Assessment of Barriers to Salmonid Passage
Corte Madera Creek Watershed

Friends has been awarded a contract by National Fish and Wildlife Foundation, in collaboration with the National Marine Fisheries Service (NOAA Fisheries), the California Department of Fish and Game, and the California Department of Transportation (Caltrans) to assess barriers to salmonid passage in the Corte Madera Creek Watershed. The funds were provided to the San Francisco Bay Salmonid Habitat Restoration Fund by Caltrans as required mitigation for possible impacts on steelhead and salmon from pile driving and other activities undertaken as part of the San Francisco-Oakland Bay Bridge East Span Seismic Safety Project. The funds are being used to benefit salmonids in central and south San Francisco Bay watersheds.

The work is divided into four major tasks: (1) stream crossing assessment, (2) an assessment of fish passage in the concrete flood control channel upstream of the College of Marin pedestrian bridge, (3) an analysis of bank stability and fish passage in Corte Madera Creek between the upstream end of the Ross fish ladder and the Lagunitas Road bridge, and (4) updating the rating curve for the Ross Gage to support numerical modeling of the creek. This work began in May 2005 and we expect to compete all work by November 2006. There will public meetings periodically to present results and receive input from stakeholders.

Fairfax Creek, leaving a long culvert under Sherman Street, joins San Anselmo Creek. Photo by Lou Vaccaro.

Task 1: Stream Crossing Assessment

This work is being done by Michael Love and Associates. Methods for conducting the stream crossing inventory and fish passage evaluation include seven activities, to be accomplished generally in the following order:

1. Locate stream crossings;
2. Make initial site visits and collect data;
3. Estimate tributary-specific hydrology and design flows for presumed migration period;
4. Enter data and analyze passage; passage is first evaluated with a first-phase evaluation filter referred to as the Green-Gray-Red filter. Sites determined to be Gray and/or Red then require an in-depth evaluation with FishXing computer modeling software;
5. Collect and interpret existing habitat information;
6. Prioritize sites for corrective treatment; and
7. Develop site-specific recommendations for unimpeded passage of both juvenile and adult salmonids.

Task 2: USACE Flood Control Channel Assessment and Conceptual Design

The following discussion outlines the methods used to: (1) assess fish passage conditions within most of the Unit 3 USACE Flood Control Channel (this unit reaches from College Avenue to the upstream end of the concrete channel) and at the fish ladder at the top of Unit 3, (2) develop and evaluate conceptual treatment alternatives for improving fish passage within the Unit 3 channel, and (3) develop preliminary alternatives for replacing the existing fish ladder.

Conduct Video Monitoring: We will conduct video monitoring of the existing channel at various fish passage flows at five locations where staff plates (panels marked with water depth measurements) have

been installed in the concrete channel. This type of qualitative and semi-quantitative information provides a visual assessment of rapid flow conditions in the Unit 3 channel during periods of high runoff (supercritical flows) and will be useful in assessing current fish passage conditions in the Unit 3 channel. The video monitoring will also be used to verify the accuracy of the modeling. Crest gages will be installed in the concrete channel to provide information about the maximum stage reached in a particular storm.

Develop Hydrology for Project Reach: It will be necessary to develop reach-specific hydraulic information to assess the various fish passage alternatives. Computer studies of creek conditions will focus on flows associated with salmonid migration periods, and will probably consist of annual and seasonal flow-duration curves. This effort will use the updated rating curve for the Ross gage described below. It may be necessary to analyze the potential flood impacts for each of the proposed fish passage alternatives.

Analyze Existing and Proposed Fish Passage Conditions in Unit 3 Flood Control Channel: This work, to be done by Michael Love Associates with input from Ross Taylor, will emphasize developing and analyzing alternatives to improve fish passage conditions within the Unit 3 channel. Because supercritical flow conditions sometimes occur in Unit 3, we propose to analyze fish-passage conditions both qualitatively (video monitoring) and quantitatively (hydraulic modeling). The video monitoring will provide a visual reference to help validate supercritical flow results obtained from the hydraulic modeling, documenting the base fish-passage condition. The proposed passage alternatives in the Unit 3 channel will be compared to base conditions. Hydraulic model results (e.g., flow depth and velocity) will be evaluated against current NOAA Fisheries and CDFG fish passage standards as well as established swimming abilities of different species (e.g., steelhead and coho) and for species at different lifestages. A matrix for Unit 3 will be developed that describes fish passage characteristics of all proposed alternatives, in comparison with existing passage conditions.

