CORTE MADERA STREAM CROSSING INVENTORY AND FISH PASSAGE EVALUATION

FINAL REPORT

Prepared for the Friends of the Corte Madera Creek Watershed

By

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INTRODUCTION

The inventory and fish passage evaluation of stream crossings within the Corte Madera Creek watershed was conducted between June and October of 2005. The primary objective was to assess passage of juvenile and adult coastal rainbow trout/steelhead (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*) and develop a project-scheduling document to prioritize corrective treatments to provide unimpeded fish passage at road/stream intersections and at other manmade impediments such as low elevation dams.

Please note that for this report the term **stream crossing** is defined as any human-made structure, (used primarily for transportation purposes) that crosses over or through a stream channel, such as: a paved road, unpaved road, railroad track, biking or hiking trail, golf-cart path, or low-water ford. Stream crossings include culverts, bridges, and low-water crossings such as paved and unpaved fords. While technically not crossings, small dams were also included in the assessment since these structures were present within the Corte Madera Creek watershed and were having an impact on salmonid migration. For the purpose of assessing fish passage, the distinction between types of stream crossings is not as important as the effect the structure has on the form and function of the stream flow. A stream crossing encompasses the structure employed to pass stream flow as well as associated fill material within the crossing prism.

The inventory and assessment process included:

1. Locating stream crossings within anadromous stream reaches.
2. Visiting each crossing on an initial site visit to determine the type of crossing and assessment of stream channel as suitable fish habitat.
3. At crossings with culverts - collecting information regarding culvert specifications and surveying a longitudinal profile.
4. Assessing fish passage using culvert specifications and passage criteria for juvenile and adult salmonids (state and federal criteria) by employing a first-phase evaluation filter and then using a computer software program (FishXing) on a subset of sites defined as partial/temporal barriers by the filter.
5. Assessing quality and quantity of stream habitat above and below each culvert.

The prioritization process ranked culvert sites by assigning numerical scores for the following criteria:

1. Presumed species diversity within stream reach of interest (and federal listing status).
2. Extent of barrier for each species and lifestage for range of estimated migration flows.
3. Quality and quantity of potential upstream habitat gains.
4. Hydraulic capacity of current stream crossing (risk of fill failure).
5. Condition of current crossing (life expectancy).

The initial ranking was not intended to provide an exact order of priority, rather produce a first-cut rank in which sites could be grouped as high, medium, or low priority. Professional judgment was a vital component of the ranking process. On a site-specific basis, some or all of these factors were considered in developing the final ranked list:

1. Tributaries that currently support runs of steelhead and/or coho salmon. Treating migration barriers in these sections of the watershed should result in a high probability of immediate utilization of re-opened habitat.

2. Physical stress or danger to migrating salmonids at crossings where migration attempts were observed. Recent studies have revealed numerous sites in California where concentrations of migrating salmonids were subjected to decades of predation by birds and mammals or poaching by humans (Taylor 2000 and 2001). Observations of adult coho salmon injuring themselves on failed leap attempts have also been made (Taylor 2000 and 2001). Inability to enter cool-water tributaries to escape stressful/lethal mainstem water temperatures during summer months has also been observed. These factors should weigh heavily in priority ranking.

3. Amount of road fill. At stream crossings that were undersized and/or in poor condition, we assessed the volume of fill material within the road prism potentially deliverable to the stream channel if the culvert were to fail. Large, sudden contributions of sediment from road failures are often detrimental to salmonid spawning and rearing habitat.

4. Presence or absence of other stream crossings and other types of barriers. In many cases, a single stream was crossed by multiple roads under a variety of management or ownership. In these situations, close communication with other road managers, private property owners, and watershed coordinators was important. When multiple stream crossings were identified as migration barriers, a coordinated effort will be required to identify and treat them in a logical manner – generally in an upstream direction starting with the lowermost barrier or impediment.

5. Remediation project cost. One should examine the range of treatment options and associated costs when determining the order in which to proceed and what should be implemented at specific sites. In cases where federal or state listed fish species are present, costs must also be weighed against the consequences of failing to comply with Endangered Species Acts by not providing unimpeded passage.

6. Scheduling of other road maintenance and repair projects. Road managers should consider upgrading all migration barriers during other activities they may perform to the roadway, such as repaving, chip-sealing, or widening. When undersized or older crossings fail during storms, road managers should be prepared to install properly-sized crossings that provide unimpeded passage for all species and life-stages of salmonids.

7. Other factors impacting salmon and steelhead. In many cases, other limiting factors besides migration barriers exist that impair salmonid productivity. On a watershed or sub-basin level, restoration decisions must be made after carefully reviewing potential limiting factors, the source of the impacts, and the range of restoration options available, and what restoration activities are actually feasible.

Additional physical, operational, social, and/or economic factors exist that may influence the final order of sites; but these are beyond the scope of this project.

Final Product of Stream Crossing Inventory

This final report includes:

1. A count and location of all stream crossings with culverts and other manmade structures located within fish-bearing stream reaches. Locations were identified by stream name; road name; watershed name; mile marker or distance to nearest named crossroad; USGS Quad name; Township, Range and Section coordinates; and lat/long coordinates (NAD27 datum). All location data were entered into a spreadsheet for potential database uses.

2. For each site, crossing specifications were collected, including: length, diameter, type, position relative to flow and stream gradient, amount of fill material, depth of jump pool below crossing, height of leap required to enter crossing, previous modifications (if any) to improve fish passage, and evaluate effectiveness of previous modifications. At dams, a longitudinal profile and cross-sections were surveyed so that leap heights required for passage could be assessed. All site-specific data were entered into a spreadsheet for potential database uses.

3. Information regarding crossing age, wear, and performance was collected, including: overall condition of the crossing (and associated road fill) and rust line height (applicable only to metal culverts). All crossing specifications were entered into a spreadsheet for potential database uses.

4. An evaluation of fish passage at each crossing and dam location. Fish passage was evaluated by two methods. Initially, fish passage was assessed by employing a first-phase evaluation filter that was developed for Part IX of CDFG's *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003). The filter quickly determined if a crossing either met fish passage criteria for all species and life stages as defined by CDFG for the range of migration flows (**GREEN**); failed to meet passage criteria for all species and life stages (**RED**); or was a partial/temporal barrier (**GRAY**). Then FishXing (a computer software program) was used to conduct in-depth passage evaluations on the **GRAY** sites by modeling culvert hydraulics over the range of migration flows and comparing these values with leaping and swimming abilities of the species and life stages of interest. In some instances, FishXing was also utilized on crossings initially screened as **RED**. At dams, the passage evaluation was limited to assessing the leap heights required to negotiate the structure over the range of migration flows.

5. Digital photo documentation of each crossing and dam was taken to provide visual information regarding inlet and outlet configurations; as well as insertion in future reports, proposals, or presentations.

6. An evaluation of the quantity and quality of fish habitat above and below each crossing and dam location. Most information was obtained from habitat typing and fisheries surveys previously conducted by various federal and state agencies, as well as watershed groups and private consultants. Where feasible, a first-hand inspection and evaluation of stream habitat occurred. Lengths of potential anadromous habitat were also estimated from USGS topographic maps. In situations where formal habitat typing surveys were not conducted and/or access to stream reaches was not permitted, professional judgment of biologists and/or watershed coordinators familiar with watershed conditions was utilized.

7. A ranked list of crossings and dams that require treatment to provide unimpeded fish passage to spawning and rearing habitat. On a site-by-site basis, general recommendations for providing unimpeded fish passage were provided.

Project Justification

Migration Barrier Impacts to Salmonids

Fish passage through crossings (especially culverts) is an important factor in the recovery of depleted salmonid populations throughout the Pacific Northwest. Although most fish-bearing streams with culverts at stream crossings tend to be relatively small in size with only a couple of miles or less of upstream habitat, thousands of these exist and the cumulative effect of blocked habitat is probably quite significant. Recent research regarding watershed restoration considers the identification, prioritization, and treatment of migration barriers to restore ecological connectivity for salmonids a vital step towards recovering depressed populations (Roni et al. 2002).

Culverts often create temporal, partial or complete barriers for anadromous salmonids on their spawning migrations (Table 1) (adapted from Robison et al. 2000).

Typical passage problems created by culverts are:

- Excessive drop at outlet (too high of entry leap required);
- Excessive velocities within culvert;
- Lack of depth within culvert;
- Excessive velocity and/or turbulence at culvert inlet; and
- Debris accumulation at culvert inlet and/or within culvert.

Table 1. Definitions of barrier types and their potential impacts.

Barrier Category	Definition	Potential Impacts
Temporal	Impassable to all fish some of the time	Delay in movement beyond the barrier for some period of time
Partial	Impassable to some fish at all times	Exclusion of certain species and life stages from portions of a watershed
Total	Impassable to all fish at all times	Exclusion of all species from portions of a watershed

Even if culverts are eventually negotiated, excess energy expended by fish may result in their death prior to spawning or reductions in viability of eggs and offspring. Migrating fish concentrated in pools and stream reaches below stream crossings are also more vulnerable to predation by a variety of avian and mammalian species, as well as poaching by humans. Culverts which impede adult passage limit the distribution of spawning, often resulting in under seeded headwaters and superimposition of redds in lower stream reaches.

Current guidelines for new culvert installation aim to provide unimpeded passage for both adult and juvenile salmonids (CDFG 2002, NOAA 2001). However many existing culverts on federal, state, county, city, and private roads are barriers to anadromous adults, and more so to resident and juvenile salmonids whose smaller sizes significantly limit their leaping and swimming abilities to negotiate culverts. For decades, "legacy" culverts on established roads have effectively disrupted the spawning and rearing behavior of all four species of anadromous salmonids in California: Chinook salmon (*O. tshawytscha*), coho salmon, coastal rainbow trout (steelhead are anadromous coastal rainbow trout), and coastal cutthroat trout (*O. clarki clarki*).

In recent years, there has been a growing awareness of the disruption of in-stream migrations of resident and juvenile salmonids caused at road/stream intersections. In-stream movements of juvenile and resident salmonids are highly variable and still poorly understood by biologists. Juvenile coho salmon spend approximately one year in freshwater before migrating to the ocean, and juvenile steelhead may rear in freshwater for up to four years prior to out-migration (one to two years is most common in California). Thus, juveniles of both species are highly dependent on stream habitat.

Many studies indicate that a common strategy for over-wintering juvenile coho salmon is to migrate out of larger river systems into smaller streams during late-fall and early-winter storms to seek refuge from possibly higher flows and potentially higher turbidity levels in mainstem channels (Skeesick 1970; Cederholm and Scarlett 1981; Tripp and McCart 1983; Tschaplinski and Hartman 1983; Scarlett and Cederholm 1984; Sandercock 1991; Nickelson et al. 1992). Recent research conducted in coastal, northern California watersheds suggests that juvenile salmonids migrate into smaller tributaries in the fall and winter to feed on eggs deposited by spawning adults as well as flesh of spawned-out adults (Roelofs, pers. comm). Direct observation at numerous culverts in northern California confirmed similar upstream movements of three year-classes of juvenile steelhead (young-of-year, 1-year old and 2-year old) (Taylor 2000; Taylor 2001).

The variable life history of resident coastal rainbow trout is exhibited by seasonal movements in and out of one or more tributaries within a watershed. These smaller tributaries are where most culverts are still located since larger channels tend to be spanned by bridges.

Planning Efforts to Address Migration Barriers

In 2003 Ross Taylor and Associates completed an assessment of approximately 90 county-maintained stream crossings with culverts located throughout Marin County, including six in the Corte Madera Creek watershed. Additional crossings were also examined for potential passage problems including a series of weirs in Ross Creek behind the Branson School, a dam on San Anslemo Creek near Pacheco Avenue, and the Army Corps flood control channel. It was apparent that many additional crossings and probable migration barriers were present in the watershed however these were not maintained by the County of Marin and were not within the scope of the initial assessment. Most of these additional crossings were located within the city limits of Ross, Fairfax, and San Anselmo. In addition to the city-maintained crossings, several dams and the 1.5 mile-long flood control channel were also noted as migration barriers.

Anadromous salmonids will benefit from this planning effort because the final document provides the Friends of the Corte Madera Creek Watershed with a prioritized list of stream crossing locations to fix that will provide unimpeded passage for all species (and life stages) of salmonids. Report information will assist in proposal development to seek State and Federal money to implement treatments. The inventory will also provide city road managers with a comprehensive status evaluation of the overall condition and storm-flow capacities of crossings on fish-bearing stream reaches within their jurisdictions, providing vital information to assist each City's general planning and road maintenance needs.

METHODS AND MATERIALS

Methods for conducting the stream crossing inventory and fish passage evaluation included seven tasks; accomplished generally in the following order:

1. Location of stream crossings.
2. Initial site visits and data collection.
3. Estimation of tributary-specific hydrology and design flows for presumed migration period.
4. Data entry and passage analyses. Passage was 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 required an in-depth evaluation with FishXing – a computer modeling software.
5. Collection and interpretation of existing habitat information.
6. Prioritization of sites for corrective treatment.
7. Development of site-specific recommendations for unimpeded passage of both juvenile and adult salmonids.

These methods were fairly consistent with the protocol recently developed for Part IX of the CDFG *California Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003). These methods were developed to be consistent with current state and federal fish passage criteria for anadromous salmonids (CDFG 2002, NMFS 2001).

Three modifications to the original CDFG protocol were made during the Corte Madera Creek fish passage assessment project:

- Use of more rigorous criteria (decreased minimum water depths and increased swimming abilities) for assessing passage of adult salmonids (see page 19).
- A reduction of the weight of crossing sizing and condition in the ranking score (see page 26).
- Crossings that had an "extent of barrier" score ≥12 points were re-ranked with no upper limit on the "habitat quantity" score (see page 27).

The first two modifications to the original CDFG protocol were initiated in response to results generated by the original methods during assessments completed prior to 2003. All protocol changes were discussed with CDFG and NOAA personnel prior to their use in assessment projects conducted by Ross Taylor and Associates in 2003-04. In-depth explanations to the rationale of modifying the methodology are provided at appropriate places within the Methods and Materials.

Location of Stream Crossings

Preliminary project scoping for stream crossings to survey included examination of Marin County road maps and counting road/stream intersections on known (current and historic) anadromous stream reaches. Several on-the-ground surveys were also conducted to determine types of structures at various locations, including the status of private driveways along Sleepy Hollow Creek. Most of the preliminary scoping was conducted by Sandra Guldman and the Friends of the Corte Madera Creek Watershed. Additional sites were also investigated by Ross Taylor and Associates once the project started.

Access Permission

Because Corte Madera Creek's predominantly urban setting most crossings were located on private property, often with houses adjacent to the stream channel. Access permission requests were mailed by Sandra Guldman to landowners at addresses adjacent to potential survey sites. Once in the field prior to entering the creek, we generally attempted to personally notify the landowner that we were present.

Initial Site Visits

The objective of the initial site visits was to collect physical measurements at stream crossings to utilize with the first-phase evaluation filter and with the FishXing passage evaluation software. Notes describing the type and condition of each crossing, as well as qualitative comments describing stream habitat immediately above and below each crossing were also included. Site photographs taken included: upstream and downstream sides of the crossing, locations of cross-section tape, stream channel conditions, and/or crossing condition such as damage or unique features.

Stream Crossing Type

Potential sites were visited in the field and all crossings were first identified as either: culverts, bridges, dams, or weirs. Field measurements were collected at culverts, dams, and weirs; however the initial investigation closely examined all crossings identified on maps as bridges because of the length of their span. Typically any structure with a combined span greater than 20 feet is defined by road managers as a bridge – yet from a fish passage perspective if these structures had a smooth concrete floor they were defined as concrete box culverts, surveyed, and evaluated for passage.

Crossing Location

The location of each stream crossing within a fish-bearing stream reach was described by: road name; stream name; watershed name; name of USGS quad map; Township, Range, and Section; latitude and longitude; and mile marker or distance to nearest named cross-road. If more than one stream crossing was present within a single Corte Madera Creek tributary, a number was assigned to the stream name with the #1 crossing located farthest downstream (numbering then proceeded in an upstream direction). Lat/long coordinates were determined using Terrain Navigator (Version 3.01 by MapTech™), a geo-referenced mapping software program; or in the field with a handheld GPS unit. For data entry and analyses purposes, all lat/long coordinates were provided in the North American 1927 datum (NAD27).

Longitudinal Survey

A longitudinal survey was shot at each crossing to provide accurate elevation data for FishXing passage analyses. We utilized an auto-level (Topcon™ AT-G7) with an accuracy of ± 2.5 mm, a domed-head surveyor's tripod, and a 25' leveling rod in 1/100' increments. All data and information were written on water-proof data sheets with a pencil. Data sheets were photocopied to provide back-ups in case of loss or destruction of originals.

Once a site was located in the field by the two-person survey crew, bright orange safety cones with signs marked "Survey Party" were placed to warn oncoming traffic from both directions. Bright orange vests were also worn by the survey crew to increase one's visibility to traffic.

To start the survey, a 300-foot tape (in 1/10' increments) was placed down the approximate center of the stream channel. The tape was started on the upstream side of the crossing, usually in the riffle crest of the first pool or run habitat unit above the crossing. This pool or run was considered the first available resting habitat for fish after negotiating the stream crossing.

The tape was set to follow any major changes in channel direction. The tape was set through the culvert (or over the dam or weir) and continued downstream to at least the riffle crest (or tail-water control) of the pool immediately downstream of the crossing outlet. If a tail-water cross-section was measured, the 300-foot tape was set past the tail-water control to measure downstream channel slope. Extreme caution was used when wading through or over the crossings. A hardhat and flashlight were standard items used during the surveys.

The tripod and mounted auto-level were set in a location to eliminate or minimize the number of turning points required to complete the survey. If possible, a location within the stream channel was selected to avoid road traffic. The leveling rod was placed at the thalweg (deepest point of channel cross-section at any given point along the center tape) at various stations along the center tape, generally capturing visually noticeable breaks in slope along the stream channel.

At all sites, a temporary benchmark (TBM) was established in order to allow someone (such as a city public works employee) to easily re-survey the site to either check the accuracy of our surveys or to conduct a survey prior to designing or implementing a treatment. TBM's were typically established by spray-painting an "X" on a relatively permanent feature such as a concrete wing-wall or head-wall. The locations of all TBM's were clearly marked on the site sketches.

At all sites, elevations required to run FishXing were measured (Figures 1 and 2):

1. crossing inlet (if culvert) or upstream edge of dam/weir,
2. crossing outlet (if culvert) or downstream edge of dam/weir,
3. maximum pool depth within five feet of the outlet,
4. outlet pool tail-water control,
5. a point downstream of the tail-water control, and
6. cross-section at the tail-water control.

Each cross-section was comprised of approximately eight to 10 elevations from the left bank-full channel margin to the right bank-full margin. These cross sections allowed for more accurate modeling of changes in tail-water elevations over varying stream discharges with the FishXing software.

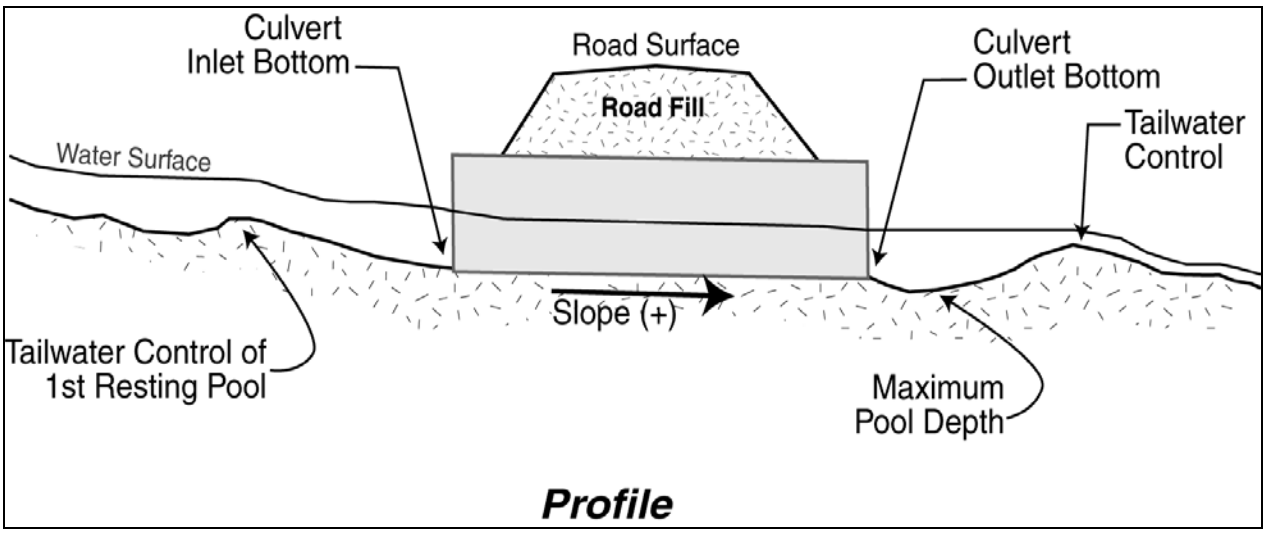


Figure 1. Diagram of required survey points though a culvert at a typical stream crossing.

Figure 2. Example of tape locations for measuring cross-section and downstream channel slope, San Anselmo Creek at Fairfax-Bolinas Road.

On a site-specific basis, the following additional survey points provided useful information for evaluating fish passage with FishXing:

- Apparent breaks-in-slope within the crossing. Older culverts often sag when road fills slump, creating steeper sections within a culvert. If only inlet and outlet elevations are measured, the overall slope will predict average velocities less than actual velocities within steeper sections. These breaks-in-slope may act as velocity barriers, which are masked if only the overall slope of the culvert is measured. The tripod and auto-level were set within the culvert or channel to measure breaks-in-slope.

- Steep drops in the stream channel profile immediately upstream of the culvert inlet. Measure the elevation at the tail of the first upstream holding water (where the tape was set) to estimate the channel slope leading into the culvert. In some cases, a fish may negotiate the culvert only to fail at passing through a velocity chute upstream of the inlet entrance. Inlet drops often create highly turbulent conditions during elevated flows.

- Multi-stage drops over and dams and weirs. In some cases, dams were constructed on top of existing bed-rock outcrops that protruded farther downstream than the concrete face. These situations most likely create unfavorable hydraulic conditions for leap attempts by adult steelhead.

All elevations were measured to the nearest 1/100' and entered with a corresponding station location (distance along center tape) to the nearest 1/10'.

Channel widths

Where feasible, at least five measurements of the active channel width above the crossing (visually beyond any influence the crossing may have on channel width) were taken. Active channel is defined as the portion of channel commonly wetted during and above winter base flows and is identified by a break in rooted vegetation or moss growth on rocks along stream margins. Some stream crossing design guidelines utilize active channel widths in determining the appropriate widths of new culvert installations (CDFG 2002; NMFS 2001; Robison et al 2000; Bates et al. 1999).

Fill Estimate:

At most crossings, the volume of road fill placed above the stream channel was estimated from field measurements. Fill volume estimates are incorporated into the ranking of sites for treatment and can assist in:

1. Determining potential volume of sediment deliverable to downstream habitat if the stream crossing failed.
2. Developing rough cost estimates for barrier removal by estimating equipment time required for fill removal and disposal site space needed.

Road fill volume is estimated using procedures outlined in Flannigan et al. (1998). The following measurements are taken to calculate the fill volume (Figure 3):

1. Upstream and downstream fill slope lengths (L_d and L_u).
2. Slope (%) of upstream and downstream fill slopes (S_d and S_u).
3. Width of road prism (W_r).
4. Top fill width (W_f).
5. Base fill width (W_c).

