____ Relinquished by: _____ Received by: _____ Received by: _____
 (sign and date) (sign and date) (sign and date) (sign and date) (sign and date)

Address of Project Advisor:

Address of Sampler:

91728	44078	96998	25780	58455	99398	16299	30849	56199	45791
56489	18412	62384	48356	75118	51724	7962	62571	13801	10633
26008	30424	44745	71156	73603	52920	32012	56567	28693	22644
49864	5438	98149	44583	87573	37067	80217	52738	22178	48264
39666	4377	80040	38685	96850	54884	5688	88314	54190	6957
83576	92168	37324	72652	78431	59142	55787	17989	81991	95926
23670	80579	84178	799	71974	99821	43125	50789	90272	35574
87975	76200	53759	19222	76617	25341	85869	89617	14629	31322
26124	80985	95411	51349	9322	52887	66059	93470	20527	91142
89224	48066	62669	15806	9590	64712	2723	42518	14275	12582
16945	56219	70292	83056	84787	39471	8409	60760	16240	38967
68995	89831	64408	65234	45348	53418	23153	7967	3207	90746
83774	11014	22528	147	17261	99443	35455	92555	13866	64339
42548	51674	42715	27867	39232	7665	54904	58891	1231	29431
64710	20643	66849	39263	77285	57101	96155	28881	945	98860
63165	93728	94343	89748	33536	5512	35890	81693	89378	94102
40560	45532	29546	76068	75350	8114	78700	97206	12674	59472
40497	85910	64852	78287	41305	65074	86565	36817	90469	33320
78253	65886	91014	5189	27810	8425	50837	90848	15566	55301
6726	60284	15637	76386	26291	82058	93008	31185	27787	27832
75398	44114	94338	94110	84544	24230	39688	30293	10743	80838
76322	63173	16930	97452	15667	38601	92162	19744	35484	46763
66649	15644	69687	45869	1547	33766	22164	16953	87813	48022
37893	12167	98162	96011	91455	9461	14744	29528	12735	8861
2140	94216	48465	39993	72352	35922	13664	23909	75847	77078
61458	48058	32617	89494	9373	81388	98574	55392	9903	20920
62625	61463	6986	43373	71397	44207	77525	65801	94388	61531
75058	34685	37439	96897	1716	96907	97725	4668	58993	79548
52831	73191	64944	86567	78534	36705	35228	94795	57045	29891
34633	63695	99933	8600	46315	75279	82753	80519	22842	91397
32432	87083	55613	38712	77856	21022	91372	62566	65890	41602
44172	13651	34399	25967	52017	93718	30391	81218	70272	42931
92844	78189	15041	43163	57278	16716	51717	94447	63929	32066
43231	19607	27777	38990	94169	81895	68611	65469	3589	77865
82916	26280	2108	97253	89662	9628	10004	86829	79043	83724
49574	12138	99224	60236	1127	88024	4866	86393	93601	13793
72409	56938	92585	42321	47203	97135	26727	49075	49157	121
77156	14992	87483	53367	56545	34281	63976	56392	43359	57029
34228	59830	28700	56993	50813	66532	58929	84038	99788	77246
98423	49581	30802	87072	90228	63318	80658	92848	37173	88826

18570	29895	7607	89572	52690	70464	20532	50443	64823
2448	67832	89598	62241	8618	57946	20735	91040	44269
99987	97585	40238	5032	99367	24618	99400	42672	64405
19350	20110	40749	42085	32769	66135	87928	50806	64671
62954	20328	99145	25362	57235	21427	61430	91451	31827
25836	69393	13558	631	57294	68296	26794	88383	72800
5704	42530	45130	58296	767	30820	90684	91403	10505
62636	75475	75436	73633	16104	46156	38379	51443	75871
41374	32300	43184	13209	49485	65678	13028	99745	3989
9893	60624	78947	40480	46413	19390	16444	49445	99840
52721	2834	37041	47563	80565	61660	48533	81939	13101
83253	23619	84503	72779	15167	58008	85127	56060	52025
14066	97892	2900	42295	28319	37390	73110	81942	65509
8636	49709	42290	53164	95177	62109	39033	60637	75271
75508	62576	62870	63572	55039	96969	43323	97335	66539
89666	71232	46334	75514	90964	95384	77535	96106	8001
79232	3529	47061	60679	89791	57068	1857	10567	60706
26900	6028	22247	21495	37898	25824	50810	9045	62681
33249	38154	71746	43830	30152	28796	32991	24347	64861
97355	64451	41273	50353	71747	39207	44071	71818	158
64143	21112	59108	53389	12792	54159	35051	47583	8138
89287	55276	10858	47845	69191	3803	16748	47367	50568
26002	83088	53066	87662	23548	83322	42079	91795	20860
51560	56871	81329	1819	50614	56453	30235	19327	50809
20539	28795	1253	98196	76344	24413	87415	68523	53665
62821	77929	69327	82278	45165	94453	23030	45423	96938
27414	66399	10635	6220	6352	87505	6859	77638	64724
78594	7897	16036	6669	83452	15921	12177	83870	5922
83312	64623	31661	52888	11672	9061	3522	26574	15936
32818	28634	4868	49362	51474	18688	42195	10806	88513
20594	4938	77394	96024	8082	86273	37304	35314	26903
18556	6618	27256	28236	14398	28143	79891	25227	45087
77237	24983	15875	82995	90914	94509	99814	29822	66623
95016	65072	72685	47373	82479	21491	84350	73390	42078
18355	78424	41804	11162	73271	28251	40180	89616	91159
14186	45382	75616	47801	29002	57439	39816	85482	6533
52433	31802	66033	3487	22033	86061	31103	20172	68028
38782	19888	12117	38651	27799	98799	77047	67341	12936
14052	30597	29937	27004	14969	11078	22217	30415	41066
8146	80866	770	99774	53536	43431	33634	47960	39999