Since the intent of this work is to improve fish passage conditions in the Unit 3 channel, the proposed hydraulic modeling will be conducted over the range of fish passage flows. It is anticipated that the fish passage flows will be much lower than current project flood flows (up to 3200 cfs). To provide consistency in the overall Corte Madera Flood Control Channel goals, we currently propose to analyze the effects of any fish passage alternatives against one or two project flood flows, which will be determined as the flood control project moves forward.

Proposed hydraulic modeling will consist of both one-dimensional and two-dimensional hydraulic models capable of handling supercritical flow conditions.

Conduct One-dimensional Hydraulic Analysis: A one-dimensional hydraulic model (1-d model) will be used to analyze existing and proposed modifications to the Unit 3 channel using an average of flows across the channel. We currently propose using HEC-RAS for the 1-d modeling. The 1-d model will be used to provide flow conditions over the entire range of developed fish-passage flows, and one or two flood control project flows. It is anticipated that the 1-d modeling effort will provide data on:

- Cross-section averaged fish-passage flow conditions (e.g., flow depth and velocity) for the entire range of steady state fish passage flows;
- Where fish will be located in the channel as they swim upstream;
- Flow regime, to help assess stability and hydraulic behavior of supercritical flow conditions in the Unit 3 channel;
- Entrance and exit stage discharge relationships for the proposed fish ladder improvements;
- Effects of the proposed fish passage alternatives on existing flood conditions; and
- Boundary conditions for additional hydraulic modeling work.

Conduct Two-dimensional Hydraulic Analysis: We currently propose to conduct two-dimensional hydraulic modeling of the existing and proposed modifications to the Unit 3 channel, to define the

variable flow conditions that exist across the channel. Flow conditions within a specific fish passage treatment, such as a pool, can more accurately be modeled and assessed with a 2-d model.

It will be necessary to use a 2-d model capable of handling supercritical flow conditions. The proposed 2-d modeling will generally involve the following:

- Define a study reach to model existing and proposed fish passage alternatives. We propose to model a representative section of the Unit 3 channel (e.g., 500 to 1000 feet);
- Model boundary conditions developed from the 1-d hydraulic model;
- Perform sensitivity analyses of model parameters;
- Compare modeled results of existing channel to video monitoring; and
- Analyze 2-d flow conditions for three fish passage flows (e.g., a low, average, and high fish passage flow) for each developed alternative.

Analyze Existing and Proposed Fish Ladder: The project team will develop preliminary designs for replacing the existing "temporary" fish ladder at the upstream end of the Unit 3 channel. The existing and proposed fish ladder designs will be analyzed using a combination of standard equations and, when available, dimensionless flow equations developed for unique fish ladders (e.g., vertical slot fish ladder). The fish ladder will also be evaluated using the 1-d hydraulic model at flood flows. As with the Unit 3 channel, we propose to analyze both existing conditions and proposed fish ladder designs. The existing conditions will provide the base condition against which all of the proposed fish ladder designs will be compared. Hydraulic model results (e.g., flow depths, velocities, turbulence) will be evaluated against current NOAA Fisheries and CDFG fish-passage standards as well as other established criteria for different life stages. A matrix of proposed fish ladders will be developed which describes fish passage characteristics of all proposed alternatives in comparison with existing passage conditions.