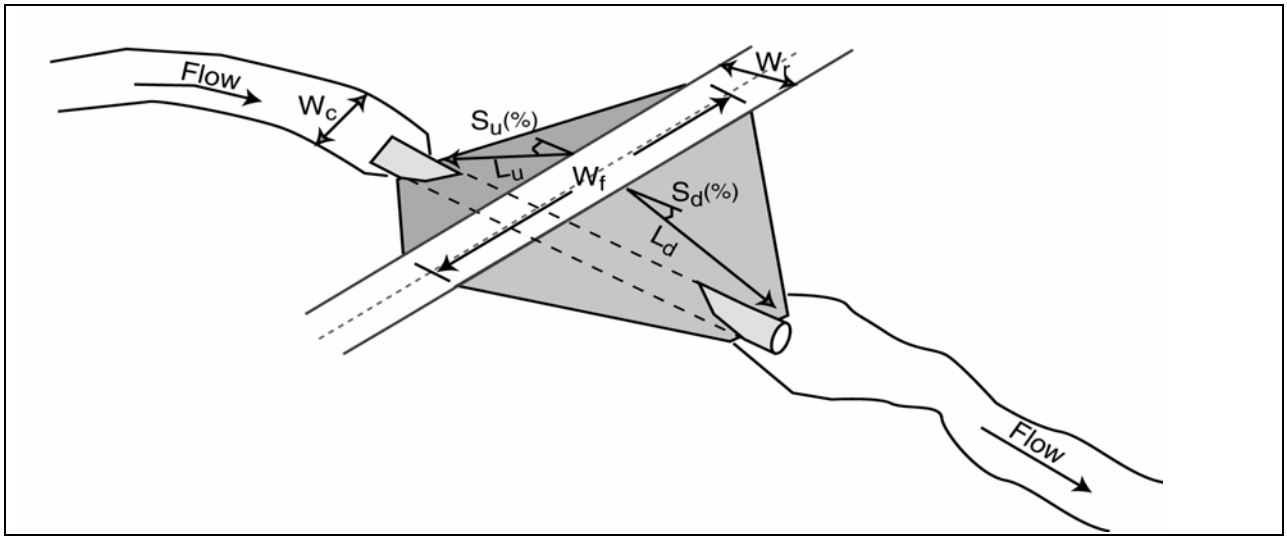


Figure 3. Road fill measurements.

Equations (1) through (4) were used calculate the fill volume.

(1) Upstream prism volume, V_u:

$$V_u = 0.25(W_f + W_c)(L_u \cos S_u)(L_u \sin S_u)$$

(2) Downstream prism volume, V_d:

$$V_d = 0.25(W_f + W_c)(L_d \cos S_d)(L_d \sin S_d)$$

(3) Volume below road surface, V_r:

$$V_r = 0.25(H_u + H_d)(W_f + W_c)\ W_r$$

where: $H_u = L_u \sin S_u$, and

$H_d = L_d \sin S_d$

(4) Total fill volume, V:

$$V = V_u + V_d + V_r$$

NOTE: The fill measurements used as part of this inventory protocol were meant to generate rough volumes for comparison between sites while minimizing the amount of time required collecting the information. These volume estimates may contain significant error and should not be used for designing replacement structures.

Other Site-specific Measurements

For each crossing with a culvert, the following specifications were collected:
1. Length (to nearest 1/10 of foot);
2. Dimensions: diameter (circular), or height and width (box culverts), or span and rise (pipe arches and open-bottom arches);
3. Type: corrugated metal pipe (CSP), structural steel plate (SSP), concrete pipe, concrete box, open-bottom pipe arch, squashed pipe-arch, or a composite of materials;
4. Overall condition of pipe (good, fair, poor, extremely poor);
5. Height and width of rustline (if present);
6. Position relative to flow and stream gradient;
7. Depth of pool below culvert;
8. Height of jump required to enter culvert;
9. Previous modifications (if any) to improve fish passage; and
10. Condition of previous modifications.

For crossing that was a dam or weir, the following specifications were collected:
1. Length (to 1/10');
2. Dimensions: width of structure, location and dimensions of any notches;
3. Construction material;
4. Overall condition (good, fair, poor, extremely poor);
5. Depth of pool below dam or weir;
6. Height of leap required to clear the structure;
7. Previous modifications (if any) to improve fish passage; and
8. Condition of previous modifications.

Qualitative notes describing stream habitat immediately upstream and downstream of each crossing were taken. Where feasible, variable lengths of the stream channel above and below crossings were walked to detect presence of salmonids, other fish species, and provide additional information regarding habitat conditions.

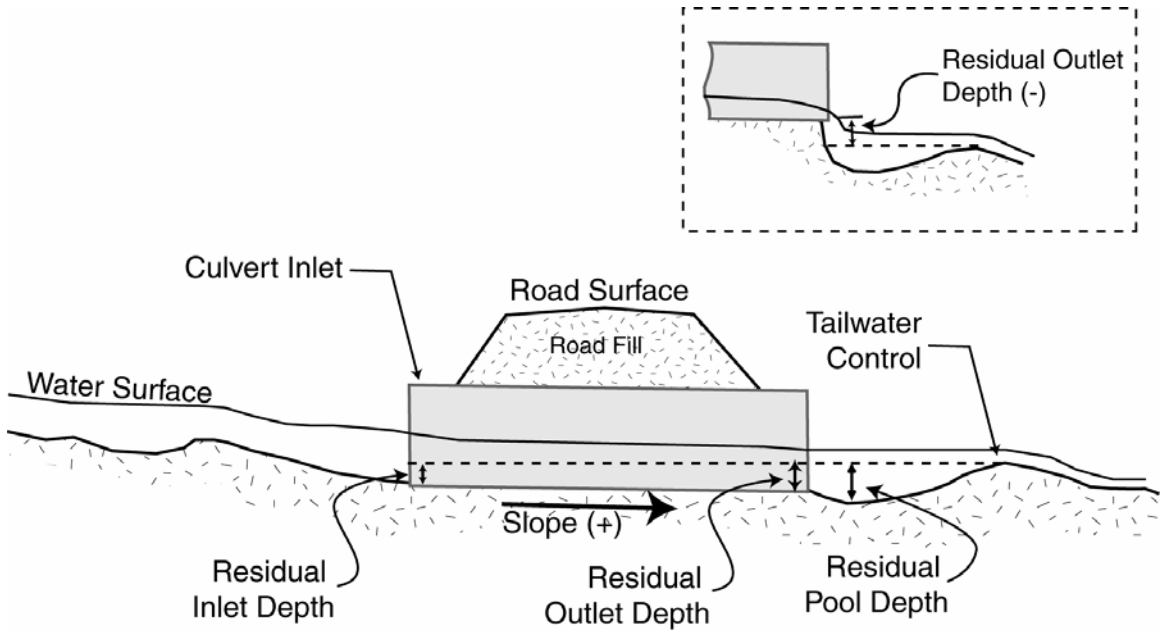
Data Entry and Passage Analyses

All survey and site visit data were recorded on waterproof data sheets. Then data for each crossing were entered into a spreadsheet. A macro was created to calculate thalweg elevations of longitudinal profiles to compute crossing and channel slopes.

First-phase Passage Evaluation Filter: GREEN-GRAY-RED

A filtering process was used to assist in identifying sites which either met, or failed to meet, state and federal fish passage criteria for all fish species and life-stages (CDFG 2002; NMFS 2001). Using the field inventory data, the following values were calculated: average active channel width, crossing slope, residual inlet depth and drop at outlet (Figure 4). The first-phase passage evaluation filter was employed to reduce the number of crossings which required an in-depth passage evaluation with FishXing. The filter criteria were designed to quickly classify crossings into one of three categories:

- **GREEN**: Conditions assumed adequate for passage of all salmonids, including the weakest swimming life-stage.
- **GRAY**: Conditions may not be adequate for all salmonid species or life-stages presumed present. Additional analyses required to determine extent of barrier for each species and life-stage.
- **RED**: Conditions do not meet passage criteria at any flows for strongest swimming species presumed present. In some instances, assume "no passage" and move to analysis of habitat quantity and quality upstream of the barrier. A subset of "RED" sites required additional assessment with FishXing.



Residual Pool Depth = (Elev $_{\text{Tailwater Control}}$ – Elev $_{\text{Pool Bottom}}$)

Outlet Depth = (Elev $_{\text{Tailwater Control}}$ – Elev $_{\text{Culvert Outlet}}$) *(No outlet drop if Outlet Depth ≥ 0)*

Residual Inlet Depth = (Elev $_{\text{Tailwater Control}}$ – Elev $_{\text{Culvert Inlet}}$)

Figure 4. Measurements used in Green-Grey-Red filtering criteria.

A spreadsheet macro was utilized that followed the CDFG flowchart to determine a stream crossing's status as Green, Gray, or Red (Figure 5). Depending on geographic location within California, species of interest will vary. Within anadromous-bearing watersheds, CDFG has determined that crossings classified as "Green" must meet upstream passage criteria for both adult and over-wintering juvenile salmonids at all expected migration flows.

Many stream crossings have unique characteristics which may hinder fish passage, yet they are not recognized in the filtering process. For crossings meeting the "Green" criteria, a review of the inventory data and field notes was necessary to ensure no unique passage problems existed before classifying the stream crossings as "100% passable".

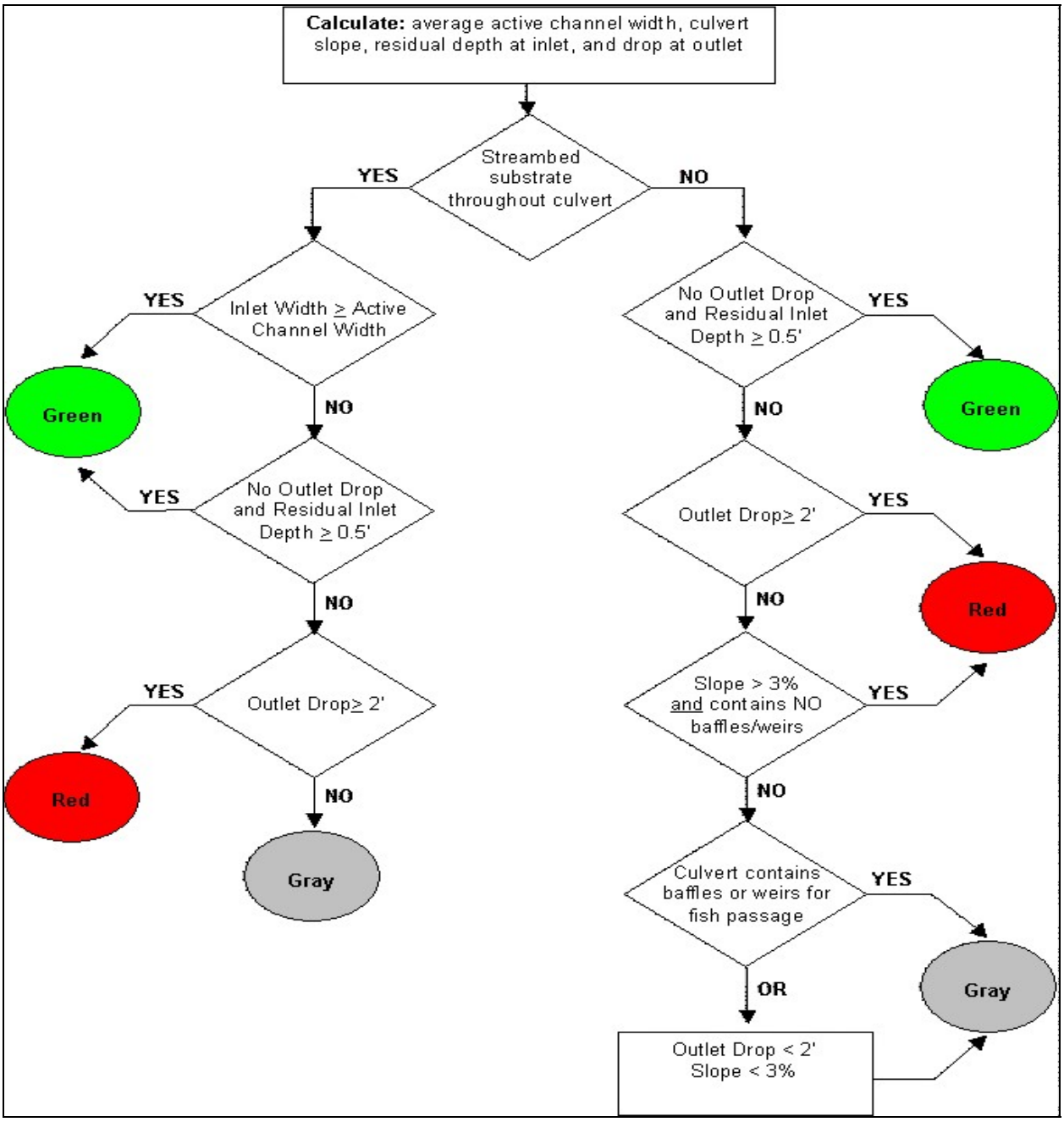


Figure 5. GREEN-GRAY-RED first-phase passage evaluation filter.

FishXing Overview

FishXing is a computer software program developed by Six Rivers National Forest's Watershed Interactions Team - a group of scientists with diverse backgrounds in engineering, hydrology, geomorphology, geology and fisheries biology. Mike Furniss, a Forest Service hydrologist for Six Rivers, managed program development. The initial version of FishXing was released in March, 2000. FishXing has since undergone two revisions, with version 3.0 due for release in early 2006. A beta copy of version 3.0 was utilized in the analyses of the Corte Madera Creek data. In-depth information regarding FishXing (or a copy of the most-recent version) may be obtained at the Fish Crossing homepage on the internet (www.stream.fs.fed.us/fishxing/).

FishXing is an interactive software package that integrates a culvert design and assessment model for fish passage nested within a multimedia educational setting. Culvert hydraulics are well understood and model output closely resembles reality. FishXing successfully models (predicts) hydraulic conditions throughout the culvert over a wide range of flows for numerous culvert shapes and sizes. The model incorporates fisheries inputs including fish species, life stages, body lengths, and leaping and swimming abilities. FishXing uses the swimming abilities to determine whether the culvert installation (current or proposed) will accommodate fish passage over a desired range of migration flows, and identify specific locations within the culvert that impede or prevent passage. Software outputs include water surface profiles and hydraulic variables such as water depths and average velocities displayed in both tabular and graphical formats. FishXing's application to dams and weirs was limited to assessing changes in drop heights of these structures over the range of migration flows for adult anadromous salmonids.

Fish Passage Criteria – First Deviation from CDFG Passage Assessment Protocol

FishXing utilized survey elevation and crossing specifications to evaluate passage at sites defined as "GRAY" by the first-phase evaluation filter for each species and life-stages of salmonids known to currently or historically reside in the Corte Madera Creek watershed. The swimming abilities and passage criteria recommended in the original CDFG fish-passage protocol and the alternate values used in the Corte Madera Creek project for each species and life-stage are listed Table 2.

The CDFG fish-passage protocol recommended using conservative values for assessment under the assumption that although many individual fish will have swimming abilities surpassing those listed, swim speeds and minimum water depths were selected to ensure stream crossings accommodated passage of weaker individuals within each age class. This assumption is better suited for the *design* of new crossings where being conservative hopefully allows for the passage of all fish. However, for *assessment* purposes, the use of conservative swimming values and minimum water depths generated many "RED" sites that, in fact, were allowing the passage of adult salmonids. This discrepancy was first noticed during Ross Taylor and Associates' Marin County assessment project (in 2002) where extensive spawning survey data confirmed adult coho salmon and steelhead consistently spawning upstream of crossings initially assessed as "RED".

If the objective of the passage assessment is to identify crossings that are truly barriers to adult migration, as well as, accurately estimate the percentage of temporal passage to allow a gradation in the scoring matrix; then using conservative values is not appropriate. The use of more rigorous passage criteria should reduce the number of "RED" sites and generate a wider range of "extent of barrier" scores for the "GRAY" sites.

FishXing used the survey elevation and crossing specifications to evaluate passage at sites defined as "Grey" by the first-phase evaluation filter for each species and life-stages of salmonids known to currently or historically reside in Corte Madera Creek. The swimming abilities and passage criteria used for each species and life-stage are listed Table 2. Although some individual fish will have swimming abilities surpassing those listed below, swim speeds were selected to ensure stream crossings accommodate passage of weaker individuals within each age class.

Table 2. Fish species and life stages used in the fish passage along with associated swimming abilities and passage criteria. Values in parentheses are the conservative values recommended in the CDFG protocol. Passage flows are based on current adult salmonid criteria combined with observational data from northern California coastal streams.

Fish Species/Age Class	**Adult Steelhead and Coho**	**Resident Trout**	**Juvenile Salmonids**
Fish Length	500 mm	200 mm	80 mm
Prolonged Mode Swim Speed Time to Exhaustion	 (6 ft/sec) **8 ft/sec** 30 min	 4 ft/s 30 min	 1.5 ft/s 30 min
Burst Mode Swim Speed Time to Exhaustion	 (10 ft/sec) **16 ft/sec** 5 sec	 5.0 ft/s 5 s	 3.0 ft/s 5 s
Maximum Leaping Speed	(12.0 ft/sec) **16 ft/sec**	6.0ft/s	3.0 ft/s
Velocity Reduction Factors for Corrugated Metal Culverts **	Inlet = 1.0 Barrel = 1.0 Outlet = 1.0	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8
Minimum Required Water Depth	(0.8 ft) **0.5 ft**	0.5 ft	0.3 ft
Minimum Passage Flow *(Use the larger of the two flows)*	50% exceedance flow or 3 cfs	90% exceedance flow or 2 cfs	95% exceedance flow or 1 cfs
Maximum Passage Flow	1% exceedance flow	5% exceedance flow	10% exceedance flow

** Velocity reduction factors only apply to culverts with corrugated walls, baffles, or natural substrate. All other culverts had reduction factors of 1.0 for all fish.

FishXing and other hydraulic models report the average cross-sectional water velocity, often failing to account for spatial variations. Stream crossings with natural substrate or corrugations will have regions of reduced velocities that can be utilized by migrating fish. These areas are often too small for larger fish to use, but can enhance juvenile passage success. FishXing allows the use of reduction factors that decrease the calculated water velocities proportionally. As shown in Table 2, velocity reduction factors were used in the passage analysis of resident fish and juveniles with specific types of stream crossing structures.

Using FishXing, the range of flows that met the depth, velocity, and leaping criteria for each life-stage were identified. The range of flows meeting the passage requirements were then compared to the entire range of fish passage flows to determine "percent passable".

Hydrology and Design Flow

When examining stream crossings that require fish passage, three specific flows are considered: peak flow capacity of the stream crossing, the upper fish passage flow, and the lower fish passage flow. Because flow is not gauged on most small streams, it must be estimated using techniques that required hydrologic information about the stream crossing's contributing watershed, including:

- Drainage area;
- Mean annual precipitation;
- Mean annual potential evapotranspiration; and
- Average basin elevation.

Drainage area and basin elevations were calculated from a 1:24,000 USGS topographic map. For most projects, mean annual precipitation (MAP) and potential evapotranspiration (PET) are estimated from regional maps produced by Rantz (1968).

Peak Flow Capacity

Peak flows are typically defined in terms of a recurrence interval, but reported as a quantity; often as cubic feet per second (c.f.s.). Current guidelines recommend all stream crossings pass the flow associated with the 100-year flood without damage to the stream crossing (NOAA, 2001). Additionally, infrequently maintained crossings with culverts should accommodate the 100-year flood without overtopping the culvert's inlet.

Determination of a crossing's flood capacity assisted in ranking sites for remediation. Undersized crossings have a higher risk of catastrophic failure, which often results in the immediate delivery of sediment from the road- fill into the downstream channel. Depending on the amount of road-fill, this pulse of sediment may have a minor-to-catastrophic impact on downstream rearing and spawning habitat. Undersized crossings can also adversely affect sediment transport and downstream channel stability, creating conditions that hinder fish passage, degrade habitat, and may cause damage to other stream crossings and/or private property.

The first step was to estimate hydraulic capacity of each inventoried stream crossing. Capacity is generally a function of the shape and cross-sectional area of the inlet. Capacity was calculated for two different headwater elevations: water ponded to the top of the culvert inlet (HW/D = 1). Nomograph equations developed by Piehl et. al (1988) were used to calculate capacity of circular culverts. Federal Highways nomographs presented in Norman et al (1995) were used for pipe-arches, open bottom arches, oval pipes and box culverts.

The second step was to estimate peak flows at each crossing. This required estimating the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year peak flows. Regional flood estimation equations developed by Waananen and Crippen (1977) were used to estimate peak flows for the various recurrence intervals (Figure 6). The equations incorporate drainage area, MAP, and mean basin elevation as variables to predict peak flow in North Coast region California streams.

The third step was to compare the stream crossing capacity to peak flow estimates. Risk of failure was assessed by comparing a stream crossing's hydraulic capacity with the estimated peak flow for each recurrence interval. Each crossing was placed into one of six "sizing" categories:

1. equal to or greater than the 100-year flow,
2. between the 50-year and 100-year flows,
3. between the 25-year and 50-year flows,
4. between the 10-year and 25-year flows,
5. between the 10-year and 5-year flows.
6. less than the 5-year storm flow.

These six categories were utilized in the stream crossing ranking matrix.

Fish Passage Flows

It is widely agreed that designing stream crossings to pass fish at all flows is impractical (CDFG 2002; NOAA 2001; Robison et al. 2000; SSHEAR 1998). Although anadromous salmonids typically migrate upstream during higher flows triggered by hydrologic events, it is presumed that migration is naturally delayed during larger flood events. Conversely, during low flow periods on many smaller streams, water depths within the channel can become impassable for both adult and juvenile salmonids. To identify the range of flows that stream crossings should accommodate for fish passage, lower and upper flow limits have been defined specifically for streams within California (CDFG 2002; NOAA 2001).

To evaluate the extent to which a crossing is a barrier, passage was assessed between the lower and upper passage flows for each fish species and life stage of concern. Identifying the exceedence flows required obtaining average daily stream flow data from gauged streams. Daily average flow data for small streams in Marin County were available from the USGS.

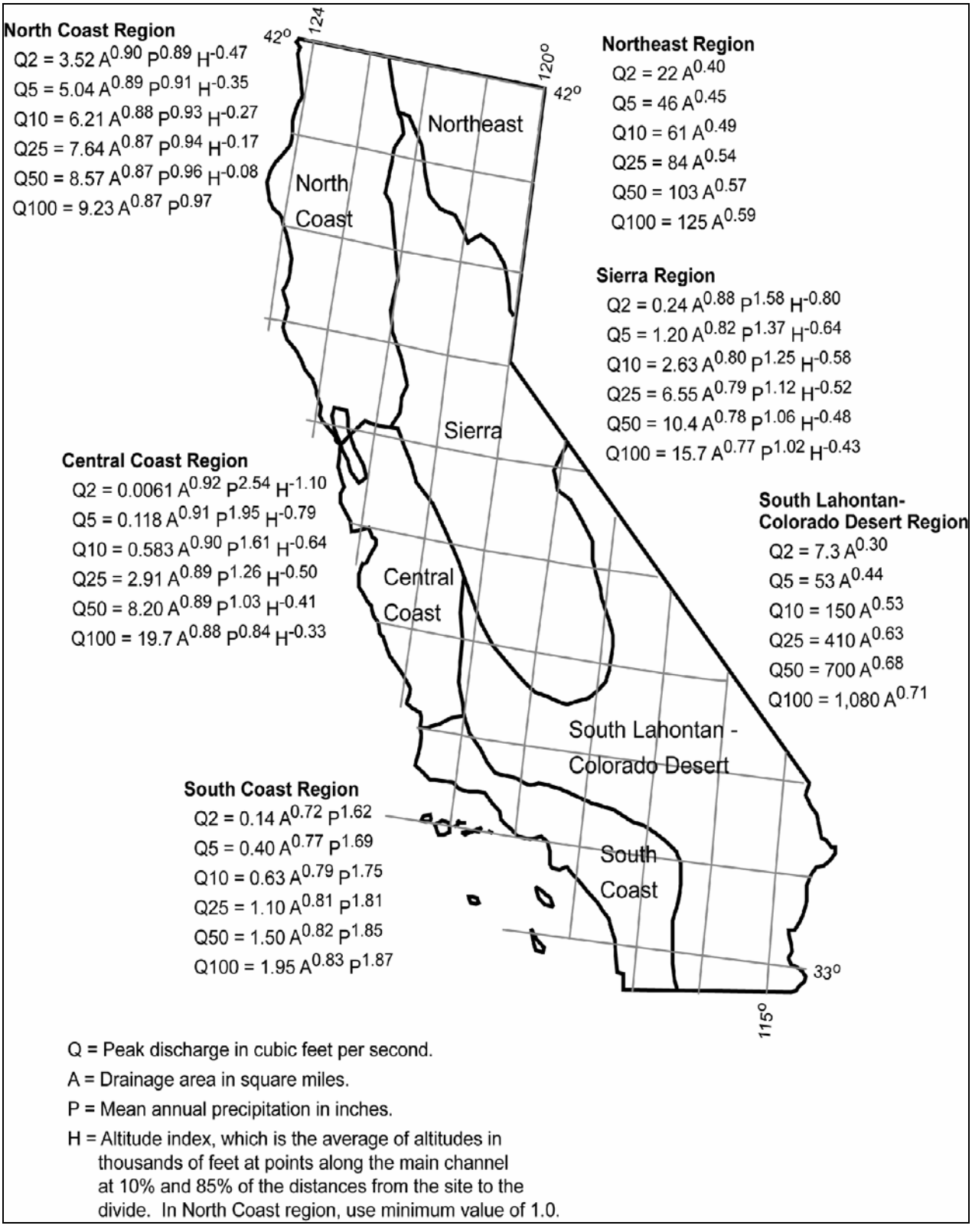


Figure 6. California regional regression equations for estimating peak flows associated with a 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year recurrence interval (Waananen and Crippen, 1977).

The following steps were followed to estimate upper and lower passage flows:

1. Obtained flow records from local stream gauges that met the following requirements:
   - At least five years of recorded daily average flows (do not need to be consecutive years);
   - A drainage area less than 100 square miles, and preferably less than 10 square miles; and,
   - Unregulated flows (no upstream impoundments or water diversions) during the migration season are desired.

2. Divided the flows (Q) for each gauged stream by its drainage area (A), resulting in units of cfs/mi^2.

3. Created regional flow duration curve by taking the median of the exceedence flows (Q/A) of the gauged streams (Appendix C).

4. Determined the upper and lower passage flows for each stream crossing using the regional flow duration curve and the drainage area of the stream crossing.

When analyzing fish passage with FishXing, these flows were used to determine the extent to which the crossing is a barrier. The stream crossing must meet water velocity and depth criteria between Q_{lp} and Q_{hp} to be considered 100% passable (NOAA 2001). For the ranking matrix, at each stream crossing, the extent of the migration barrier was determined for each salmonid species and life stage presumed present.

Habitat Information

Because this project addressed fish passage in numerous tributaries throughout the Corte Madera Creek watershed, the assessment of stream habitat conditions associated with the surveyed stream crossings was based primarily on previously completed surveys and reports, as well as the professional judgment of biologists and restoration groups familiar with the watershed. We relied heavily on the habitat information and fish presence/distribution data contained in *Fisheries Resources Conditions of the Corte Madera Creek Watershed* (Rich 2000). Additional CDFG reports and memos also provided information on past, present, and future land uses within watersheds where stream crossings were located.

Professional judgment from on-site inspection of stream crossings and stream habitat also aided habitat assessment and evaluation. In some cases, with landowner permission, longer reaches of stream were walked to better assess quality of habitat above and below the surveyed crossings.

Habitat Quantity

Lengths of potential anadromous salmonid habitat upstream of each crossing were estimated by two methods:

1. Lengths measured in the field during habitat typing or fisheries surveys. If access was permitted, these surveys were terminated where the field crews thought the limit of anadromy was located. The surveys were often terminated at obvious features such as natural waterfalls, extremely steep-sloped boulder cascades, or at permanent human-made structures such as dams.

2. Measured off of digitized USGS 7.5 Minute Series topographic maps (Terrain Navigator, Version 3.01by MapTech). The upper limit of anadromous habitat was considered when the channel exceeded an eight percent slope for at least a 300-foot channel reach.

The habitat quantity value used in the ranking matrix varied, but usually if a habitat typing survey identified an obvious feature where anadromy was terminated – this was the value used. In other instances, the eight-percent slope was used only if on-the-ground survey information was unavailable.

The presence of previously assessed stream crossings above and below each site included in this project was also considered when evaluating potential habitat gains. The location (and status) of these previously assessed crossings were considered when developing the final ranking matrix for the purpose of selecting sites for treatment scheduling.

Initial Ranking of Stream Crossings for Treatment

The ranking objective was to arrange the sites in an order from high to low priority using a suite of site-specific information. However, the "scores" generated were not intended to be absolute in deciding the exact order of scheduling treatments. Once the first-cut ranking was completed, professional judgment played an important part in deciding the order of treatment. As noted by Robison et al. (2000), numerous social and economic factors influenced the exact order of treated sites.

Because the Friends of Corte Madera Creek intends on assisting the various cities (and other responsible entities) in treating stream crossings identified as "high-priority" by submitting proposals to various fisheries restoration funding sources, additional opportunities for re-evaluating the biological merit of potential projects will occur through proposal review committees composed of biologists from CDFG and other agencies. The methodology for ranking migration barriers at stream crossings is a developing process and will undoubtedly require refinement as additional information is obtained.

This report also acknowledges (but makes no attempt to quantify or prioritize) that other potentially high-priority restoration projects exist throughout California, and these must all be considered when deciding where and how to best spend limited restoration funds. However, recent research regarding watershed restoration considers the identification, prioritization, and treatment of human-made migration barriers to restore ecological connectivity for salmonids a vital (and often initial) step towards recovering depressed populations (Roni et al. 2002).

Ranking Criteria

The criteria and scoring for ranking stream crossings were relatively consistent with those developed for Part IX of CDFG's *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003), except for two aspects. The second deviation from the CDFG protocol entailed reducing the weight of the current crossing's sizing and condition scores on the site's total score. Again, this modification to the CDFG protocol resulted from carefully analyzing data sets from previously completed assessment projects. The ranking matrix developed for the *Restoration Manual* can generate a maximum possible score of 39 points, with a maximum of 10 points (25.6%) associated with crossing condition and sizing. In some instances, crossings with very little upstream habitat (<1,000') and/or met the adult passage criteria on 70-100% of the range of migration flows were ranking near the top due primarily to poor condition and under-sizing.

Undersized crossings that are in poor condition should be of concern to road managers. However, if the primary purpose of the ranking matrix is to identify sites to treat with fisheries restoration funding, then more weight should be put on the biological-related criteria so that crossings which are serious impediments to migration with significant reaches of potential upstream habitat rank higher than crossings in need of replacement with maintenance funds.

The weight of the sizing and condition criteria score was reduced by utilizing the average of the two values. This resulted in a maximum possible total score of 34 points, with sizing and condition criteria comprising a weight of 14.7% of the maximum total score. This adjustment in scoring crossing capacity and condition has already occurred on the following projects: San Mateo County, Marin County, Russian River, Santa Cruz County, and the Morro Bay watershed fish passage assessment projects.

The method utilized for the Five County Clean-up assessment assigned a score or value for the following criteria at each crossing location. The total score was the sum of four criteria: species diversity, extent of barrier, average value of crossing sizing and current condition, and total habitat score.

1. **Species diversity:** number of salmonid species known to occur (or historically occurred) within the stream reach at the crossing location. **Score:** ESA listing status as threatened: Coho salmon = **2** points; Steelhead = **2** points. NOTE: although there is historic evidence that coho salmon were probably present in Corte Madera Creek, there was insufficient information to determine which tributaries were coho-bearing and which were not. Thus all sites were scored as having "steelhead" only.

2. **Extent of barrier:** for three age classes of salmonids (adults, resident trout/2+, and 1+/young-of-year), over the range of estimated migration flows, assign one of the following values. **Score: 0** = 80-100% passable; **1** = 60-80% passable; **2** = 40-60% passable; **3** = 20-40% passable; **4** = less than 20% passable; **5** = 0% passable (RED by first-phase evaluation filter). For a total score, sum scores given for adult species and each year-class of juveniles. **Maximum score = 15 points.**

3. **Sizing (risk of failure):** for each crossing, assign one of the following values as related to flow capacity. **Score: 0 =** sized to NMFS standards of passing 100-year flow at less than inlet height. **1** = sized for at least a 50-year flow, low risk. **2** = sized for at least a 25-year flow, moderate risk. **3** = sized for less than a 25-year flow, moderate to high risk of failure. **4** = sized for less than a 10-year event, high risk of failure. **5** = sized for less than a five-year event, high risk of failure.

4. **Current condition:** for each crossing, assign one of the following values. **Score: 0** = good condition. **1** = fair, showing signs of wear. **3** = poor, floor rusting through, crushed by roadbase, etc. **5** = extremely poor, floor rotted-out, severely crushed, damaged inlets, collapsing wingwalls, slumping road-base, etc.

5. **Crossing Score:** for each crossing, combine the sizing and condition values and compute the average value. **Maximum score = 5 points.**

6. **Habitat quantity:** above each crossing, length in feet to sustained 8% gradient. **Score:** Starting at a 500' minimum; 0.5 points for each 500' length class (**example**: **0** points for <500'; **1** point for 1,000'; **2** points for 2,000'; **3.5** points for 3,500'; and so on). **Maximum score = 10 points.**

7. **Habitat quality:** for each stream reach within the vicinity of the crossing, assign a "multiplier" of quality (relative to other streams and stream-reaches in inventory) after reviewing available habitat information.

- **Score: 1.0 = Excellent-** Relatively undeveloped, "pristine" watershed conditions. Habitat features include dense riparian zones with mix of mature native species, frequent pools, high-quality spawning areas, cool summer water temperatures, complex in-channel habitat, and/or channel floodplain relatively intact. High likelihood of no future human development. Presence of migration barrier(s) is obviously the watershed's limiting factor.

- **0.75 = Good-** Habitat is fairly intact, but human activities have altered the watershed with likelihood of continued activities. Habitat still includes dense riparian zones of native species, frequent pools, spawning gravels, cool summer water temperatures, complex in-channel habitat, and/or channel floodplain relatively intact. Presence of migration barrier(s) is most likely one of the watershed's primary limiting factors.

- **0.5 = Fair-** Human activities have altered the watershed with likelihood of continued (or increased) activities, with apparent effects to watershed processes and features. Habitat impacts include riparian zone present but lack of mature conifers and/or presence of non-native species, infrequent pools, sedimentation evident in spawning areas (pool tails and

riffle crests), summer water temperatures periodically exceed stressful levels for salmonids, sparse in-channel complex habitat, floodplain intact or slightly modified). Presence of migration barrier(s) may be one of the watershed's limiting factors (out of several factors).

- **0.25 = Poor**- Human activities have drastically altered the watershed with high likelihood of continued (or increased) activities, with apparent effects to watershed processes. Habitat impacts include riparian zones absent or severely degraded, little or no pool formations, excessive sedimentation evident in spawning areas (pool tails and riffle crests), stressful to lethal summer water temperatures common, lack of in-channel habitat, floodplain severely modified with levees, riprap, and/or residential or commercial development. Other limiting factors within watershed are most likely of a higher priority for restoration than remediation of migration barriers. NOTE: a "poor" habitat rating was also assigned to stream reaches that were either too small and/or too steep to provide adequate habitat for anadromous salmonids even though the stream reach was potentially available for fish utilization.

8. **Total habitat score:** Multiply #5 by #6 for habitat "score". A multiplier assigned for habitat quality, weighs the final score more on quality than sheer quantity of upstream habitat. **Maximum score = 10 points.** For each culvert location, the five ranking criteria were entered into a spreadsheet and total scores computed. Then the list was sorted by "Total Score" in a descending order to determine an initial ranking. On closer review of the rank, some professional judgment was used to slightly adjust the rank of several sites. The list was then divided subjectively into groups defined as "high", "medium", or "low" priority.

The high-priority sites were generally characterized as serious impediments to migration with significant amounts of upstream habitat for anadromous salmonids. Sites that scored at least 12 points for the "extent of criteria" score were ranked a second time after an adjustment was made to the "habitat quantity" score in which there was no maximum score – one point for every 1,000 feet of potential habitat. This was the third, and final, modification of the CDFG method. This second ranking of high-priority sites created a wider spread of total scores and allowed the actual amount of potential habitat to influence rank.

Medium-priority sites were characterized as limited in upstream habitat gains and/or were only significant impediments to juvenile migration. Low-priority sites were either limited in upstream habitat, habitat condition was poor, and/or the site allowed passage of adults and most juveniles.

Remediation of crossings identified as "high-priority" should be accomplished by submitting proposals to various fisheries restoration funding sources. The information provided in this report should be used to document the logical process employed to identify, evaluate, and rank these migration barriers.

The various cities that manage the roads where most of the crossings were located should consider ranking medium and low-priority sites a second time focusing mainly on crossing condition, sizing, and amount of fill material within the road prism. A risk assessment may be conducted to determine the consequence of potential sediment delivery to the downstream channel if or when a crossing failed. Most medium and low-priority sites should not be considered candidates for treatment via limited restoration funding sources, unless an imminent site failure would deliver a significant amount of sediment to downstream salmonid habitat.

However, this information will provide road managers a list of sites in need of future replacement with road maintenance funds. When these replacements are implemented, this report should provide guidance on treatments with properly-sized crossings conducive to adequate flow conveyance and unimpeded fish passage.

Additional Considerations for Final Ranking

On a site-specific basis, some or all of these factors were considered in rearranging the first-cut ranking to develop a final list for project scheduling:

1. Fish observations at crossings. Sites where fish were observed during migration periods were given higher priority in the final ranking. The species of salmonids observed, the number of fish, frequency of attempts, and the number of failed versus successful passage attempts were important variables considered. Sites with fish present are areas where immediate re-colonization of upstream habitat is likely to occur. Many streams in northern California have experienced immediate re-colonization after migration barriers were treated.

2. Stocks of fish presumed present. Streams currently supporting runs of steelhead were given a higher priority over streams that historically supported anadromous fish populations.

3. Amount of road fill. At stream crossings that were undersized and/or in poor condition, we examined the volume of fill material within the road prism potentially deliverable to the stream channel if the culvert were to fail.

4. Presence, location, and barrier status of other stream crossings. In many cases, an individual stream was crossed by multiple roads under a variety of management or ownership. In these situations, close communication amongst road managers will be important in project selection and implementation. If multiple crossings are migration barriers, a coordinated effort is required to identify and treat them in a logical manner – generally in an upstream direction starting with the lowermost crossing.

5. Remediation project cost. In some cases, sites were raised in priority if cost-effective retrofits were feasible treatment options. Conversely, some sites were lowered in priority because the only feasible treatments were full replacements of culverts underneath large amounts of fill and/or buildings.

6. Scheduling of other road maintenance and improvement projects. The upgrading of migration barriers during other scheduled maintenance and/or improvement activities was considered. When undersized or older crossings fail during storms, city road managers should be prepared to install properly-sized crossings that provide unimpeded passage for all species and life-stages of fish.

RESULTS

Initial Site Visits

Initial site visits were conducted at 48 stream crossings and 26 crossings were surveyed and included in the evaluation and ranking process (Figure 7 and Appendix A). Reasons for excluding sites from the evaluation varied and are listed in the right-hand column of Appendix A.

The 26 surveyed stream crossings were each given a unique ID number (Table 3). A table of the 26 assessed stream crossings and their location information and characteristics is provided in Appendix A. A more detailed summary of location information, site-specific characteristics, site photographs, maps, and habitat descriptions for the 26 stream crossings was assembled in a separate document titled *Catalog of Corte Madera Stream Crossings Located on Anadromous Stream Reaches*.

The following list is an overview of the crossings inventoried:

1. A variety of crossing configurations and materials were discovered. Concrete box culverts (nine sites) and concrete arch culverts (six sites) were the predominant type of crossing encountered. Circular pipes were found at only two stream crossing locations. Three crossings were modified with fish ladders and two dams were also assessed.

2. Fourteen of the 26 assessed crossings were in good condition (53.8% of the sites) and reflect the longevity of concrete as a construction material. Another 10 crossings (38.5% of the sites) were described as in "fair" condition, and starting to show signs of deterioration. The most common deterioration observed within concrete structures was excessive wear on the invert (bottom). Two crossings were classified as being in "extremely poor" condition and are in need of replacement. The two sites are Ross Creek #1/Park Drive and Fairfax Creek #5/Sir Francis Drake Blvd.

3. Thirteen crossings were property sized when compared to recently released NMFS guidelines that recommend stream crossings pass the 100-year storm flow at less than 100% of inlet height. Another six crossings were sized to pass greater than a 25-year storm flow.

4. Only three of the 26 crossings were significantly undersized, overtopping on less than a 25-year storm flow (Table 4). These crossings were R-04, FX-01, and FX-05. Of these three, FX-01 was the most severely undersized, 100% of inlet height was exceeded on less than a 10-year storm flow.

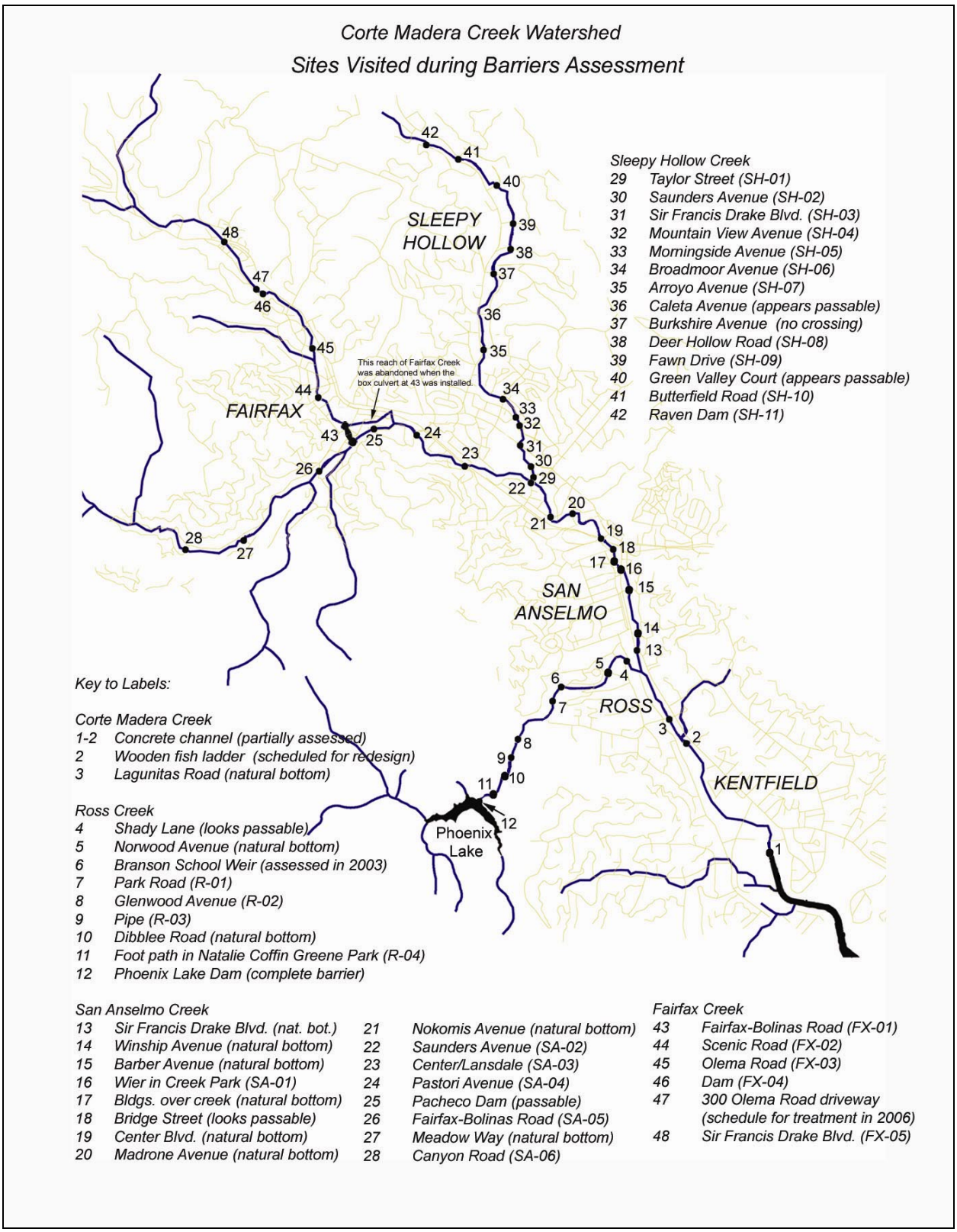


Figure 7. Map of Corte Madera Creek watershed and the locations of the 48 stream crossings examined during initial site visits (created and updated by Sandra Guldman).

Table 3. Site ID numbers for 26 Corte Madera Creek stream crossings in Marin County, California.

SITE ID #	STREAM NAME	ROAD NAME or LOCATION	CROSSING TYPE
R-01	Ross Creek #1	Park Drive	Concrete arch culvert
R-02	Ross Creek #2	Glenwood Avenue	Concrete arch culvert
R-03	Ross Creek #3	In Natalie Coffin Park	Drop over utility pipe
R-04	Ross Creek #4	In Natalie Coffin Park	Foot bridge w/concrete invert
SA-01	San Anselmo Creek #1	In Creek Park	Concrete weir with inlet apron
SA-02	San Anselmo Creek #2	Saunders Avenue	Fish ladder under bridge
SA-03	San Anselmo Creek #3	Center Blvd/Lansdale	2-bay box into arch culvert
SA-04	San Anslemo Creek #4	Pastori Avenue	Fish ladder w/in box culvert
SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	Concrete box culvert
SA-06	San Anselmo Creek #6	Canyon Road	Fish ladder w/in box culvert
SH-01	Sleepy Hollow Creek #1	Taylor Street	Concrete arch culvert
SH-02	Sleepy Hollow Creek #2	Saunders Avenue	Concrete arch culvert
SH-03	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	Concrete arch culvert
SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	Concrete arch culvert
SH-05	Sleepy Hollow Creek #5	Morningside Avenue	Concrete box culvert
SH-06	Sleepy Hollow Creek #6	Broadmore Avenue	Concrete box culvert
SH-07	Sleepy Hollow Creek #7	Arroyo Avenue	SSP pipe-arch culvert
SH-08	Sleepy Hollow Creek #8	Deer Hollow Road	Concrete box culvert
SH-09	Sleepy Hollow Creek #9	Fawn Drive	Concrete box culvert
SH-10	Sleepy Hollow Creek #10	Butterfield Road	Concrete box culvert
SH-11	Sleepy Hollow Creek #11	Near Raven Drive	Concrete dam – filled in
FX-01	Fairfax Creek #1	Fairfax-Bolinas Road	Concrete box culvert
FX-02	Fairfax Creek #2	Scenic Road	Concrete box culvert
FX-03	Fairfax Creek #3	Olema Road	Concrete box culvert
FX-04	Fairfax Creek #4	Next to Olema Road	Concrete dam – filled in
FX-05	Fairfax Creek #5	Sir Francis Drake Blvd.	SSP circular pipe

Table 4. Hydraulic capacities of the 26 Corte Madera Creek stream crossings. Capacity is expressed as both a discharge (c.f.s.) and a return-interval (years) for flows overtopping culvert inlet (HW/D=1). N/A = not applicable for sites that were dams and weirs.