Task 3: Unit 4 Bank Stability Analysis and Conceptual Treatments

Stetson Engineers will prepare three feasibility-level designs of replacement fish ladder structures, biotechnical bank protection works, and other features associated with integrated fish passage and flood control improvements in the 650-ft-long reach of Corte Madera Creek between the existing fish ladder and Lagunitas Road bridge (Unit 4). Michael Love and Ross Taylor will recommend three conceptual plans and provide conceptual design details for necessary and appropriate fish passage structures, one each for three alternatives under consideration for completion of the USACE flood control project.

Each of the USACE alternatives entails a distinct treatment of channel bed and bank conditions in Unit 4. Stakeholders must agree on an alternative, and whichever alternative is ultimately selected, there has been strong support for minimizing the use of hard surfaces. Three alternatives will be evaluated, having respective capacities of 3200 cfs (no change in capacity), 4100 cfs, and 5400 cfs.

If the 3200 cfs capacity alternative were selected, the existing fish ladder would be replaced and the existing channel grade in Unit 4 would be maintained by replacing the grade control function of the existing ladder with a rock-lined grade control drop structure. This alternative would not necessarily involve direct and permanent modifications to existing channel bed and bank surfaces, and upstream effects on hydraulics and bank stability would be less. According to a variation that may be beneficial to fish passage and reduce maintenance, the existing ladder could be removed and replaced with a vertical below-grade concrete cut-off wall to prevent undermining of the existing concrete channel, and the upstream channel regraded to create a smooth transition with the concrete channel, thus obviating the need for a fish passage structure. The sediment basin below Lagunitas Road Bridge would not be enlarged under the no-project alternative, and would continue to be excavated annually.

Following the 5400 cfs plan, the sediment basin beneath Lagunitas Road bridge would be substantially enlarged and reinforced. The existing fish ladder and grade control structure would be removed and replaced with a concrete cut-off wall. The Unit 4 channel bed at the downstream end would be lowered to the level of the channel invert and banks would be regraded in the 650-ft-long reach between the upstream end of the concrete channel and the Lagunitas Road bridge. One option for this alternative is to reinforce a portion of the right bank (looking downstream) with vertical retaining walls.

The left bank would be entirely replaced with a 16-ft-high vertical sheet-pile wall. Because many stakeholders find this option unacceptable, Stetson will analyze bank stability and evaluate the feasibility of using biotechnical bank stabilization techniques for the 5400 cfs alternative rather than hard, vertical armoring.

Following the 4100 cfs plan, the sediment basin would be enlarged, but not as much as for the 5400 cfs capacity. The existing fish ladder and grade control structure would be removed and replaced with a below-grade concrete cut-off wall. The Unit 4 channel bed and banks would be regraded in the 650-ft-long reach between the upstream end of the concrete channel and the Lagunitas Road bridge. The banks would not be graded to vertical, but would instead be extended down to the channel invert and be treated with vegetated rock rip-rap or other biotechnical stabilization technique. The 4100 cfs plan would probably include provisions for fishways to be installed within the rock-lined grade control drop structures at both ends of the enlarged sediment basin.

Stetson's designs will, in addition to accommodating flood control objectives:

- maximize fish passage at the subject range of flows;
- create and retain self-sustaining, low-maintenance riparian and aquatic habitat in Unit 4; and,
- minimize need for vertical and hardscape channel bank reinforcements.

Task 4: Rating Curve Update for Calibration of Numerical Models

Historically, the gage site in Ross has been rated "poor" by USGS. Evidently, this was due, at least in part, to the unstable nature of the gage site cross-section. Specifically, the average channel bed elevation at the gage cross-section varied between about elevation 8 ft MSL (1951), about 13 ft MSL (1988, 1991), and about 12 ft MSL (2000) (see Figure 1).