SITE ID #	STREAM NAME	ROAD NAME or LOCATION	Capacity (c.f.s.) at HW/D = 1	Capacity – Recurrence Interval
R-01	Ross Creek #1	Park Drive	2,108	>100 year
R-02	Ross Creek #2	Glenwood Avenue	1,600	>100 year
R-03	Ross Creek #3	In Ross Creek Park	N/A	N/A
R-04	Ross Creek #4	In Ross Creek Park	488	10 – 25 year
SA-01	San Anselmo Creek #1	In Creek Park	N/A	N/A
SA-02	San Anselmo Creek #2	Saunders Avenue	6,400	>100 year
SA-03	San Anselmo Creek #3	Center Blvd/Lansdale	2,430	50 year
SA-04	San Anslemo Creek #4	Pastori Avenue	4,550	>100 year
SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	2,060	>100 year
SA-06	San Anselmo Creek #6	Canyon Road	2,996	>100 year
SH-01	Sleepy Hollow Creek #1	Taylor Street	800	25 – 50 year
SH-02	Sleepy Hollow Creek #2	Saunders Avenue	800	25 – 50 year
SH-03	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	800	50 – 100 year
SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	800	50 – 100 year
SH-05	Sleepy Hollow Creek #5	Morningside Avenue	840	≈100 year
SH-06	Sleepy Hollow Creek #6	Broadmore Avenue	840	≈100 year
SH-07	Sleepy Hollow Creek #7	Arroyo Avenue	900	50 – 100 year
SH-08	Sleepy Hollow Creek #8	Deer Hollow Road	1,560	>100 year
SH-09	Sleepy Hollow Creek #9	Fawn Drive	897	>100 year
SH-10	Sleepy Hollow Creek #10	Butterfield Road	519	≈100 year
SH-11	Sleepy Hollow Creek #11	Near Raven Drive	N/A	N/A
FX-01	Fairfax Creek #1	Fairfax-Bolinas Road	465	5 – 10 year
FX-02	Fairfax Creek #2	Scenic Road	1,300	>100 year
FX-03	Fairfax Creek #3	Olema Road	1,300	>100 year
FX-04	Fairfax Creek #4	Next to Olema Road	N/A	N/A
FX-05	Fairfax Creek #5	Sir Francis Drake Blvd.	372	10 – 25 year

Passage Analyses

The **GREEN**-**GRAY**-**RED** first-phase evaluation filter reduced the number of sites requiring in-depth analyses with FishXing. The initial use of the first-phase filter was followed by passage evaluations with FishXing on all **GRAY** and several **RED** sites. Passage for adult anadromous salmonids was assessed with the more rigorous swimming abilities of 8ft/sec for prolonged swimming mode, 16 ft/sec for burst speed swimming mode and exit velocity, and a minimum water depth of 0.5 feet.

It is important to note that crossings which failed to meet the more rigorous criteria may still actually provide partial or temporal passage during certain flow conditions. The values used for the passage evaluations were more rigorous than CDFG's recommended criteria, yet were still less than the maximum values recorded for adult coho salmon and steelhead. Some passage probably also occurs at sites where FishXing identified the only violation of the passage criteria as a lack-of-depth. However, **RED** sites were given a "total barrier" score in the ranking matrix unless a FishXing assessment confirmed some passage for adults.

FishXing proved an extremely useful tool in estimating the extent of passage at all 16 **GRAY** and identifying the probable causes of blockages. Five of the 10 **RED** sites were also assessed with FishXing (Table 5). At three of these sites, passage was only evaluated for adult anadromous salmonids. At Raven and Olema dams the assessment was limited to modeling changes in vertical drop and pool depth over a wide range of flows, from less than the estimated adult migration flows to well above. At Raven Dam (SH-11) the vertical drop was 8.4' at 20 c.f.s. and was 7.9' at 150 c.f.s. At Olema Dam (FX-04) the vertical drop varied from 13.2' at 10 c.f.s. to 11.8' at 150 c.f.s.

Each of the four Corte Madera Creek tributaries (Ross, San Anselmo, Sleepy Hollow, and Fairfax creeks) had stream crossings that ranged from failing to meet passage criteria for all age-classes of anadromous salmonids to providing high levels of good passage conditions (Figures 8-11). Both Ross and Fairfax creeks have stream crossings located near their mouths that severely reduce or prevent steelhead from utilizing these tributaries for spawning and rearing (Figures 8 and 11).

However, like most models which attempt to predict complex physical and biological processes with mathematics, there were limitations and assumptions that must be acknowledged when using FishXing. Many stream crossings have site-specific characteristics that may influence hydraulics in a way that the software cannot account for, such as a box culvert outlet with an irregularly-poured concrete edge. In other cases, varying materials (and condition) within the crossing and at the tail-water control rendered the selection of a proper roughness coefficient difficult. This was especially true at many of the sites due to the extensive use of concrete, riprap, and retaining walls throughout the Corte Madera Creek watershed.

Biological considerations are probably more difficult to account for than the physical attributes of the stream crossings in interpreting FishXing results. Over the past six winters, repeated visits to numerous crossings with culverts in northern California during migration flows revealed some confounding results generated by FishXing:

1. Adult salmonids having great difficulties entering perched culverts which FishXing suggested were easily within the species' leaping and swimming capabilities.
2. Adult salmonids successfully migrating through water depths defined as "too shallow" by current fish passage assessment and design criteria.

The behavior and abilities of fish are too varied and complex to be summed up with an equation or a number taken from a published article. Even a single fishes' leaping and swimming abilities at a culvert may change as numerous attempts are made. Extensive winter-time observations at culverts in northern California have documented individual fish become fatigued over repetitive attempts, and conversely documented other fish gaining access to culverts after numerous failed attempts (Taylor 2000-05; Love pers. comm.).

Due to these factors, passage evaluation results generated by FishXing were used conservatively in the ranking matrix by lumping "percent passable" into large (20%) categories. Adult steelhead and coho salmon (assumed historically present) were grouped in the "adult" run, resident coastal rainbow trout and two-year old (2+) steelhead were grouped as the "resident trout" run, and one-year old (1+) and young-of-the-year (y-o-y) steelhead and coho salmon were grouped as the "juvenile" run.

For each site, by age-class, FishXing evaluation results are provided in Appendix B. The "Comments" column in Appendix B lists assumptions made concerning specific sites while running FishXing. Also provided in Appendix B are the hydrologic data and information utilized to calculate peak flows and range of fish passage flows.

Table 5. Results of the **GREEN-GRAY-RED** first-phase evaluation filter for 26 stream crossings in the Corte Madera Creek watershed, Marin County, CA.

SITE ID #	STREAM NAME	ROAD NAME or LOCATION	FILTER RESULTS	FISHXING ASSESS.
R-01	Ross Creek #1	Park Drive	**RED**	**Y***
R-02	Ross Creek #2	Glenwood Avenue	**GRAY**	**Y**
R-03	Ross Creek #3	In Ross Creek Park	**GRAY**	**Y**
R-04	Ross Creek #4	In Ross Creek Park	**RED**	**Y**
SA-01	San Anselmo Creek #1	In Creek Park	**GRAY**	**Y**
SA-02	San Anselmo Creek #2	Saunders Avenue	**RED**	**N**
SA-03	San Anselmo Creek #3	Center Blvd/Lansdale	**RED**	**N**
SA-04	San Anslemo Creek #4	Pastori Avenue	**GRAY**	**Y**
SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	**GRAY**	**Y**
SA-06	San Anselmo Creek #6	Canyon Road	**GRAY**	**Y**
SH-01	Sleepy Hollow Creek #1	Taylor Street	**RED**	**Y***
SH-02	Sleepy Hollow Creek #2	Saunders Avenue	**GRAY**	**Y**
SH-03	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	**GRAY**	**Y**
SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	**GRAY**	**Y**
SH-05	Sleepy Hollow Creek #5	Morningside Avenue	**GRAY**	**Y**
SH-06	Sleepy Hollow Creek #6	Broadmore Avenue	**GRAY**	**Y**
SH-07	Sleepy Hollow Creek #7	Arroyo Avenue	**GRAY**	**Y**
SH-08	Sleepy Hollow Creek #8	Deer Hollow Road	**RED**	**N**
SH-09	Sleepy Hollow Creek #9	Fawn Drive	**RED**	**N**
SH-10	Sleepy Hollow Creek #10	Butterfield Road	**GRAY**	**Y**
SH-11	Sleepy Hollow Creek #11	Near Raven Drive	**RED**	**Y***
FX-01	Fairfax Creek #1	Fairfax-Bolinas Road	**RED**	**Y**
FX-02	Fairfax Creek #2	Scenic Road	**GRAY**	**Y**
FX-03	Fairfax Creek #3	Olema Road	**GRAY**	**Y**
FX-04	Fairfax Creek #4	Next to Olema Road	**RED**	**Y***
FX-05	Fairfax Creek #5	Sir Francis Drake Blvd.	**GRAY**	**Y**

*Passage assessed for adult salmonids only.

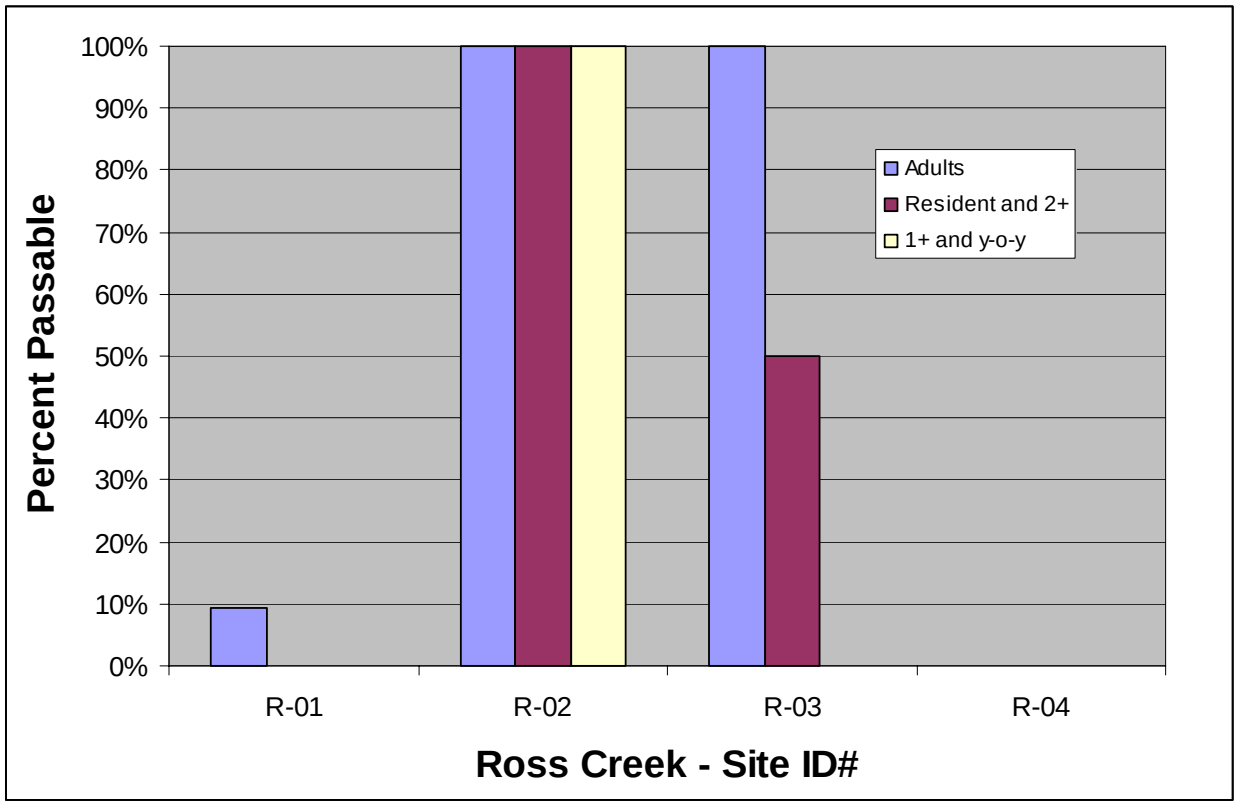


Figure 8. Passage evaluation results for four stream crossings in Ross Creek, Corte Madera Creek watershed, Marin County, CA.

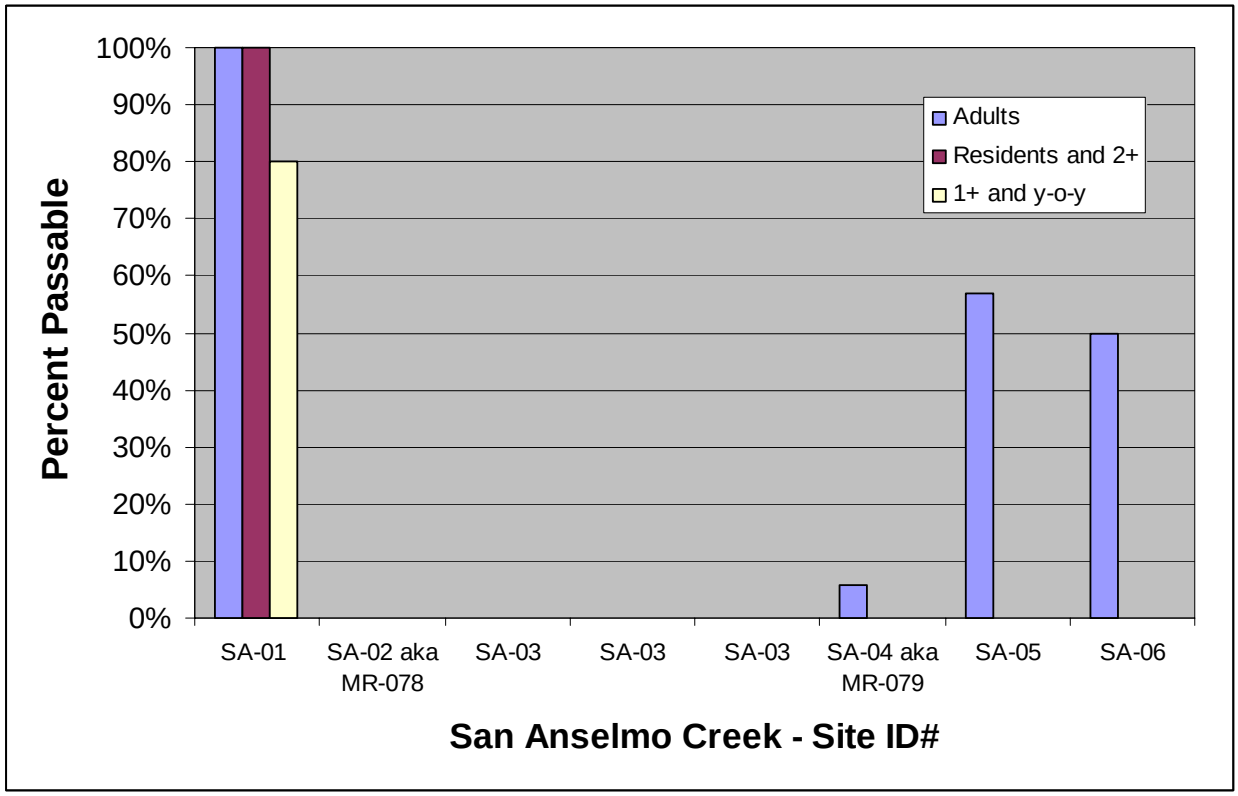


Figure 9. Passage evaluation results for six stream crossings in San Anselmo Creek, Corte Madera Creek watershed, Marin County, CA. SA-03 is comprised of two-bay box and arch.

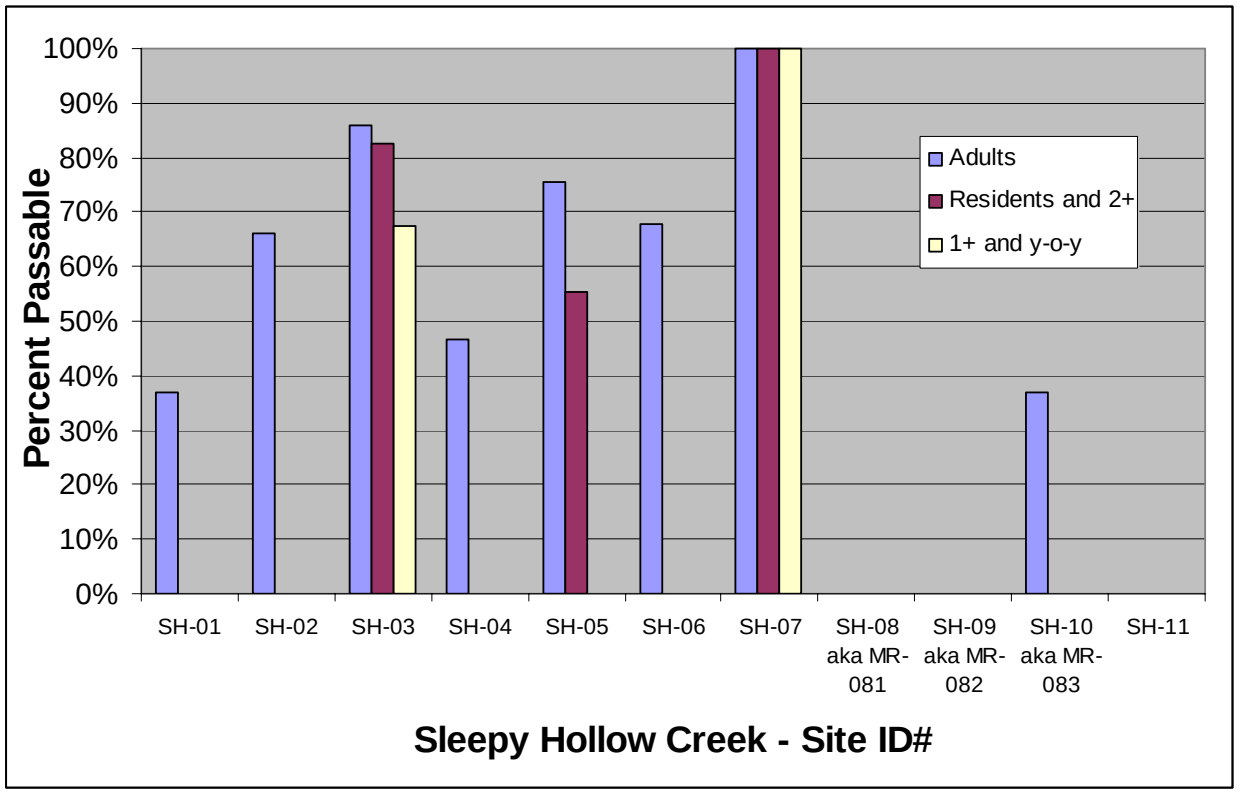


Figure 10. Passage evaluation results for 11 stream crossings in Sleepy Hollow Creek, Corte Madera Creek watershed, Marin County, CA.

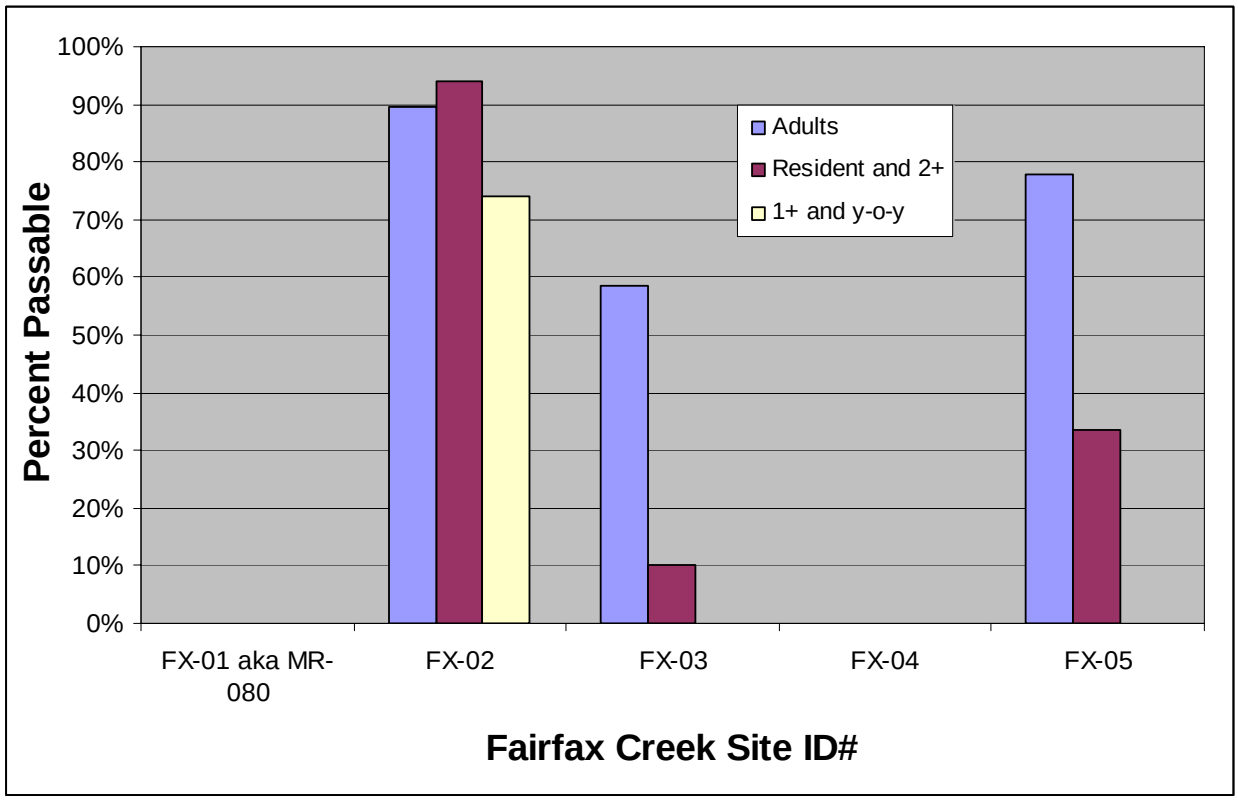


Figure 11. Passage evaluation results for five stream crossings in Fairfax Creek, Corte Madera Creek watershed, Marin County, CA.

Ranking Matrix

The 26 Corte Madera Creek stream crossing locations were sorted by "Total Score", the sum of the four ranking criteria (Appendix C). A separate ranking matrix for the high-priority sites with "extent of barrier" scores ≥12 points was also generated that utilized the full lengths of potential upstream habitat. (Appendix C). The right-hand column of the final ranking matrix provides information on the passage analyses, general recommendations for treatment and suggested changes in treatment order due to professional judgment and other factors (Table 6).

As previously mentioned in the Methods section, the primary purpose of the ranking matrix developed for the CDFG protocol was to roughly sort the sites into a descending order of scores where sites could be grouped as high, medium, or low priority. There are many other factors to consider when selecting sites to treat that were not feasible to capture in a discrete scoring matrix. On a site-specific basis, one or more of the following factors were considered when recommending that a site be either raised or lowered in the ranking for project scheduling:

- Additional migration barriers above or below a site that would limit the amount of re-opened habitat by treating just this crossing – lower in ranking.
- Criteria other than "extent of barrier" accounting for large percentage of a site's final score – lower in ranking.
- FishXing flagged "lack-of-depth" as the only passage criteria violation – lower in ranking.
- Expensive replacement is only feasible treatment option – lower in rank.
- Cost-effective retrofit versus expensive replacement – raise in ranking.
- Site with limited reach of upstream habitat, but of good-quality and currently utilized by coho salmon (or coho known to occur immediately downstream of crossing) – raise in ranking.
- Limited upstream habitat benefit, but high likelihood of crossing failure and potential for significant sediment release to good-quality downstream habitat – raise in ranking.
- Instances where two streams' culverts meet at a common confluence and the two sites could be addressed as a single project – raise in ranking.
- In streams with multiple crossings, re-arranging sites so that treatment proceeds in an upstream direction – either raise or lower in ranking.

Adjustments to the suggested order of treatment scheduling in this final report were made after two drafts of the ranking matrix and one draft of Table 5 were circulated for review by Friends of the Corte Madera Creek watershed, city road managers, and agency and consulting biologists familiar with the watershed. However, as new information becomes available after the completion of this report, the exact order of treatment will probably continue to change.

Table 6. Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
High	**SA-02 aka MR-078**	San Anselmo Creek #2	Saunders Avenue	15	33,200	22.0	33.6	**High-Priority due to:** severity of the barrier and the significant reach of habitat located upstream, more than six miles. The site was assessed as a high-priority crossing in 2003 as part of the Marin County fish passage assessment project (Taylor, 2003). The current fish ladder appears ineffective and should be replaced or retrofitted. A literature review conducted by Taylor and Associates confirmed that the current structure fails to meet Denil fish ladder specifications. The narrow concrete channel downstream of the fish ladder is also an impediment to fish migration. The design of a new fish passage structure needs to address the downstream concrete channel too. The City of San Anselmo Public Works should consult with CDFG and NOAA hydraulic engineers for design assistance. NOTE: Stetson Engineering and Michael Love and Associates are working on a treatment design in another phase of the NOAA-funded Corte Madera Creek Passage Program.
High	**SA-04 aka MR-079**	San Anselmo Creek #4	Pastori Avenue	15	28,900	21.0	30.5	**High-Priority due to:** severity of the barrier and the significant reach of habitat located upstream, more than five miles. The site was assessed as a high-priority crossing in 2003 as part of the Marin County fish passage assessment project (Taylor, 2003). The current fish ladder appears ineffective and should be replaced or retrofitted. A literature review conducted by Taylor and Associates confirmed that the current structure fails to meet Denil fish ladder specifications. The design of a new fish passage structure needs to address potential grade changes in channel. The City of San Anselmo Public Works should consult with CDFG and NOAA hydraulic engineers for design assistance. NOTE: Stetson Engineering and Michael Love and Associates are working on a treatment design in another phase of the NOAA-funded Corte Madera Creek Passage Program.

Table 6 (continued). Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
High	**SA-03**	San Anselmo Creek #3	Center Blvd. and Lansdale Avenue	15	31,200	22.0	25.3	**High-Priority due to:** severity of the barrier and the significant reach of potential habitat located upstream – nearly six miles of stream channel with less than an eight percent slope. This site is located between the two crossings with ineffective fish ladders (SA-02 and SA-04) that are currently having treatments designed. Recommend exploring options to retrofit the existing crossing because a replacement would be cost-prohibitive. This crossing is comprised of a 152-foot long two-bay concrete box culvert attached to the upstream side a 130-foot long concrete arch with greater than a three-foot drop at the outlet. The crossing goes under a large intersection of several roads that have large traffic loads, making a replacement logistically quite difficult. Downstream weirs to raise tail-water elevation and baffles or weirs within the crossing to increase depths are needed to improve passage conditions.
High	**SH-01**	Sleepy Hollow Creek #1	Taylor Street	13	26,000	18.5	22.5	**High-Priority due to:** severity of barrier is probably worse than predicted by FishXing. Although the first-phase filter identified this site as "RED", adult steelhead passage was assessed with FishXing. Lack-of-depth was the only problem flagged, however velocities >8ft/sec occur at the perched outlet during migration-level flows. FishXing was unable to model the hydraulics at the stepped outlet which may create confusing attraction flows. Treatment is also a high-priority since this crossing is located at the mouth of Sleepy Hollow Creek - a project would immediately open up nearly 7,000 feet of habitat up to the next serious impediment at Deer Hollow Road (SH-08). A retrofit with a series of downstream weirs to raise tail-water elevation is recommended to cost-effectively improve passage through this crossing. A full replacement may be too cost-prohibitive, plus there are issues concerning head-cutting of the channel if the current culvert was removed.

Table 6 (continued). Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
High	**SH-08 aka MR-081**	Sleepy Hollow Creek #8	Deer Hollow Road	15	17,000	20.0	21.8	**High-Priority due to:** outlet is perched 5.8 ft and spills over bedrock/concrete drop. Because the current box culvert is properly sized, a retrofit is recommended to improve conditions for fish passage. At least five to six boulder weirs are probably required to sufficiently raise the tail-water elevation and corner baffles within the culvert will increase depths and decrease velocities. Consider feasibility of constructing a concrete fish ladder onto the bedrock outcrop at the culvert outlet – especially if a series of boulder weirs is not feasible due to lack-of-access across private property for construction. A series of sloped, concrete weirs with low-flows notches through the box culvert would increase depths and reduce veloocities. Recommend consulting with CDFG and NOAA hydraulic engineers for design assistance.
High	**FX-01 aka MR-080**	Fairfax Creek #1	Fairfax-Bolinas Road	15	10,800	21.4	21.7	**High-Priority due to:** severity of the barrier and the significant reach of potential habitat located upstream – more than two miles of stream channel. This site is located at the mouth of Fairfax Creek and prevents adult steelhead from re-colonizing this significant Corte Madera Creek tributary. Treatment options at this site are problematic because of several factors. A retrofit is probably not feasible because the box culvert is undersized and the inlet overtops on less than a 10-year storm flow, thus further reduction of capacity by baffles or weirs within the culvert is not recommended. The crossing's outlet is within 25 feet of the confluence of Fairfax Creek and San Anselmo Creek, thus there is insufficient room for a series of downstream boulder weirs to raise tail-water elevation. A full replacement may be cost-prohibitive due to the length of the existing crossing. Town of Fairfax's Public Works Department should consult with CDFG and NOAA hydraulic engineers for design assistance.

Table 6 (continued). Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
Med.	**SA-05**	San Anselmo Creek #5	Fairfax-Bolinas Road	12	14,000	19.5	21.5	**Drop in ranking to Medium-Priority due to:** the crossing meets adult passage on 57% of the flows and the primary passage criteria violation is a lack-of-depth so additional adult passage probably occurs during a wider range of flows when the depth is <0.5". Some passage of resident trout may also occur. Excessive velocities probably prevent juvenile passage. Retrofit existing box culvert with a downstream weir to back-water culvert to increase depths. Consider partial removal of culvert floor and reconstruction at a lower elevation. Other higher-priority projects exist within the Corte Madera Creek watershed.
High	**R-01**	Ross Creek #1	Park Drive – within Branson School campus	14	5,200	21.1	21.1	**High-Priority due to:** severity of the barrier, the extremely poor condition of the arch culvert, and the relatively good-quality of the upstream habitat. There are several extensive fractures in the arch's concrete - recommend having a qualified structural engineer assess condition. Passage was assessed over the combined length of the upstream apron and arch culvert. The short break-in-slope right at the outlet was not successfully modeled by FishXing and may create unfavorable hydraulic conditions for fish passage. Recommend replacement with a properly sized open-bottom arch or a bridge to provide unimpeded fish passage.
Med.	**SH-09 aka MR-082**	Sleepy Hollow Creek #9	Fawn Drive	15	16,100	19.5	21.0	**Drop in ranking to Medium-Priority due to:** site probably allows some passage and current available habitat is only 4,200 feet (up to Raven Dam). For adult salmonids, FishXing indicated a lack-of-depth violation up to 30 c.f.s., then excess velocities. From site photographs, the crossing appears partially passable for adults. Fish passage could be cost-effectively improved by installing fully-spanning, sloped concrete weirs within the box culvert, a notched outlet beam, and possibly a single downstream boulder weir. Recommend consulting with CDFG and NOAA hydraulic engineers for design assistance.

Table 6 (continued). Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
Med.	**SA-06**	San Anselmo Creek #6 aka Cascade Creek	Canyon Road	12	8,300	20.7	20.7	**Drop in ranking to Medium-Priority due to:** inability to assess the fish ladder with FishXing. Fish ladder slope (17.5%) is close to the upper limit for adult passage and assumed to be insufficient for resident and juvenile passage. FishXing can not model fish laders therefore adult passage was found using research by Katopodis (1992). Recommend making visits to site during winter storms to observe hydraulics during migration-level flows. The ladder should also be inspected during winter storms to make sure debris is not clogging the ladder and causing passage problems.
High	**SH-11**	Sleepy Hollow Creek #11	Raven Dam – next to Raven Road	15	12,000	20.3	20.5	**High-Priority due to:** severity of the barrier and the length of potential upstream habitat – approximately 2.2 miles. Raven Dam was assessed by FishXing to determine the total height of the drop over the lip of the dam at varying flows. Assessment did not consider the two-stage drop that actually occurs at the site (the dam was built onto an existing bedrock outcrop). At 20 c.f.s. drop = 8.4'; at 50 c.f.s. drop = 8.2'; at 100 c.f.s. drop = 8.0'; at 150 c.f.s. drop = 7.9'. Explore options for dam removal and restoration/re-grade of the stream channel. However, three downstream crossings (SH-01, 08, 09) should first be treated to restore adult steelhead passage up to this barrier.
High	**FX-04**	Fairfax Creek #4	Olema Dam – next Olema Road	15	5,500	20.3	20.3	**High-Priority due to:** severity of the barrier and length of potential upstream habitat – just over one mile. FishXing was used to determine the total height of the drop over the dam at varying flows. Assessment did not consider the two-stage drop that occurs at the site. At 10 c.f.s. drop = 13.2'; at 30 c.f.s. drop = 12.7'; at 62 c.f.s. = 12.3'; at 100 c.f.s. drop = 12.0'; at 150 c.f.s. drop = 11.8'. Explore options for dam removal and restoration of the stream channel. However, the downstream crossing at the mouth of Fairfax Creek (FX-01) should first be treated to restore adult steelhead passage up to this barrier. Consideration must be made to potential effects of channel re-grade to private property adjacent to the stream channel.

Table 6 (continued). Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
Med.	**SH-04**	Sleepy Hollow Creek #4	Fawn Drive	15	24,000	19.5	20.0	**Medium-Priority due to:** the only passage criteria violation was "lack-of-depth" thus some level of passage probably occurs at this crossing. Crossing invert is actually u-shaped so depths at varying flows are greater than estimated by FishXing. Some resident trout passage may occur too. Retrofit existing box culvert with a downstream weir to back-water culvert and increase depths. Consider a lower priority project to possibly implement after treating high priority sites. Recommend periodic inspection of crossing and elevation of downstream channel and tail-water control.
Med.	**R-04**	Ross Creek #4	Unnamed path in Natalie Coffin Park	15	800	18.9	18.9	**Medium-Priority due to:** although the crossing was assessed as a complete barrier, the lack of available upstream habitat renders this a medium to low priority site for fish passage. There is less than 1,000 feet of channel up to the base of Phoenix Dam. If a fish ladder were installed on the dam, then the priority of treating this crossing would be elevated. The extended inlet apron at this crossing is the "wading pool" area in Natalie Coffin Park. Outlet is also perched and has a steep break-in-slope
Med.	**SH-10 aka MR-083**	Sleepy Hollow Creek #10	Butterfield Road	13	13,000	18.0	18.8	**Medium-Priority due to:** although FishXing indicated that the crossing may impede adult passage and block juvenile passage, actual passage of adults and residents may be higher due to lack-of-depth identified as the primary criteria violation. Current crossing is adequately sized for storm flow conveyance and in fair condition.

Table 6 (continued). Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
Med.	**FX-03**	Fairfax Creek #3	Olema Road	11	8,000	17.5	17.5	**Medium-Priority due to:** only criteria violation for adult salmonids was "lack-of-depth" so actual passage is higher than estimated. The perched outlet is problematic for resident trout and younger juvenile age classes. Recommend raising tailwater elevation by approxiamtely two-feet with two or three boulder weirs to backwater culvert. However, treatment of FX-01 is the top priority for restoring steelhead runs to Fairfax Creek, followed by site FX-04 (Olema Dam).
Med.	**FX-05**	Fairfax Creek #5	Sir Francis Drake Blvd.	9	3,500	16.8	16.8	**Medium-Priority due to:** the extremely poor condition of the SSP culvert. FishXing assessed the culvert as fully passable for adult salmonids and partially passable for resident/2+ fish. Actual passage may be lower due to the poor condition of the culvert and the concrete lining along the entire length of the invert. Current crossing is also under-sized for storm flow conveyance – inlet is overtopped between 25-50 year storm flow. A complete replacement with maintenance funds may be warrented due to the overall poor condition of the SSP culvert. However, as a fisheries restoration project, two downstream barriers (FX-01 and 04) should be treated before this site in upper Fairfax Creek.
Low	**SH-02**	Sleepy Hollow Creek #2	Saunders Avenue	11	25,600	N/A	16.0	**Low-Priority due to:** the only passage criteria violation for adult and resident/2+ salmonids is lack-of-depth, so actual passage is probably greater than estimated. Stream flow is concentrated to the right-bank side of the culvert, thus actual depths within culvert are greater than estimated since FishXing assumed a flat culvert invert. Recommend periodic inspection to ensure that backwatering effect by tail-water control remains effective.

Table 6 (continued). Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
Low	**SH-06**	Sleepy Hollow Creek #6	Broadmore Avenue	11	23,000	N/A	16.0	**Low-Priority due to:** the only passage criteria violation for adult and resident/2+ salmonids is lack-of-depth, so actual passage is probably greater than estimated. Consider a lower priority project to possibly implement after treating high priority sites. Recommend periodic inspection of crossing and elevation of downstream channel and tail-water control.
Low	**SH-05**	Sleepy Hollow Creek #5	Morningside Avenue	8	23,700	N/A	12.5	**Low-Priority due to:** adequate level of passage for adult salmonids and older juveniles. The crossing is adequately sized for storm flow conveyance and is in good condition.
Low	**R-03**	Ross Creek #3	Within Natalie Coffin Park	7	950	9.5	9.5	**Low-Priority due to:** passage assessment was based only on the drop height over the 18" diameter utility pipe at varying flows which appeared to allow adequate passage of most age-classes of salmonids. No treatment recommended other than periodic inspection to assess changes in channel grade and drop over pipe.
Low	**FX-02**	Fairfax Creek #2	Scenic Road	1	8,800	7.4	7.4	**Low-Priority due to:** nearly unimpeded passage for all age-classes of salmonids. Crossing is also properly sized for storm flow conveyance and is in good condition. Recommend periodic inspection for maintenance.
Low	**SA-01**	San Anselmo Creek #1	Weir in Creek Park	1	63,600	N/A	6.0	**Low-Priority due to:** nearly unimpeded passage for all age-classes of salmonids. Site was assessed for passage based on the drop height over the weir and over the upstream apron (29.5') at varying flows. Drop over weir was less than 1.0' at all flows, is 0.5' at 10 c.f.s. and is back-watered 0.5' deep at 50 c.f.s.

Table 6 (continued). Ranked list of 26 Corte Madera Creek stream crossings located in anadromous-bearing stream reaches.

Rank	Site ID#	Stream Name	Road Name	Barrier Score (15 pts max)	Length Upstream Habitat (ft)	TOTAL SCORE - Habitat Limited	TOTAL SCORE – No Habitat Limit	Comments Regarding Site and any Adjustments made to Final Rank
Low	**SH-03**	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	1	24,800	N/A	6.0	**Low-Priority due to:** crossing was run in FishXing as if it had a flat concrete floor, but in reality it has a U-shaped floor that creates nearly 1.8' of additional depth and extensive back-watering. Would assume nearly unimpeded passage for all life-stages. Recommend periodic inspection to ensure that backwatering by tail-water control remains effective.
Low	**SH-07**	Sleepy Hollow Creek #7	Arroyo Avenue	0	21,000	N/A	5.0	**Low-Priority due to:** site was assessed by FishXing as providing unimpeded passage for all age classes of salmonids at all migration flows. The crossing is adequately sized for storm flow conveyance and is in good condition. Recommend periodic inspection to ensure that backwatering by tail-water control remains effective.
Low	**R-02**	Ross Creek #2	Glenwood Avenue	0	3,800	N/A	3.9	**Low-Priority due to:** although defined as "GRAY" by the first-phase filter, FishXing estimated that there was adequate depth throughout the crossing for unimpeded passage of all age classes of salmonids. Crossing is also properly sized for storm flow conveyance and is in good condition.

Scheduling of Site-Specific Treatments

High-Priority Sites

As mentioned in the comments column of Table 6, options for treating two crossings (SA-02 and SA-04) are being developed as another task under the NOAA-funded Corte Madera Creek fish passage project. In addition to the two sites with ineffective fish ladders, options for improving fish passage through the Corte Madera Creek ACE flood control channel and fish ladder at the upper end of the flood channel are also being addressed by the NOAA-funded project.

The fact that SA-03, located in between SA-02 and SA-04, is a severe barrier makes it a high-priority site to consider after treating after the fish ladders. As previously mentioned, site-specific factors renders SA-03 a difficult crossing at which to improve fish passage conditions.

Because other high-priority stream crossings are under the jurisdiction of various entities, the Friends of Corte Madera Creek will have to share the assessment results with these groups and assist in facilitating the development of proposals to fund treatments. In Ross Creek, the highest priority crossing is R-01, located on the campus of the Branson School. The first step in treating this crossing is to have a structural engineer examine the cracks in the arch culvert to assess the condition and safety. A full replacement may be required if the arch is determined to truly be in poor condition.

In Sleepy Hollow Creek the highest priority crossing is SH-01 at Taylor Street. Treatment of this crossing will restore a high level of fish passage up to SH-08 at Deer Hollow Road – 7,000 feet upstream of Taylor Street. The perched box culvert at Deer Hollow Road would then be the next Sleepy Hollow Creek site to treat, specifically with a retrofit to reduce the leap required at the severely perched outlet. Raven Dam (SH-11) would then be the third highest priority within Sleepy Hollow Creek. Issues to consider at this site will be grade-control to prevent head-cutting of the channel and excavation/transport/storage of the sediment accumulated on the upstream side of the dam.

In Fairfax Creek, the highest priority crossing to treat is FX-01 due to its location at the mouth of Fairfax Creek. Again, site-specific factors render this a difficult site to cost-effectively treat, yet this box culvert prevents any steelhead spawning and rearing to occur in Fairfax Creek. Olema Dam (FX-04) presents the same issues raised with treatment of Raven Dam – grade-control and sediment accumulated upstream of the dam.

Medium-Priority Sites

The exact scheduling for treating of the remaining "moderate-priority" sites is unknown at the time because:

1. Road managers and the Friends of Corte Madera Creek have large tasks of completing the scheduling, contracting, permitting, and implementation required to treat high-priority locations identified by this assessment. The focus should be on completing these higher priority projects with properly designed and constructed treatments before addressing the next tier of sites.

2. When addressing the "medium-priority" tier of crossings, the current biological condition and/or importance (such as quantity) of the streams start to diminish. Thus, these sites may not rank well compared to other types of projects proposed to state and federal funding sources. However, other sources of funding, such as urban stream programs should be considered. Sites in poor condition (such as FX-05) should be eventually treated with county maintenance and repair funds.

Low-Priority Sites

Generally low-priority sites either allowed fish passage, or have minimal biological benefit if treated. However, these sites should be examined for "consequence-of-risk" as to current condition, sizing, and quantity of fill within the road prism. All future replacements with maintenance funds should include properly sized crossings that permit unimpeded passage of adult and juvenile salmonids.

Limited fisheries restoration dollars should probably not be spent on improving fish passage in these streams, unless significant improvements occur to impacts of other land management activities. However, road managers should carefully examine this list and determine which locations may be treated with existing maintenance funds.

For example, each Town's Public Works Department may have a general plan for improvements to specific traffic corridors or routes. Also, when low-priority culverts fail during winter storms, planners should examine the sizing of the failed structure and budget for properly-sized replacements. When applying for FEMA funds, road managers should utilize this report to explain why the replacement should be a larger and higher-quality crossing (for both fisheries and future-flood benefits).

Design Options for Improving Fish Passage

All stream crossing replacement projects should follow recently developed state criteria and federal guidelines for facilitating adult and juvenile fish passage (CDFG 2002; NMFS 2001). However, site-specific characteristics of the crossing's location should always be carefully reviewed prior to selecting the type of crossing to install. These characteristics include local geology, slope of natural channel, channel confinement, and extent of channel incision likely from removal of a perched culvert. For additional information, Bates et al. (1999) is

recommended as an excellent reference to use when considering fish-friendly culvert installation options and Robinson et al. (2000) provides a comprehensive review of the advantages and disadvantages of the various treatment alternatives as related to site-specific conditions.

CDFG Allowable Design Options

Active Channel Design Option is a simplified design method that is intended to size a crossing sufficiently large and embedded deep enough into the channel to allow the natural movement of bed load and formation of a stable bed inside the culvert. Determination of the high and low fish passage design flows, water velocity, and water depth is not required for this option since the stream hydraulic characteristics within the culvert are intended to mimic the stream conditions upstream and downstream of the crossing.

The Active Channel Design Option is suitable for the following conditions:

- New and replacement culvert installations
- Simple installations with channel slopes of less than 3%.
- Short culvert lengths (less than 100 feet).
- Passage is required for all fish species and lifestages.

Culvert Setting and Dimensions

Culvert Width – the minimum culvert width shall be equal to, or greater than, 1.5 times the active channel width.

Culvert Slope – the culvert shall be placed level (0% slope).

Embedment – the bottom of the culvert shall be buried into the streambed not less than 20% of the culvert height at the outlet and not more than 40% of the culvert height at the inlet. Embedment does not apply to bottomless culverts.

Stream Simulation Design Option

The Stream Simulation Design Option is a design process that is intended to mimic the natural stream processes within a culvert. Fish passage, sediment transport, flood and debris conveyance within the crossing are intended to function as they would in a natural channel. Determination of the high and low fish passage flows, water velocity, and water depth is not required for this option since the stream hydraulic characteristics within the culvert are designed to mimic the stream conditions upstream and downstream of the culvert.

Stream simulation crossings are sized as wide, or wider than, the bankfull channel and the bed inside the culvert is sloped at a gradient similar to that of the adjacent stream reach. These crossings are filled with a streambed mixture that is resistant to erosion and is unlikely to change grade, unless specifically designed to do so. Stream simulation crossings require a greater level of information on hydrology and topography and a higher level of engineering expertise than the Active Channel Design Option.

The Stream Simulation Design Option is suitable for the following conditions:

- New and replacement culvert installations.
- Complex installations with channel slopes less than 6%.
- Moderate to long culvert length (greater than 100 feet).
- Passage required for all fish species and lifestages.
- Ecological connectivity is required.

Culvert Setting and Dimensions

Culvert Width – the minimum culvert width shall be equal to, or greater than, the bankfull channel width. The minimum culvert width shall not be less than six feet.

Culvert Slope - the culvert slope shall approximate the slope of the stream through the reach in which it is being placed. The maximum slope shall not exceed 6%.

Embedment – the bottom of the culvert shall be buried into the streambed, not less than 30% and not more than 50% of the culvert height. Embedment does not apply to bottomless culverts.

Substrate Configuration and Stability

- Culverts with slopes greater than 3% shall have the bed inside the culvert arranged into a series of step-pools with the drop at each step not exceeding 0.5 feet for juvenile salmonids.

- Smooth walled culverts with slopes greater than 3% may require bed retention sills within the culvert to maintain the bed stability under elevated flows.

- The gradation of the native streambed material or engineered fill within the culvert shall address stability at high flows and shall be well graded to minimize interstitial flow through it.

Hydraulic Design Option

The Hydraulic Design Option is a design process that matches the hydraulic performance of a culvert with the swimming abilities of a target species and age class of fish. The method targets specific species of fish and therefore does not account for ecosystem requirements of non-target species. There can be significant errors associated with estimation of hydrology and fish swimming speeds that are mitigated by making conservative assumptions in the design process. Determination of the high and low fish passage design flows, water velocity, and water depth are required for this option.

The Hydraulic Design Option requires hydrologic data analysis, open channel flow hydraulic calculations and information on the swimming ability and behavior of the target group of fish. This design option can be applied to the design of new and replacement culverts, and can be used to evaluate the effectiveness of retrofits for existing culverts.