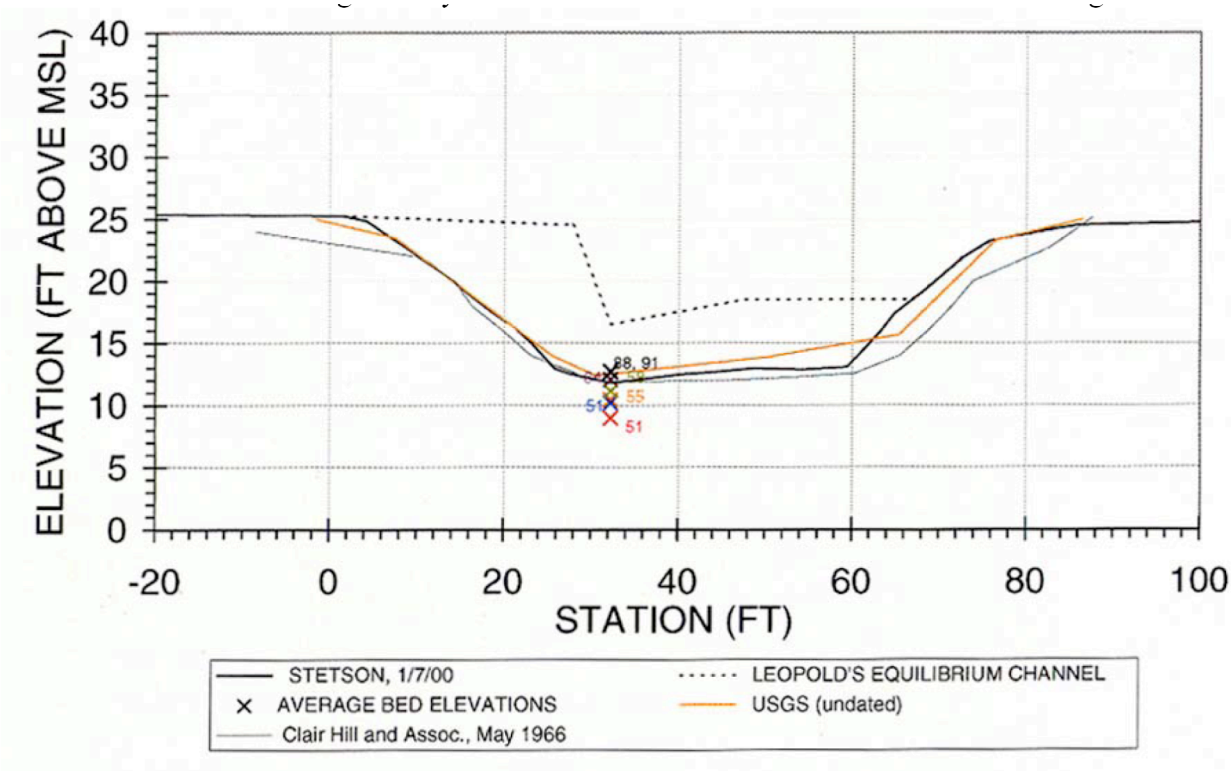
The rate of bed elevation changes appears to have decreased as the degree of urbanization of the upper watershed approached its practical maximum, and a new equilibrium is established. However, the bed elevation is probably subject to future fluctuations during moderate and large floods, and possibly as the result of channel modifications within Unit 4 of the flood control channel.

The currently used rating curve does not appear to accurately represent existing conditions, perhaps because the rating curve currently used by the FCD to convert electronic stage gage readings to discharge values may be the original rating curve used by USGS, or a rating curve only partially updated (datum shift method) by USGS as late as 1991. USGS may have neglected to completely update the rating curve due to the problems of gage cross-section instability and/or failure of the gage cross-section to contain flows exceeding approximately 50-year flood stage.

The fish ladder replacement and biotechnical bank stabilization design work to be done during 2005 and 2006 will rely heavily on the development of 1-d and 2-d hydraulic models and accurate water surface elevation calibration; specifically, model calibration will depend on assigning accurate discharge values to observed water surface elevations.

To provide the discharge information, Stetson Engineers will update the rating curve using USGS published standard measurement methods for the purposes of model calibration at fish flows, i.e., for flows up to approximately 500 cfs.

Figure 1: Historical channel geometry and channel bed level fluctuation at Ross gage, 1951 – 2000.



Source: Stetson Engineers Inc. 2000. Corte Madera Creek Watershed Geomorphic Assessment.