The Hydraulic Design option is suitable for the following conditions:

- New, replacement, and retrofit culvert installations.
- Low to moderate channel slopes (less than 3%).
- Situation where either Active Channel Design or Stream Simulation Options are not physically feasible.
- Swimming ability and behavior of target fish species is known.
- Ecological connectivity is not required.
- Evaluation of proposed improvements to existing culverts.

For more information regarding the Hydraulic Design, obtain the most recent copy of the CDFG *Culvert Criteria for Fish Passage*, available on the Department's website.

NMFS Order of Preferred Alternatives

1. *No crossing* - relocate or decommission the road.

2. *Bridge* - spanning the stream to allow for long-term dynamic channel stability.

3. *Streambed simulation strategies* – bottomless arch, embedded culvert design, or ford.

4. *Non-embedded culvert* – this often referred to as a hydraulic design, associated with more traditional culvert design approaches limited to low slopes for fish passage.

5. *Baffled culvert or structure designed with a fish way* – for steeper slopes.

For more information, or to obtain a copy of the NMFS *Guidelines for Salmonid Passage at Stream Crossings* go to the Southwest Region website at: http://swr.nmfs.noaa.gov

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APPENDIX A:

STREAM CROSSING SITE SURVEY DATA SETS

Potential Barriers to Salmonid Passage
Corte Madera Creek Watershed, Marin County

Map Site No. *	Assess. Site ID #	Stream Name	Road Name	Responsibility for Maintenance	Type of Crossing	Comments and Survey Status
1		Corte Madera	Not a road	County	Concrete channel	Partially assessed in 2003
2		Corte Madera	Not a road	County	Fish ladder	Scheduled for re-design
3		Corte Madera	Lagunitas Road	Ross	Bridge	Natural bottom - not a barrier
4		Ross	Shady Lane	Ross	Bridge w/u.s. weir	Not assessed, took photos, looks passable
5		Ross	Norwood	Ross	Bridge	Natural bottom - not a barrier
6		Ross	Branson School Weir	Branson School	Weirs	Surveyed in 2003 - passable for adults
7	R-01	Ross	Park Road	Branson School	Concrete Arch	**SURVEYED**
??	R-02	Ross	Glenwood Avenue	Ross	Concrete Box	**SURVEYED**
??	R-03	Ross	Not a road	MMWD	Drop over sewer pipe	**SURVEYED**
8		Ross	Dibblee	MMWD	Bridge	Natural bottom - not a barrier
??	R-04	Ross	Unnamed walking path	MMWD	Bridge w/concrete apron	**SURVEYED -** wading pool area
9		Ross	Phoenix Lake Dam	MMWD	Dam	Complete barrier - took photos
10		San Anselmo	Sir Francis Drake Blvd	Ross	Bridge	Natural bottom - not a barrier
??		San Anselmo	Winship Ave	Ross	Bridge	Natural bottom - not a barrier
??		San Anselmo	Barber Ave	Ross	Bridge	Natural bottom - not a barrier
11	SA-01	San Anselmo	Sir Francis Drake Blvd	San Anselmo	Creek Park weir	**SURVEYED**
12		San Anselmo	Not a road	San Anselmo	Bldgs. over creek	Natural bottom - not a barrier
13		San Anselmo	Bridge Street	San Anselmo	Bridge w/d.s. weir	Not assessed, took photos, looks passable
14		San Anselmo	Center Blvd.	San Anselmo	Bridge	Natural bottom - not a barrier
15		San Anselmo	Madrone	San Anselmo	Bridge	Natural bottom - not a barrier
16		San Anselmo	Nokomis	San Anselmo	Bridge	Natural bottom - not a barrier
17	SA-02	San Anselmo	Saunders Ave	San Anselmo	Fish ladder	Assessed in 2003 as Site #MR-078
18	SA-03	San Anselmo	Center/Lansdale	San Anselmo	Box/arch composite	**SURVEYED**
19	SA-04	San Anselmo	Pastori Ave	Private	Fish ladder	Assessed in 2003 as Site #MR-079
20	SH-01	Sleepy Hollow	Taylor Street	San Anselmo	Concrete Arch	**SURVEYED**
21	SH-02	Sleepy Hollow	Saunders Ave	San Anselmo	Concrete Arch	**SURVEYED**
22	SH-03	Sleepy Hollow	Sir Francis Drake Blvd	San Anselmo	Concrete Arch	**SURVEYED**
23	SH-04	Sleepy Hollow	Mountain View Ave	San Anselmo	Concrete Arch	**SURVEYED**
24	SH-05	Sleepy Hollow	Morningside Ave	San Anselmo	Concrete Box	**SURVEYED**

Potential Barriers to Salmonid Passage (continued)
Corte Madera Creek Watershed, Marin County

Map No. *	Assess. Site ID #	Stream Name	Road Name	Responsibility for Maintenance	Type of Crossing	Comments and Survey Status
25	SH-06	Sleepy Hollow	Broadmore Ave	San Anselmo	Concrete Box	**SURVEYED**
26	SH-07	Sleepy Hollow	Arroyo Ave	San Anselmo	SSP Arch	**SURVEYED**
27		Sleepy Hollow	Caleta Ave	San Anselmo	Bridge	Appears to be new, took photos
28		Sleepy Hollow	Burkeshire	San Anselmo	None	No crossing is present at this location
29	SH-08	Sleepy Hollow	Deer Hollow Road	County of Marin	Concrete Box	Assessed in 2003 as Site #MR-081
30	SH-09	Sleepy Hollow	Fawn Drive	County of Marin	Concrete Box	Assessed in 2003 as Site #MR-082
31		Sleepy Hollow	Green Valley Court	County of Marin	Bridge ?	This may be a box culvert, but highly embedded
32	SH-10	Sleepy Hollow	Butterfield Road	County of Marin	Concrete Box	Assessed in 2003 as Site #MR-083
33	SH-11	Sleepy Hollow	Raven Dam	Private	Dam	**SURVEYED**
34		San Anselmo	Pacheco Dam	Fairfax	Breached dam	Surveyed in 2003 - passable for adults
35	FX-01	Fairfax	Fairfax-Bolinas Rd	Fairfax	Box culvert	Assessed in 2003 as Site #MR-080
36	SA-05	San Anselmo	Fairfax-Bolinas Rd	Fairfax	Box culvert	**SURVEYED**
37		San Anselmo	Meadow Way	Fairfax	Bridge	Natural bottom - not a barrier
38	SA-06	San Anselmo	Canyon Road	Fairfax	Bridge w/fish ladder	**SURVEYED**
??	FX-02	Fairfax	Scenic Road	Fairfax	Concrete Box	**SURVEYED**
39	FX-03	Fairfax	Olema Road	Fairfax	Concrete Box	**SURVEYED**
40	FX-04	Fairfax	Not a road	Private	Dam	**SURVEYED**
41		Fairfax	Under Apartments	Fairfax	Concrete Box	Not surveyed, scheduled for treatment in 2006
42	FX-05	Fairfax	Sir Francis Drake Blvd	County of Marin	SSP Pipe	**SURVEYED**

* Numbers are used to identify locations on the accompanying map (see Figure 7 in report).

Areas where private driveways bridge a creek:
Sir Francis Drake in the vicinity of Barber Ave. (San Anselmo)
Butterfield Road in the vicinity of Arroyo (Sleepy Hollow Creek)
The northern arm of the Alameda (Sleepy Hollow Creek)
Off Cascade Drive in Fairfax (San Anselmo Creek)

CORTE MADERA CREEK - SITE LOCATIONS AND CHARACTERISTICS

ID #	Stream Name	Road Name	USGS Quad	Township, Range, Section	Lattitude and Longitude Coordinates	Crossing Owner-ship	Milemarker or Name and Distance to nearest Crossroad	Type of Crossing	Construction Material	Corrugation Dimensions	Crossing Length (ft)	Culvert Dimensions: Diameter, height/width, or rise/span (ft)	% Slope thru Crossing	Rustline Height (ft)	Inlet Type
R-01	Ross Creek #1	Park Drive	San Rafael	T1N, R6W	37° 57' 52.8" 122° 33' 57.9"	Branson School	0.2 mi. to Fernhill Avenue	Concrete arch culvert	Concrete	Smooth	18.0	14.0' Rise x 16.2' Span	inlet to outlet = -0.33%	N/A	Wingwall
R-02	Ross Creek #2	Norwood Avenue	San Rafael	T1N, R6W	37° 57' 57.8" 122° 33' 41.4"	Town of Ross	50' to Hilgirth Avenue	Concrete box culvert	Concrete	Smooth	19.5	14.0 'H x 20.0'W	0.01	N/A	Headwall
R-03	Ross Creek #3	Not a road	San Rafael	T1N, R6W	37° 57' 26.6" 122° 34' 18.8"	MMWD	0.4 mi. to Glenwood Avenue	Drop over a sewer or water main pipe	Steel pipe	N/A	18"	N/A	N/A	N/A	N/A
R-04	Ross Creek #4	Unnamed walking path in town park	San Rafael	T1N, R6W	37° 57' 26.0" 122° 34' 20.0"	Town of Ross	0.4 mi. to Glenwood Avenue	Bridge with concrete apron	Concrete	Smooth	72.5 - for entire length of concrete invert	3.6' H x 24.4 W	overall = 2.30%; under footbridge = 4.09%; outlet apron = 8.75%	N/A	N/A
SA-01	San Anselmo Creek #1	Creek Park weir - Adjacent to SFD Blvd.	San Rafael	T2N, R7W	37° 58' 32.1" 122° 33' 39.9"	Town of San Anselmo	Next to intersection of SFD Blvd and Bank Street	Concrete weir	Concrete	N/A	Apron + weir = 30.0'	Weir = 25.8' wide	Apron slope = 0.32%	N/A	N/A
SA-02 aka MR-078	San Anselmo Creek #2	Saunders Avenue	San Rafael	T2N, R7W	37° 58' 53.33" 122° 34' 12.18"	Town of San Anselmo	0.1 mi. to Sir Francis Drake Blvd	Fish ladder under bridge	Concrete	Smooth	59.6	15.0 H x 37.0 W	fish ladder= 12.26% concrete= 0.44%	N/A	Wingwall
SA-03	San Anselmo Creel #3 1 of 3	Center Blvd/Lansdale Avenue	San Rafael	T2N, R7W	37° 58' 57.0" 122° 34' 35.0"	Town of San Anselmo	At San Anselmo Avenue	Box Culvert on LB	Concrete	Smooth	152.0	10.2 H x 15.4 W	0.53%	N/A	Wingwall
SA-03	San Anselmo Creel #3 2 of 3	Center Blvd/Lansdale Avenue	San Rafael	T2N, R7W	37° 58' 57.0" 122° 34' 35.0"	Town of San Anselmo	At San Anselmo Avenue	Box Culvert on RB	Concrete	Smooth	147.7	10.2 H x 14.7 W	0.58%	N/A	Wingwall
SA-03	San Anselmo Creel #3 3 of 3	Center Blvd/Lansdale Avenue	San Rafael	T2N, R7W	37° 58' 57.0" 122° 34' 35.0"	Town of San Anselmo	At San Anselmo Avenue	Arch culvert with flat floor	Concrete	Smooth	130.2	15.9 Rise x 32.0 Span	0.23%	N/A	N/A

CORTE MADERA CREEK - SITE LOCATIONS AND CHARACTERISTICS

ID #	Inlet Alignment to Channel	Inlet Apron	Outlet Configuration	Outlet Apron	Culvert Embedded?	Crossing-Culvert Condition	Average Active Channel Width (ft)	Estimated Road fill (cubic yards)	Previous Fish Passage Modifications to Crossing	Additional Comments from Initial Site Visit
R-01	>45°	Yes - concrete apron extends 21.3' upstream of Xing	Sheet flow over steeply slope concrete apron	Yes - sloped at 31.58% over 6.3' distance.	No	Extremely poor - structural cracks evident	25.0	N/A	None	Site surveyed on 7/7/05 and temperatures were measured at 5:15PM. Air temp = 24oC and water temp = 17oC. Habitat rated as "fair" with highly embedded rifffles and pools with minimal cover. Outlet pool was full of fish - some juvenile steelhead, mostly green sunfish and roach. Crossing appears in very poor condition with numerous cracks visible in concrete.
R-02	<30°	No	At Stream Grade	No	Partially with sand, gravel and small cobbles.	Good	17.5	N/A	None	Site surveyed on 6/9/05 and temperatures were measured at 10:30 AM. Air temp = 17°C and water temp = 15°C. Fair salmonid habitat - some pools and riffles, yet minimal amounts of instream cover and most of the channel is confined by retaining walls constructed of various materials.
R-03	<30°	N/A	Freefall into Pool	N/A	N/A	Good	22.6	N/A	None	Site surveyed on 6/6/05 and temperatures were measured at 2:00 PM. Air and water temperature were not measured at this site. Pipe is 18" in diameter and is perpendicular to the stream channel. Habitat appeared good, however lack of flow may be an issue later in the summer when flow no longer spills over Phoenix Dam.
R-04	<30°	Yes - concrete floor extends 57.0' upstream of bridge	Freefall into Pool	Yes - concrete floor extends 4.5' past downstream side of bridge.	No	Good	22.6	No fill to measure	None	Site surveyed on 6/6/05 at 3:30 PM. Air and water temperature were not measured at this site. The area upstream of the footbridge appears to be a wading pool with an extended concrete apron and stone/mortar sides and steps. Habitat appeared good, however lack of flow may be an issue later in the summer when flow no longer spills over Phoenix Dam.
SA-01	<30°	Yes - extends 28.2' upstream of weir.	Freefall into Pool	No	N/A	Fair	Not measured due to vertical retaining walls	N/A	None	Site was surveyed on 7/8/05 and temperatures were measured at 10:30 AM. Air temp = 17°C and water temp = 16°C. Instream habitat was rated as "poor" with shallow pools, high levels of fines and silt, and the banks constricted by retaining walls. The weir does not appear to pose a serious impediment to steelhead migration. Roach were the only fish species observed, both upstream and downstream of the weir.
SA-02 aka MR-078	<30°	No	At Stream Grade	N/A	No	Good	23.8	147	Denil fish ladder	Crossing was surveyed in 2003 during County of Marin's assessment project. Data Collected at 11:30 am Air=20.5C Water=17C Pretty good fish habitat. Channel is partially confined by concrete walls and in developed resedential area. Xing design is a Denil fish ladder which recieves all low flow and only a fraction of flood events. The long concrete runway would be challenging for migrating fish. Questionable effectiveness of design.
SA-03	<30°	No	This culvert is attached to arch - xing 3 of 3	N/A	No	Good	27.1	N/A	None	Site was surveyed on 7/8/05 and temperatures were measured at 2:15 PM. Air temp = 21°C and water temp = 16°C. Instream habitat was rated as "poor" with shallow pools, minimal instream cover/complexiety, high levels of fines and silt, and the banks constricted by retaining walls and chunks of concrete. A moderate abundance (10-50 fish) of y-o-y steelhead were observed both u.s. and d.s. of xing. Extremely abundant (>100 fish) numbers of roach were observed throughout.
SA-03	<30°	No	This culvert is attached to arch - xing 3 of 3	N/A	No	Good	27.1	N/A	None	Site was surveyed on 7/8/05 and temperatures were measured at 2:15 PM. Air temp = 21°C and water temp = 16°C. Instream habitat was rated as "poor" with shallow pools, minimal instream cover/complexiety, high levels of fines and silt, and the banks constricted by retaining walls and chunks of concrete. A moderate abundance (10-50 fish) of y-o-y steelhead were observed both u.s. and d.s. of xing. Extremely abundant (>100 fish) numbers of roach were observed throughout.
SA-03	N/A	No	Freefall into Pool	Yes - sloped at 1.42% over a 33.0' length	No	Good	27.1	N/A	None	Site was surveyed on 7/8/05 and temperatures were measured at 2:15 PM. Air temp = 21°C and water temp = 16°C. Instream habitat was rated as "poor" with shallow pools, minimal instream cover/complexiety, high levels of fines and silt, and the banks constricted by retaining walls and chunks of concrete. A moderate abundance (10-50 fish) of y-o-y steelhead were observed both u.s. and d.s. of xing. Extremely abundant (>100 fish) numbers of roach were observed throughout.

CORTE MADERA CREEK - SITE LOCATIONS AND CHARACTERISTICS

ID #	Stream Name	Road Name	USGS Quad	Township, Range, Section	Lattitude and Longitude Coordinates	Crossing Owner-ship	Milemarker or Name and Distance to nearest Crossroad	Type of Crossing	Construction Material	Corrugation Dimensions	Crossing Length (ft)	Culvert Dimensions: Diameter, height/width, or rise/span (ft)	% Slope thru Crossing	Rustline Height (ft)	Inlet Type
SA-04 aka MR-079	San Anselmo Creek #4	Pastori Avenue	San Rafael	T2N, R7W	37° 59' 7.60" 122° 35' 10.64"	Private property - marin town and country club	0.1 mi. to Belmont Ave	Fish ladder under bridge	Concrete	Smooth	25.3	12.0 H x 37.0 W	Fish Ladder= 20.40%	N/A	Wingwall
SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	San Rafael	T2N, R7W	37° 58' 54.9" 122° 35' 30.5"	Town of Fairfax	100' to Porteous Avenue	Concrete box culvert	Concrete	Smooth	47.0	14.0 H x 18.0 W	0.85	N/A	Headwall
SA-06	San Anselmo Creek #6 aka Canyon Creek	Canyon Road	San Rafael	T2N, R7W	37° 58' 31.1" 122° 36' 19.2"	Town of Fairfax	0.1 mi. to Cascade Drive	Fish ladder within concrete box culvert	Concrete and steel plates within fish ladder	Smooth	Length thru ladder = 53.6	11.4 H x 28.0 W	Fish Ladder = 17.53%	N/A	Wingwall
SH-01	Sleepy Hollow Creek #1	Taylor Street	San Rafael	T2N, R6W	37° 58' 54.9" 122° 34' 10.2"	Town of San Anselmo	75' to Saunders Avenue	Concrete arch culvert	Concrete	Smooth	30.7	10.4 Rise x 12.2 Span	4.36	N/A	Wingwall
SH-02	Sleepy Hollow Creek #2	Saunders Avenue	San Rafael	T2N, R6W	37° 58' 57.9" 122° 34' 12.3"	Town of San Anselmo	100' to Park Drive	Concrete arch culvert	Concrete	Smooth	42.7	12.0 Rise x 10.0 Span	1.22	N/A	Headwall
SH-03	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	San Rafael	T2N, R6W	37° 59' 04.0" 122° 34' 17.0"	Town of San Anselmo	100' to Aspen Drive	Concrete arch culvert	Concrete	Smooth	60.3	9.9 Rise x 9.5 Span	1.91	N/A	Headwall
SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	San Rafael	T2N, R6W	37° 59' 09.8" 122° 34' 16.6"	Town of San Anselmo	25' to Rivera Street	Concrete arch culvert	Concrete	Smooth	32.3	7.0 Rise x 15.2 Span	1.27	N/A	Headwall
SH-05	Sleepy Hollow Creek #5	Morningside Avenue	San Rafael	T2N, R6W	37° 59' 12.0" 122° 34' 18.0"	Town of San Anselmo	100' to Meadowcroft Drive	Concrete box culvert	Concrete	Smooth	40.0	7.7 H x 14.0 W	0.78	N/A	Wingwall
SH-06	Sleepy Hollow Creek #6	Broadmore Avenue	San Rafael	T2N, R6W	37° 59' 16.6" 122° 34' 22.9"	Town of San Anselmo	25' to Brookside Drive	Concrete box culvert	Concrete	Smooth	50.0	7.5 H x 14.0 W	0.58	N/A	LB = headwall; RB = wingwall
SH-07	Sleepy Hollow Creek #7	Arroyo Avenue	San Rafael	T2N, R6W	37° 59' 31.4" 122° 34' 30.2"	Town of San Anselmo	30' to Butterfield Road	SSP pipe arch	SSP set on concrete footings	On sides = 6" x 2"	39.8	9.35 Rise x 13.8 Span	-0.95	N/A	Wingwall

CORTE MADERA CREEK - SITE LOCATIONS AND CHARACTERISTICS

ID #	Inlet Alignment to Channel	Inlet Apron	Outlet Configuration	Outlet Apron	Culvert Embedded?	Crossing-Culvert Condition	Average Active Channel Width (ft)	Estimated Road fill (cubic yards)	Previous Fish Passage Modifications to Crossing	Additional Comments from Initial Site Visit
SA-04 aka MR-079	<30°	No	Freefall into Pool	N/A	No	Good	23.1	1,125	Denil fish ladder	Crossing was surveyed in 2003 during County of Marin's assessment project. Data collected at 2:30 pm Air=23C Water=18C. Good fish habitat. Xing within city of Fairfax. Xing design is a Denil fish ladder which recieves all low flow and only a fraction of flood events.
SA-05	<30°	No	At Stream Grade	No	No	Fair - invert worn to exposed rebar in several locations	21.2	1,959	None	Site was surveyed on 6/10/05 and temperatures were measured at 11:20 AM. Air temp = 20°C and water temp = 14°C. Crossing is located upstream of downtown Fairfax. Habitat was rated as "good" when compared to lower reaches of San Anselmo Creek. A moderate abundance (10-50 fish) of y-o-y and 1+ steelhead were observed upstream of the culvert.
SA-06	<30°	No	Freefall into Pool	Yes	No	Fair - concrete at inlet is cracked. Fish ladder in good condition.	27.9	N/A	Denil fish ladder	Site was surveyed on 6/10/05 and temperatures were measured at 9:30 AM. Air temp = 16oC and water temp = 13.5oC. Crossing is located in upper section of watershed and salmonid habitat was rated as "good" with numerous pools and relatively unembedded spawning substrate. A moderate abundance (10-50 fish) of y-o-y and 1+ steelhead were observed upstream and downstream of the crossing.
SH-01	<30°	No	Freefall into Pool - two step drop over aprons	Yes - two step drop past culvert outlet	No	Fair - invert worn to rebar, several cracks in walls, outlet is undercut.	Use upstream width = 18.6	743	None	Site was surveyed on 6/8/05 and temperatures were measured at 11:50 AM. Air temp = 17°C and water temp = 16°C. Crossing is the lowermost in the Sleepy Hollow sub-basin and appears to be a significant impediment to fish passage. Salmonid habitat was rated as "poor". Numerous roach and sticklebacks were observed along with a single 1+ steelhead.
SH-02	<30°	No	At Stream Grade	No	Partially with sand, gravel and small cobbles.	Good	Use upstream width = 18.6	973	None	Site was surveyed on 6/8/05 and temperatures were measured at 12:00 PM. Air temp = 17oC and water temp = 15oC. Salmonid habitat was rated as "poor" due to the lack of cover in pools, highly embedded substrate and severe channel confinement by retaining walls. The only fish species observed were roach and sticklebacks.
SH-03	<30°	No	At Stream Grade and back-watered.	Yes - extends downstream past survey points - embedded.	No	Good	Use upstream width = 18.6	1,543	None	Site was surveyed on 6/8/05 and temperatures were measured at 2:30 PM. Air temp = 16°C and water temp = 15°C. The culvert has a V-shaped invert and is back-watered for about 2/3's of its length. The deepest pool is within the culvert. Habitat was rated as "poor". Crossing is adjacent to the High School campus.
SH-04	<30°	No	At Stream Grade	No	No	Good	Use upstream width = 18.6	349	None	Site was surveyed on 6/7/05 and temperatures were measured at 4:45 PM. Air temp = 17°C and water temp = 15°C. Habitat rated as "poor" few pools with no cover/structure, shallow featureless channel with lots of sand/silt. The only fish species observed were roach and sticklebacks.
SH-05	<30°	Yes - extends 29.5' upstream.	At Stream Grade	No	No	Good	Use upstream width = 18.6	429	None	Site was surveyed on 6/8/05 and temperatures were measured at 9:30 AM. Air temp = 16°C and water temp = 15°C. Habitat was rated as "poor" and the only fish species observed were roach and sticklebacks. Culvert appears fairly passable.
SH-06	<30°	No	Freefall into pool.	No	No	Fair - invert cracked and slumping.	18.6	612	None	Site was surveyed on 6/7/05 and temperatures were measured at 3:15 PM. Air temp = 16°C and water temp = 14°C. Habitat was rated as "poor" since the channel was dominated by rip-rap and chunks of concrete. Substrate was mostly sand and silts. The only fish species observed were roach and sticklebacks.
SH-07	30° - 45°	No	At Stream Grade	No	Open-bottom comprised of sand and silt	Good	18.4	665	None	Site was surveyed on 6/7/05 and temperatures were measured at 2:15 PM. Air temp = 15°C and water temp = 14°C. This crossing has an open bottom, yet concrete cross-beams at the inlet and outlet with a deep pool within the crossing. Habitat was rated as "poor". Roach and sticklebacks were extremely abundant (>100 fish) and a single y-o-y steelhead was observed.

CORTE MADERA CREEK - SITE LOCATIONS AND CHARACTERISTICS

ID #	Stream Name	Road Name	USGS Quad	Township, Range, Section	Lattitude and Longitude Coordinates	Crossing Owner-ship	Milemarker or Name and Distance to nearest Crossroad	Type of Crossing	Construction Material	Corrugation Dimensions	Crossing Length (ft)	Culvert Dimensions: Diameter, height/width, or rise/span (ft)	% Slope thru Crossing	Rustline Height (ft)	Inlet Type
SH-08 aka MR-081	Sleepy Hollow Creek #8	Deer Hollow Road	Novato	T2N, R6W	38° 00' 1.35" 122° 34' 21.19"	County of Marin	0.1 M to Butterfield Rd	Concrete box culvert	Concrete	Smooth	27.3	11.8 X 13.0	0.84	N/A	Wingwall
SH-09 aka MR-082	Sleepy Hollow Creek #9	Fawn Drive	Novato	T2N, R6W	38° 00' 8.82" 122° 34' 20.86"	County of Marin	0.1 M to Butterfield Rd	Concrete box culvert	Concrete	Smooth	48.9	8.5 X 13.5	4.21	N/A	Wingwall
SH-10 aka MR-083	Sleepy Hollow Creek #10	Butterfield Road	Novato	T2N, R6W	38° 00' 26.76" 122° 34' 40.72"	County of Marin	at Sleepy Hollow Rd	Concrete box culvert	Concrete	Smooth	75.3	6.15 X 11.8	0.81	N/A	Wingwall
SH-10 aka MR-083	Sleepy Hollow Creek #11	Not a crossing - Raven dam	Novato	T2N, R7W	38° 00' 30.2" 122° 34' 49.4"	Private property	0.1 mi. to Legend Road	Dam - filled in with sediment, no water storage on u.s. side.	Concrete	N/A	14.7	Width of dam = 20.7'	N/A	N/A	N/A
FX-01 aka MR-080	Fairfax Creek #1	Fairfax-Bolinas Road	San Rafael	T2N, R7W	37° 59' 7.97" 122° 35' 20.78"	Town of Fairfax	0.1 mi. to Park Rd	Concrete box culvert	Concrete	Smooth	458.0	6.35 X 9.9	0.94	N/A	Wingwall
FX-02	Fairfax Creek #2	Scenic Road	San Rafael	T2N, R7W	37° 59.2' 23.3" 122° 35' 32.3"	Town of Fairfax	25' to Arroyo Road	Concrete box culvert	Concrete	Smooth	40.0	11.1 H x 14.0 W	0.03	N/A	Headwall
FX-03	Fairfax Creek #3	Olema Road	San Rafael	T2N, R7W	37° 59.0' 31.1" 122° 35' 33.9"	Town of Fairfax	0.1 mi. to Sir Francis Drake Blvd	Concrete box culvert	Concrete	Smooth	44.0	10.3 H x 14.0 W	0.64	N/A	Wingwall
FX-04	Fairfax Creek #4	Not a road - dam	San Rafael	T2N, R7W	37° 59.0' 45.8" 122° 35' 52.1"	Private	100' to Westbrae Drive	Dam - filled in with sediment, no water storage on u.s. side.	Concrete set on bedrock	N/A	From notch at top of dam to d.s. edge of bedrock = 16.0'.	Dam total width = 22.0' Low-flow notch = 9.5' Notch is 2.1' lower than the rest of dam wall.	From notch at top of dam to d.s. edge of bedrock = 71.88	N/A	N/A
FX-05	Fairfax Creek #5	Sir Francis Drake Blvd.	Novato	T2N, R7W	38° 0.0' 01.5" 122° 36' 08.4"	County of Marin	50' to Glen Drive	SSP circular pipe	SSP	Upper culvert = 6" x 2" on sides and smooth concrete invert.	Total = 174.6; upper section of culvert = 142.0	8.0	1.12	1.8	Wingwall

CORTE MADERA CREEK - SITE LOCATIONS AND CHARACTERISTICS

ID #	Inlet Alignment to Channel	Inlet Apron	Outlet Configuration	Outlet Apron	Culvert Embedded?	Crossing-Culvert Condition	Average Active Channel Width (ft)	Estimated Road fill (cubic yards)	Previous Fish Passage Modifications to Crossing	Additional Comments from Initial Site Visit
SH-08 aka MR-081	<30°	No	Freefall into Pool	Slope=34.80% Length=15.0 ft	No	Fair- floor is worn	18.4	739	None	Crossing was surveyed in 2003 during County of Marin's assessment project. Data collected at 3 pm. Air=22C Water=12.5C Good fish habitat. Culvert seems to be on top of a bedrock outcropping which has a natural 5-6 ft drop. In residental area.
SH-09 aka MR-082	30° - 45°	No	At Stream Grade	N/A	No	Good	18.4	767	None	Crossing was surveyed in 2003 during County of Marin's assessment project. Data collected at 4 pm. Air=22C Water=15C. Good fish habitat. Moderate redwood & hardwood canopy. In residential area. Scour at inlet.
SH-10 aka MR-083	<30°	No	At Stream Grade	N/A	No	Fair- Floor worn	18.4	1,347	None	Crossing was surveyed in 2003 during County of Marin's assessment project. Data collected at 5 pm. Air=21C Water=13C. Good fish habitat. Dense hardwood canopy. In residential area. Roughness provided from worn floor.
SH-10 aka MR-083	<30°	No	Freefall into Pool	N/A	N/A	Good	19.4	N/A	None	Site was surveyed on 6/7/05 and temperatures were measured at 11:15 AM. Air temp = 15°C and water temp = 14°C. This dam has two large drops and is a definite migration barrier to all age classes of steelhead. Habitat was rated as "Fair to good" relative to lower reaches of Sleepy Hollow Creek. Numerous (50-100 fish) roach and sticklebacks were observed and 10-20 y-o-y steelhead were observed both above and below the dam.
FX-01 aka MR-080	<30°	No	Freefall into Pool	No	No	Fair	11.1	3,014	No	Crossing was surveyed in 2003 during County of Marin's assessment project. Data collected at 5:00 pm. Air=20C Water=17C Good fish habitat beyond the 172 ft long inlet apron/channel. Outlet is 20 ft from confluence with San Anselmo Cr. Culvert is under full length of Sherman Ave and exits behind residences.
FX-02	<30°	Yes - upstream of culvert is 172' long apron/concrete channel.	At stream grade	No	No	Good	14.0	650	None	Site was surveyed on 6/10/05 and temperatures were measured at 2:00 PM. Air temp = 21°C and water temp = 16°C. Habitat was rated as "fair" relative to other tributary reaches within the Corte Madera Creek watershed. Crossing is located in a residential neighborhood and most of the adjacent banks were armoured with rip-rap and/or retaining walls. The only fish species observed were roach (50-100 fish) in the channel downstream of the crossing.
FX-03	<30°	No	Freefall into pool	No	No	Fair - invert worn and cracked.	13.1	546	None	Site was surveyed on 6/8/05 and temperatures were measured at 4:45 PM. Air temp = 16°C and water temp = 16°C. Habitat was rated as "Fair" relative to other tributary reaches within the Corte Madera Creek watershed. There were undercut banks and pooltails with suitable spawning substrates. The riparian was a dense overstory of mostly hardwoods. The only fish species observed were roach in extremely abundand numbers (>100 fish).
FX-04	<30°	No	Freefall into pool - three step drop over two ledges of concrete and one of bedrock.	Yes - flow sheets across bedrock that creates hydraulic conditions similar to an apron.	N/A	Fair - several cracks in face of dam.	15.8	N/A	None	Site was surveyed on 7/9/05 and temperatures were measured at 10:15 AM. Air temp = 18°C and water temp = 15°C. The dam sits on a natural bedrock outcrop and the total drop is 13.9 feet. There appears to be two separate pours of concrete to form the dam. Outlet pool (RB side) is heavily armoured with concrete retaining wall and rip-rap. Landowner expressed concern for his property if the dam was lowered or removed and directed more flow against his bank. Habitat was rated as "fair" - small pools with some cover, dense riparian, and relatively unimbedded spawning substrate. Roach were the only species observed in abundant numbers (>100 fish).
FX-05	<30°	No	At stream grade.	No	No	Extremely poor - invert rusted thru lower section and upper section patched with concrete.	15.3	1,531	None	Site was surveyed on 7/9/05 and temperatures were measured at 1:30 PM. Air temp = 22°C and water temp = 16°C. This crossing was the uppermost surveyed in Fairfax Creek - still appeared to be suitable salmonid habitat. The crossing was comprised of two sections of culvert, with the lower section in very poor condition. Habitat was rated as "fair". No fish were observed in the channel adjacent to this crossing.

CORTE MADERA CREEK - SURVEYED ELEVATIONS

ROSS CREEK #1 - PARK DRIVE **SITE ID# R-01**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.62			100.00			Temporary Bench Mark-TBM
1.5		100.62	5.20	95.42	95.87		Top end inlet pool d=0.45'
19.5		100.62	5.08	95.54			D.s. end inlet pool
20.0		100.62	4.15	96.47	97.27	4.37%	Top of inlet apron
41.3		100.62	5.08	95.54	96.24	-0.33%	Inlet invert
59.3		100.62	5.02	95.60			Outlet Invert
75.0		100.62	5.16	95.46	96.16	31.59%	Top of break-in-slope
81.3		100.62	7.15	93.47	94.97		D.s. edge outlet apron d=1.5'
81.3	7.08						Turning Point #1 (TP#1)
90.0		100.55	9.28	91.27	94.67		Max pool depth = 3.4'
142.6		100.55	5.46	95.09	95.09		TW Control d=0.0'
201.0		100.55	5.69	94.86	95.16	0.39%	Downstream channel slope d=0.3

TAILWATER CROSS-SECTION at Station 142.6'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.4		100.55	3.79	96.76			LB d=0.0
4.0		100.55	5.46	95.09			Thalweg d=0.0
17.0		100.55	4.89	95.66			Inchannel d=0.0
24.8		100.55	5.02	95.53			Inchannel d=0.0
29.0		100.55	4.26	96.29			Inchannel d=0.0
37.0		100.55	4.08	96.47			RB d=0.0
43.5		100.55	2.82	97.73			RB d=0.0

ROSS CREEK #2 - NORWOOD AVENUE **SITE ID# R-02**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.26			100.00			Temporary Bench Mark-TBM
2.0		100.26	4.72	95.54	95.84		TW Control of 1st resting habitat d=0.3'
27.0		100.26	4.94	95.32	95.82		U.s. edge inlet pool d=0.5'
39.5		100.26	7.61	92.65	95.85		Max depth inlet pool d=3.2'
52.5		100.26	5.63	94.63	95.83	-0.91%	Inlet invert d=1.2'
64.0		100.26	5.54	94.72	95.72		Max depth w/in xing d=1.0'
72.0		100.26	5.45	94.81	95.81		Outlet invert d=1.0'
73.6		100.26	5.47	94.79	95.79		Max pool depth d=1.0'
78.5		100.26	5.19	95.07	95.82		TW Control d=0.75'
132.0		100.26	5.94	94.32	94.72	1.40%	Downstream channel slope d=0.4'

TAILWATER CROSS-SECTION at Station 78.5'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
1.0		100.26	4.78	95.48			LB edge of vertical 7' high wall d=0.35'
2.3		100.26	5.19	95.07			Thalweg d=0.75'
8.5		100.26	4.62	95.64			Inchannel d=0.1'
11.0		100.26	4.80	95.46			Inchannel d=0.2
16.5		100.26	4.82	95.44			Inchannel d=0.1'
21.0		100.26	4.90	95.36			RB wetted edge
23.0		100.26	3.68	96.58			RB on Bank
24.2		100.26	2.51	97.75			RB on Bank

ROSS CREEK #3 - Utility pipe across channel in Natalie Coffin Park **SITE ID# R-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	2.01			100.00			Temporary Bench Mark-TBM
4.0		102.01	3.00	99.01	99.31		TW Control of 1st resting habitat d=0.3'
40.0		102.01	3.34	98.67	99.07		U.s. of utility pipe d=0.4'
40.7		102.01	3.03	98.98	99.03		On utility pipe d=0.05'
42.0		102.01	4.17	97.84	98.34		D.s. of pipe d=0.5'
43.8		102.01	3.42	98.59	98.59		Rip rap d=0.0'
49.4		102.01	4.52	97.49	97.69		D.s. edge of rip rap d=0.2'
52.3		102.01	5.32	96.69	97.64		Max depth w/in 5ft of pipe d=0.95'
63.8		102.01	5.56	96.45	97.65		Max pool depth d=1.2'
84.0		102.01	4.87	97.14	97.64		TW Control d=0.5'
111.0		102.01	5.25	96.76	96.96	1.45%	Downstream Slope d=0.2'

TAILWATER CROSS-SECTION at Station 84.0

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.0		102.01	1.28	100.73			LB on Bank
9.5		102.01	3.67	98.34			LB gravel bar
16.0		102.01	4.54	97.47			LB wetted edge
20.0		102.01	4.87	97.14			Thalweg d=0.5'
21.0		102.01	4.62	97.39			Inchannel d=0.25'
22.7		102.01	3.99	98.02			Inchannel boulder
24.0		102.01	4.82	97.19			Inchannel d=0.3'
25.3		102.01	4.52	97.49			RB wetted edge
25.8		102.01	3.77	98.24			RB on Bank
27.6		102.01	4.07	97.94			RB on Bank
31.8		102.01	2.31	99.70			RB on Bank

CORTE MADERA CREEK - SURVEYED ELEVATIONS

ROSS CREEK #4 - Trail Crossing in Natalie Coffin Park **SITE ID# R-04**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	3.42			100.00			Temporary Bench Mark-TBM
5.0		103.42	7.02	96.40	96.60		Top of u.s. weir d=0.2'
5.5		103.42	7.70	95.72	95.92	1.06%	U.s. edge of inlet apron d=0.2'
62.0		103.42	8.30	95.12	95.32	4.09%	Rock weir constriction d=0.2'
73.0		103.42	8.75	94.67	94.82	8.75%	D.s. side of bridge d=0.15'
76.2		103.42	9.03	94.39	94.59		D.s. apron d=0.2'
77.5		103.42	9.37	94.05	94.15		D.s. edge of apron d=0.1'
82.5		103.42	10.75	92.67	94.07		Max depth w/in 5ft d=1.4'
87.5		103.42	11.34	92.08	94.08		Max pool depth d=2.0'
100.5		103.42	10.14	93.28	94.03		TW Control d=0.75'
140.5		103.42	9.86	93.56	93.86	-0.70%	Downstream Slope d=0.3'

TAILWATER CROSS-SECTION at Station 100.5

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
5.0		103.42	5.66	97.76			LB on Bank
7.7		103.42	7.63	95.79			LB ACM
15.0		103.42	8.91	94.51			LB gravel bar
20.0		103.42	9.10	94.32			Inchannel on LWD
20.4		103.42	8.74	94.68			High point on LWD
22.4		103.42	9.32	94.10			LB wetted edge
25.7		103.42	10.02	93.40			Inchannel d=0.6'
28.3		103.42	9.19	94.23			Inchannel on boulder
29.3		103.42	9.01	94.41			High point on boulder
30.2		103.42	9.28	94.14			RB edge of boulder
31.3		103.42	10.14	93.28			TW Control d=0.75'
32.8		103.42	9.45	93.97			RB wetted edge
33.3		103.42	8.04	95.38			RB on Bank

SAN ANSELMO CREEK #1 - PARK CREEK WEIR **SITE ID# SA-01**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	2.17			100.00			Temporary Bench Mark-TBM
10.5		102.17	4.25	97.92	98.32	0.31%	U.s. edge of apron d=0.4'
39.2		102.17	4.34	97.83	98.23		Edge of weir d=0.4'
40.0		102.17	5.86	96.31	97.01		D.s. side of weir d=0.7'
42.5		102.17	6.22	95.95	97.15		Max depth w/in 5ft d=1.2'
69.0		102.17	7.63	94.54	96.94		Max. Pool Depth = 2.4'
130.0	5.10	103.87					Turning Point
130.0		103.87	8.00	95.87	96.87		TW Control d=1.0'
168.0		103.87	8.00	95.87	96.07	0.00%	Downstream channel slope d=0.2'

TAILWATER CROSS-SECTION at Station 130.0'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.5		102.17	3.40	98.77			RB edge of vertical wall
4.0		103.87	5.20	98.67			Inchannel
4.4		103.87	7.07	96.80			Inchannel d=0.15'
15.5		103.87	7.36	96.51			Inchannel d=0.4'
17.9		103.87	8.00	95.87			Thalweg d=1.0'
21.0		103.87	7.22	96.65			Inchannel d=0.3'
22.0		103.87	6.36	97.51			Inchannel - dry
23.5		103.87	7.26	96.61			Inchannel d=0.3'
25.6		103.87	6.02	97.85			Top of boulders
28.0		103.87	6.82	97.05			Inchannel - dry
29.8		103.87	4.71	99.16			Inchannel - dry
34.5		103.87	3.72	100.15			Inchannel - dry
36.3		103.87	5.72	98.15			Inchannel - dry
43.5		103.87	4.73	99.14			LB edge of vertical wall

CROSS-SECTION ACROSS WEIR at Station 39.2'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.0		102.17	3.79	98.38			RB edge of vertical 5-ft concrete wall
4.6		102.17	4.34	97.83			Thalweg d=0.4
10.0		102.17	3.93	98.24			LB wetted edge
15.0		102.17	3.98	98.19			On weir
20.0		102.17	3.91	98.26			On weir
27.5		102.17	3.80	98.37			On weir
27.8		102.17	2.44	99.73			LB - on boulder

CORTE MADERA CREEK - SURVEYED ELEVATIONS

SAN ANSELMO CREEK #3 (1 of 3; LB box that joins arch) - CENTER BLVD **SITE ID# SA-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.62						Temporary Bench Mark-TBM
0.3		100.62	4.07	96.55	96.70	0.53%	Inlet invert d=0.15'
152.3		100.62	4.87	95.75	95.95		Box section meets arch section d=0.2'

SAN ANSELMO CREEK #3 (2 of 3; RB box that joins arch) - CENTER BLVD **SITE ID# SA-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.62						Temporary Bench Mark-TBM
5.5		100.62	4.00	96.62	96.72	0.58%	Inlet invert d=0.1'
153.2		100.62	4.85	95.77	95.97		Box section meets arch section d=0.2'

SAN ANSELMO CREEK #3 (3 of 3; arch d.s. of 2-bay box) - CENTER BLVD **SITE ID# SA-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.62						Temporary Bench Mark-TBM
152.3		100.62	4.87	95.75	95.95	0.52%	U.s. edge of arch section of xing d=0.2'
226.0		100.62	5.34	95.28	95.43	0.71%	Within xing - at bend d=0.15'
226.0	4.58						Turning Point
282.5		99.86	4.78	95.08	95.28	1.42%	Outlet invert of arch d=0.2'
315.5		99.86	5.25	94.61	94.81		D.s. edge of outlet apron d=0.2'
320.0		99.86	8.69	91.17	92.97		Max pool depth = 1.8'
343.5		99.86	8.23	91.63	92.13		TW Control d=0.5'
386.5		99.86	9.01	90.85	91.85	1.81%	Downstream Channel slope d=1.0'

TAILWATER CROSS-SECTION at Station 343.5'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
1.6		99.86	4.25	95.61			LB mid-slope of rip-rapped bank
7.4		99.86	6.63	93.23			LB base of rip-rapped bank
11.2		99.86	7.82	92.04			LB wetted edge
13.2		99.86	7.19	92.67			Top of concrete chunk
17.0		99.86	7.75	92.11			Inchannel
19.0		99.86	8.23	91.63			Thalweg d=0.5'
21.0		99.86	7.34	92.52			Inchannel on concrete chunk
23.0		99.86	8.27	91.59			Inchannel d=0.4'
26.5		99.86	7.08	92.78			Top of concrete chunk
31.5		99.86	5.05	94.81			RB mid-slope of rip-rapped bank

SAN ANSELMO CREEK #5 - FAIRFAX-BOLINAS ROAD **SITE ID# SA-05**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.82			100.00			Temporary Bench Mark-TBM
1.5		100.82	4.20	96.62	96.82	0.85%	Inlet Invert d=0.2'
48.5		100.82	4.60	96.22	96.32		Outlet Invert d=0.1'
54.0		100.82	5.17	95.65	95.95		TW Control d=0.3'
116.0		100.82	5.45	95.37	95.77	0.45%	Downstream channel slope d=.4'

TAILWATER CROSS-SECTION at Station 54.0' NOTE: no outlet pool d.s. of xing

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.0		100.82	2.09	98.73			RB on Bank
5.0		100.82	3.52	97.30			RB
6.0		100.82	4.12	96.70			RB - ACM
10.0		100.82	4.78	96.04			RB wetted edge
16.5		100.82	5.17	95.65			Thalweg d=0.3'
21.9		100.82	4.70	96.12			LB wetted edge
22.5		100.82	3.98	96.84			LB - rip rap
24.8		100.82	3.15	97.67			LB on bank

SAN ANSELMO CREEK #6 - CANYON ROAD (aka CASCADE CREEK) **SITE ID# SA-06**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.18			100.00			Temporary Bench Mark-TBM
4.0		100.18	4.16	96.02	96.32	0.38%	TW Control of 1st resting habitat d=0.1'
17.0		100.18	4.21	95.97	98.37	8.12%	Top of Denil fish ladder on concrete
25.5		100.18	4.90	95.28	95.58	17.53%	Top of 1st notch on fish ladder d=0.1'
68.4		100.18	12.42	87.76	87.86		Top of bottom notch on ladder d=0.1'
70.6		100.18	13.12	87.06	87.96		D.s. edge of concrete apron
73.0		100.18	14.53	85.65	85.85		Max depth w/in 5ft d=1.0'
77.3		100.18	14.80	85.38	85.73		Max pool depth = 1.3'
93.0		100.18	13.86	86.32	86.67		TW Control d=0.3'
137.5		100.18	15.36	84.82		1.46%	Downstream channel slope

CORTE MADERA CREEK - SURVEYED ELEVATIONS

TAILWATER CROSS-SECTION at Station 93.0

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.5		100.18	9.25	90.93			LB on Bank
3.7		100.18	11.90	88.28			LB on Bank
6.0		100.18	13.60	86.58			LB wetted edge
7.5		100.18	12.50	87.68			Mid-channel boulder
9.3		100.18	13.86	86.32			Thalweg d=0.3'
10.3		100.18	13.08	87.10			Mid-channel boulder
11.0		100.18	13.73	86.45			Inchannel d=0.2'
16.0		100.18	13.47	86.71			RB wetted edge
19.5		100.18	10.78	89.40			Top edge of gabion struture
27.0		100.18	10.15	90.03			Top of gabion
33.0		100.18	9.18	91.00			Top of gabion
36.0		100.18	9.00	91.18			RB edge of gabion

SLEEPY HOLLOW CREEK #1 - TAYLOR STREET **SITE ID# SH-01**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.58			100.00			Temporary Bench Mark-TBM
19.5		100.58	5.00	95.58	95.78		TWC of 1st resting habitat d=0.2'
30.0		100.58	7.12	93.46	95.76		Pool before Inlet d=2.3'
36.3		100.58	4.96	95.62	95.72	4.36%	Inlet Invert d=0.1'
67.0		100.58	6.30	94.28	94.33		Outlet Invert d=0.05'
67.1		100.58	7.08	93.50	93.55		U.s. edge of 1st step d=0.05'
68.8		100.58	7.19	93.39	93.49		D.s. edge of 1st step d=0.1'
69.5		100.58	7.92	92.66	92.76		U.s. edge of 2nd step d=0.1'
71.6		100.58	7.93	92.65	92.75		D.s. edge of 2nd step d=0.1'
76.6		100.58	11.11	89.47	92.27		Max depth w/in 5ft of outlet d=2.8'
82.2		100.58	12.33	88.25	92.25		Max pool depth = 4.0'
124.3		100.58	9.05	91.53	91.93		TW Control d=0.4'
153.8		100.58	9.48	91.10	91.40	0.80%	Downstream channel slope d=0.3'

TAILWATER CROSS-SECTION at Station 69.0

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
1.0		100.58	5.61	94.97			LB on sloped concrete retaining wall
3.6		100.58	8.01	92.57			LB at bottom edge of retaining wall
4.3		100.58	8.16	92.42			Edge of concrete
4.5		100.58	8.29	92.29			LB gravel bar
5.5		100.58	7.11	93.47			Top of concrete chunk
7.0		100.58	6.85	93.73			More concrete chunks
9.7		100.58	8.35	92.23			Gravel bar
10.3		100.58	8.56	92.02			LB wetted edge
11.2		100.58	8.65	91.93			Inchannel d=0.3'
13.5		100.58	8.86	91.72			Inchannel d=0.2'
16.0		100.58	9.05	91.53			Thalweg d=.4'
16.4		100.58	6.21	94.37			Top of concrete chunk
18.7		100.58	5.97	94.61			RB - base of 6-ft vertical retaining wall

SLEEPY HOLLOW CREEK #2 - SAUNDERS AVENUE **SITE ID# SH-02**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	3.63			100.00			Temporary Bench Mark-TBM
8.2		103.63	4.19	99.44	99.64	3.27%	TWC of 1st resting habitat d=0.2'
27.8		103.63	4.83	98.80	99.30	1.22%	Inlet Invert d=0.5'
70.5		103.63	5.35	98.28	99.28		Outlet Invert d=1.0'
73.0		103.63	5.97	97.66	99.26		Max. Pool Depth = 1.6'
91.0		103.63	4.93	98.70	99.20		TW Control d=0.5'
136.0		103.63	5.02	98.61	98.91	0.20%	Downstream channel slope d=0.3'

TAILWATER CROSS-SECTION at Station 91.0

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.5		103.63	2.40	101.23			LB edge of 4ft vertical retaining wall
4.5		103.63	3.56	100.07			LB on bank
5.6		103.63	4.56	99.07			LB wetted edge
6.6		103.63	4.93	98.70			Thalweg d=0.5'
11.0		103.63	4.45	99.18			Gravel bar
15.0		103.63	4.51	99.12			RB wetted edge
15.1		103.63	4.23	99.40			Edge of concrete walkway
17.5		103.63	4.21	99.42			RB edge of 6ft vertical retaining wall

CORTE MADERA CREEK - SURVEYED ELEVATIONS

SLEEPY HOLLOW CREEK #3 - SIR FRANCIS DRAKE BLVD **SITE ID# SH-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	2.82			100.00			Temporary Bench Mark-TBM
4.5		102.82	4.18	98.64	98.84	4.62%	TW Control of 1st resting habitat d=0.2'
20.5		102.82	4.92	97.90	98.20	1.76%	Inlet invert d=0.3'
20.5	5.13						Turning point on inlet invert
62.3		103.03	5.56	97.47	98.17		At bend w/in culvert d=0.7'
80.8		103.03	6.28	96.75	98.20		Outlet invert d=1.45'
109.0		103.03	6.11	96.92	98.22		Max pool depth = 1.3'
131.3		103.03	5.17	97.86	98.16		TW Control d=0.3'
174.0		103.03	6.53	96.50	97.70	3.19%	Downstream channel slope d=1.2'

TAILWATER CROSS-SECTION at Station 131.3'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
1.3		103.03	5.00	98.03			LB edge of 7-ft vertical retaining wall
4.7		103.03	4.84	98.19			LB rip rap and gravel
5.0		103.03	4.64	98.39			LB gravel bar - dry
5.8		103.03	4.81	98.22			LB gravel bar - dry
7.1		103.03	4.82	98.21			LB gravel bar - dry
7.7		103.03	4.33	98.70			LB gravel bar - dry
9.0		103.03	4.52	98.51			LB gravel bar - dry
9.3		103.03	5.11	97.92			LB wetted edge d=0.2'
10.3		103.03	5.17	97.86			Thalweg d=0.3'
11.4		103.03	5.05	97.98			Inchannel d=0.2'
11.7		103.03	4.22	98.81			Edge of boulder
12.8		103.03	4.10	98.93			RB edge of 7-ft vertical retaining wall

SLEEPY HOLLOW CREEK #4 - MOUNTAIN VIEW AVENUE **SITE ID# SH-04**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.51			100.00			Temporary Bench Mark-TBM
18.5		100.51	4.80	95.71	95.81	1.27%	Inlet invert d=0.1'
50.8		100.51	5.21	95.30	95.40		Outlet Invert d=0.1'
55.8		100.51	6.11	94.40	95.20		Max pool depth = 0.8'
81.0		100.51	5.48	95.03	95.13		TW Control d=0.1'
115.5		100.51	6.06	94.45	94.75	1.68%	Downstream channel slope d=0.3'

TAILWATER CROSS-SECTION at Station 81.0'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
1.3		100.51	3.55	96.96			LB
3.3		100.51	3.85	96.66			LB
3.7		100.51	4.82	95.69			LB
5.4		100.51	5.30	95.21			LB wetted edge
10.7		100.51	5.48	95.03			Thalweg d=0.1'
16.9		100.51	5.32	95.19			RB wetted edge
17.7		100.51	4.32	96.19			RB on Bank
18.5		100.51	3.98	96.53			RB on Bank

SLEEPY HOLLOW CREEK #5 - MORNINGSIDE AVENUE **SITE ID# SH-05**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.52			100.00			Temporary Bench Mark-TBM
14.0		100.52	4.72	95.80	96.40	-1.69%	U.s. edge of inlet apron d=0.6'
43.5		100.52	4.22	96.30	96.40	0.77%	Inlet Invert d=0.1'
83.5		100.52	4.53	95.99	96.29		Outlet Invert d=0.3'
86.0		100.52	4.85	95.67	95.97		Max depth w/in 5ft d=0.3'
94.6		100.52	5.12	95.40	95.90		Max. pool depth = 0.5'
108.2		100.52	4.90	95.62	95.82		TW Control d=0.2'
141.0		100.52	4.98	95.54	95.74	0.24%	Downstream channel slope d=0.2'

TAILWATER CROSS-SECTION at Station 108.2'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
4.7		100.52	2.07	98.45			LB on Bank
7.0		100.52	4.32	96.20			LB top of gravel bar
12.0		100.52	4.54	95.98			LB gravel bar
16.5		100.52	4.49	96.03			Gravel bar
18.0		100.52	4.69	95.83			LB wetted edge
19.7		100.52	4.90	95.62			Thalweg d=0.2'
21.5		100.52	4.63	95.89			RB wetted edge
22.5		100.52	4.56	95.96			RB gravel bar
23.8		100.52	1.93	98.59			RB on Bank

CORTE MADERA CREEK - SURVEYED ELEVATIONS

SLEEPY HOLLOW CREEK #6 - BROADMOOR AVENUE **SITE ID# SH-06**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.26			100.00			Temporary Bench Mark-TBM
5.7		100.26	4.05	96.21	96.51	1.34%	TWC of 1st u.s. resting habitat d=0.3'
42.9		100.26	4.55	95.71	95.91	0.58%	Inlet invert d=0.2'
92.9		100.26	4.84	95.42	95.52		Outlet invert d=0.1'
97.0		100.26	6.67	93.59	94.89		Max depth w/in 5ft = 1.3'
108.2		100.26	7.39	92.87	94.87		Max. pool depth = 2.0'
136.5		100.26	6.49	93.77	94.87		TW Control d=1.1'
195.0		100.26	5.88	94.38	94.88	-1.04%	Downstream channel slope d=0.5'

TAILWATER CROSS-SECTION at Station 136.5'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
3.3		100.26	4.10	96.16			RB midway up bank
4.4		100.26	5.30	94.96			RB wetted edge
6.6		100.26	6.49	93.77			Thalweg d=1.1'
13.8		100.26	5.37	94.89			LB wetted edge
18.0		100.26	3.73	96.53			LB midway up rip rapped bank

SLEEPY HOLLOW CREEK #7 - ARROYO AVENUE **SITE ID# SH-07**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	1.96						Temporary Bench Mark-TBM
0.7		101.96	3.55	98.41	98.51	2.17%	TW Control of 1st resting habitat d=0.1'
62.0		101.96	4.88	97.08	97.88	-0.95%	Inlet beam d=0.8'
101.8		101.96	4.50	97.46	97.86		Outlet beam d=0.4'
104.2		101.96	5.24	96.72	97.82		Max. Pool Depth = 1.1'
130.0		101.96	4.36	97.60	97.80		TW Control d=0.2'
		101.96	3.25	98.71			Active Channel Margin - ACM
67.5		101.96	7.49	94.47	97.87		Max depth w/in xing d=3.4'

SLEEPY HOLLOW CREEK #11 - RAVEN DAM **SITE ID# SH-11**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	1.58						Temporary Bench Mark-TBM
2.0		101.58	3.20	98.38			TWC 1st u.s. resting habitat d=0.3'
33.6		101.58	3.16	98.42			U.s. edge of dam's notch d=0.2'
36.2		101.58	3.32	98.26			D.s. edge of dam's notch d=0.1'
36.3		101.58	8.95	92.63			1st drop d=0.1'
48.3		101.58	8.95	92.63			D.s. edge of dam's lower teir d=0.05
48.3	4.79	101.58					Turning point
48.4		97.42	9.89	87.53			2nd drop d=2.0'
52.1		97.42	10.17	87.25			Max depth w/in 5ft d=2.4'
61.5		97.42	11.12	86.30			Max pool depth = 3.35'
87.5		97.42	8.10	89.32			TW Control d=0.3'
142.0		97.42	10.50	86.92		4.40%	Downstream channel slope d=0.5'

TAILWATER CROSS-SECTION at Station 87.5'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
4.0		97.42	4.69	92.73			LB on bank
6.2		97.42	7.69	89.73			LB gravel bar
11.9		97.42	7.36	90.06			LB gravel bar
13.0		97.42	7.77	89.65			LB gravel bar
19.7		97.42	7.84	89.58			LB wetted edge
21.5		97.42	8.10	89.32			Thalweg d=0.3'
24.7		97.42	7.80	89.62			RB wetted edge
27.3		97.42	7.36	90.06			RB lower bank
33.0		97.42	6.85	90.57			RB lower bank
40.5		97.42	6.48	90.94			RB lower bank
44.2		97.42	5.10	92.32			RB on bank
51.0		97.42	4.91	92.51			RB on bank

FAIRFAX CREEK #2 - SCENIC ROAD **SITE ID# FX-02**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.18			100.00			Temporary Bench Mark-TBM
9.0		100.18	5.31	94.87	95.32	0.02%	Inlet Invert d=0.45'
49.0		100.18	5.32	94.86	95.31		Outlet Invert d=0.45'
54.0		100.18	5.78	94.40	95.30		Max. Pool Depth=0.9
67.0		100.18	5.34	94.84	95.24		TW Control d=0.4'
110.0		100.18	6.45	93.73	94.23	2.58%	Downstream channel slope d=0.5'

TAILWATER CROSS-SECTION at Station 67.0'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.0		100.18	4.99	95.19			LB edge of concrete wall
3.7		100.18	5.00	95.18			LB wetted edge
6.6		100.18	5.34	94.84			Thalweg d=0.4'
14.2		100.18	5.04	95.14			RB wetted edge
14.7		100.18	3.80	96.38			Top of concrete chunk
16.3		100.18	3.71	96.47			Other side of concrete chunk
16.7		100.18	4.41	95.77			RB gravel bar
21.0		100.18	3.46	96.72			RB on bank
22.8		100.18	2.65	97.53			RB on bank

CORTE MADERA CREEK - SURVEYED ELEVATIONS

FAIRFAX CREEK #3 - OLEMA ROAD **SITE ID# FX-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	2.50			100.00			Temporary Bench Mark-TBM
17.0		102.50	4.53	97.97	98.07	0.64%	Inlet Invert d=0.1'
61.0		102.50	4.81	97.69	97.79		Outlet Invert d=0.1'
63.0		102.50	6.36	96.14	97.04		Max depth w/in 5ft d=0.9'
98.2		102.50	6.82	95.68	96.98		Max. Pool Depth=1.3'
110.8		102.50	6.15	96.35	96.85		TW Control d=0.5'
146.0		102.50	6.34	96.16	96.66	0.54%	Downstream channel slope d=0.5'

TAILWATER CROSS-SECTION at Station 110.8'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
4.1		102.50	2.61	99.89			LB top of con. abutment to private xing
5.0		102.50	5.19	97.31			LB natural channel adjacent to abutment
6.0		102.50	5.66	96.84			LB wetted edge
8.8		102.50	5.84	96.66			Inchannel d=0.25'
11.0		102.50	5.24	97.26			Top of inchannel concrete chunk
11.5		102.50	6.15	96.35			Thalweg d=0.5'
15.3		102.50	5.61	96.89			RB wetted edge
20.0		102.50	4.31	98.19			RB edge of private xing abutment
21.1		102.50	2.52	99.98			RB top of concrete abutment

FAIRFAX CREEK #4 - OLEMA DAM **SITE ID# FX-04**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	1.44				100.00		Temporary Bench Mark-TBM
0.0		101.44	4.14	97.30	98.10		In pool of 1st u.s. resting habitat d=0.8'
16.8		101.44	5.01	96.43	98.13		W/in u.s. pool depth=1.7'
42.5		101.44	5.43	96.01	98.11		U.s. pool max depth = 2.1'
44.0		101.44	3.60	97.84	98.04		Thalweg on dam's notch d=0.2'
45.4		101.44	5.67	95.77	95.82		U.s. edge of concrete ledge d=0.05'
47.4		101.44	6.17	95.27	95.32		D.s. edge of concrete ledge d=0.05'
49.0		101.44	11.25	90.19	90.24		U.s. edge of bedrock shelf d=0.05
54.0		101.44	13.58	87.86	88.26		Pool scoured in bedrock shelf d=0.4'
60.0		101.44	15.10	86.34	86.64		D.s. edge of bedrock shelf d=0.3'
60.0	4.86	91.20					Turning point
62.8		91.20	8.23	82.97	84.47		Max depth w/in 5ft d=1.5'
69.5		91.20	8.64	82.56	84.56		Max pool depth d=2.0'
93.0		91.20	7.26	83.94	84.54		TW Control d=0.6'
123.0		91.20	7.79	83.41	83.81	1.77%	Downstream channel slope d=0.4'

TAILWATER CROSS-SECTION at Station 93.0'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
4.0		91.20	2.40	88.80			LB on bank
7.5		91.20	4.40	86.80			LB on bank
9.0		91.20	5.66	85.54			LB on bank
13.0		91.20	6.76	84.44			LB wetted edge
15.5		91.20	7.09	84.11			Inchannel d=0.4'
18.0		91.20	6.30	84.90			Top of concrete chunk
19.8		91.20	6.56	84.64			Top of concrete chunk
20.8		91.20	7.26	83.94			Thalweg d=0.6'
24.0		91.20	5.45	85.75			Top of concrete chunk
25.8		91.20	6.64	84.56			RB wetted edge
28.0		91.20	5.46	85.74			RB on bank
30.5		91.20	3.91	87.29			RB on bank
32.5		91.20					RB edge of 6.5' vertical retaining wall

FAIRFAX CREEK #5 - SIR FRANCIS DRAKE BLVD **SITE ID# FX-05**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	1.15			100.00			Temporary Bench Mark-TBM
0.0		101.15	1.75	99.40	99.65	1.12%	Inlet invert d=0.25'
174.6		101.15	3.70	97.45	97.55		Outlet invert d=0.1'
176.0		101.15	5.04	96.11	97.51		Max depth w/in 5ft d=1.4'
190.5		101.15	6.71	94.44	97.49		Max. Pool Depth = 3.05'
225.5		101.15	4.10	97.05	97.45		TW Control d=0.4'
258.0		101.15	5.14	96.01	96.31	3.20%	Downstream Channel Slope d=0.3'

TAILWATER CROSS-SECTION at Station 225.5'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
2.5		101.15	1.72	99.43			LB mid-slope
5.0		101.15	2.60	98.55			LB
5.8		101.15	3.72	97.43			LB wetted edge
8.5		101.15	3.82	97.33			Inchannel d=0.1'
11.5		101.15	3.24	97.91			Inchannel on rock
13.0		101.15	4.10	97.05			Thalweg d=0.4'
14.5		101.15	3.47	97.68			Inchannel on rock
15.0		101.15	3.88	97.27			Inchannel d=0.2'
16.8		101.15	3.32	97.83			Inchannel on rock
18.0		101.15	3.69	97.46			RB wetted edge
21.0		101.15	0.93	100.22			RB on rip rap

CORTE MADERA CREEK - SURVEYED ELEVATIONS

SAN ANSELMO CREEK #3 (1 of 3) - CENTER BLVD **SITE ID# SA-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.62						Temporary Bench Mark-TBM
16.0		100.62	20.97	79.65	80.85	-2.22%	TW Control of 1st resting habitat d=1.2'
44.5		100.62	20.68	79.94	80.84		Pool before Inlet d=0.9'
45.7		100.62	20.01	80.61	80.81	-0.13%	Inlet Invert d=0.2'
75.8		100.62	19.97	80.65	80.80		Outlet Invert d=0.15'
78.0		100.62	20.51	80.11	80.81		Max. Pool Depth=0.7'
82.4		100.62	20.14	80.48	80.78		TW Control d=0.3'
104.0		100.62	23.43	77.19	80.39		Downstream Pool d=3.2'
142.5		100.62	20.61	80.01	80.41	0.78%	Downstream Slope d=0.4'

TAILWATER CROSS-SECTION at Station 82.4'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
0.3		100.62	19.72	80.90			LB bottom of Concrete Wall
3.1		100.62	20.14	80.48			Thalweg d=0.3'
7.5		100.62	19.87	80.75			REW
12.3		100.62	19.16	81.46			Top of Gravel Bar
20.2		100.62	18.81	81.81			RB ACM
29.0		100.62	17.10	83.52			RB top of Bank
36.0		100.62	15.92	84.70			RB bottom of Vertical Wall

ɒ box culverts at inlet that join inside a 32' wide arch

SAN ANSELMO CREEK #3 (2 of 3) - CENTER BLVD **SITE ID# SA-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.62						Temporary Bench Mark-TBM
16.0		100.62	20.97	79.65	80.85	-1.68%	TW Control of 1st resting habitat d=1.2'
44.5		100.62	21.01	79.61	80.81		Pool before Inlet d=1.2'
45.7		100.62	20.01	80.61	80.81	-2.29%	Inlet Invert d=0.2'
75.8		100.62	19.32	81.30			Outlet Invert
79.0		100.62	19.21	81.41			TW Control
		100.62	18.81	81.81			Active Channel Margin
		100.62	18.88	81.74			Active Channel Margin

SAN ANSELMO CREEK #3 (3 of 3) - CENTER BLVD **SITE ID# SA-03**

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	0.62						Temporary Bench Mark-TBM
16.0		100.62	20.97	79.65	80.85	-7.39%	TW Control of 1st resting habitat d=1.2'
42.5		100.62	18.03	82.59			Debris at Inlet
45.7		100.62	19.47	81.15		-3.32%	Inlet Invert
75.8		100.62	18.47	82.15			Outlet Invert
78.5		100.62	18.03	82.59			TW Control
		100.62	18.81	81.81			Active Channel Margin
		100.62	18.88	81.74			Active Channel Margin

SAN ANSELMO CREEK #1 - Saunders Avenue ID# MR-078

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	2.62						Temporary Bench Mark-TBM
29.0		102.62	1.14	101.48	101.68	11.00%	Inlet Apron d=0.2'
37.0		102.62	2.02	100.60	100.80		Inlet Apron Bottom d=0.2'
49.2		102.62	4.33	98.29	100.64		Pool before Inlet d=2.35'
49.4		102.62	1.08	101.54			Top of Spillway Wall
49.4		102.62	2.32	100.30	100.60	12.26%	Inlet of Fish Ladder d=0.3'
54.2		102.62	2.96	99.66	100.56		First Partition Pool d=0.9'
54.3		102.62	2.24	100.38	100.58		First Weir d=0.2
57.2		102.62	3.51	99.11	100.01		Second Partition Pool d=0.9'
57.3		102.62	2.82	99.80	100.10		Second Weir d=0.3'
59.9		102.62	3.93	98.69	99.59		Third Partition Pool d=0.9'
60.1		102.62	3.31	99.31	99.61		Third Weir d=0.3'
62.9		102.62	4.48	98.14	99.14		Fourth Partition Pool d=1.0'
63.1		102.62	3.83	98.79	99.09		Fourth Weir d=0.3'
66.0		102.62	5.04	97.58	98.58		Fifth Partition Pool d=1.0'
66.2		102.62	4.38	98.24	98.54		Fifth Weir d=0.3'
67.0		102.62	5.22	97.40	97.50		After Last Weir d=0.1'
69.8		102.62	5.78	96.84	97.14	0.44%	Beginning of Runway d=0.3'
101.5		102.62	5.92	96.70	96.90	18.27%	Break in Runway d=0.2'
109.0		102.62	7.29	95.33	95.63		Outlet Invert d=0.3'
112.5		102.62	7.92	94.70	96.10		Max. Pool Depth=1.4'
139.0		102.62	6.67	95.95	96.05		TW Control d=0.1'
		102.62	5.64	96.98			Active Channel Margin
		102.62	5.29	97.33			Active Channel Margin
		102.62	5.79	96.83			Active Channel Margin

CORTE MADERA CREEK - SURVEYED ELEVATIONS

SAN ANSELMO CREEK #2 - Pastori Avenue ID# MR-079

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	3.44						Temporary Bench Mark-TBM
39.0		103.44	5.21	98.23		25.56%	TW Control of 1st resting habitat
46.0		103.44	3.92	99.52			Top of Spillway wall
41.7		103.44	5.90	97.54	97.84	20.40%	Inlet of Fish Ladder d=0.3'
44.0		103.44	5.66	97.78			First Weir
46.2		103.44	7.28	96.16	96.96		First Partition Pool d=0.8'
46.3		103.44	6.66	96.78	96.98		Second Weir d=0.2'
48.5		103.44	7.78	95.66	96.51		Second Partition Pool d=0.85'
48.8		103.44	7.09	96.35	96.55		Third Weir d=0.2'
50.9		103.44	8.26	95.18	96.08		Third Partition Pool d=0.9'
51.5		103.44	7.58	95.86	96.06		Fourth Weir d=0.2'
53.4		103.44	8.74	94.70	95.40		Fourth Partition Pool d=0.7'
54.0		103.44	8.24	95.20	95.40		Fifth Weir d=0.2'
55.7		103.44	9.17	94.27	95.07		Fifth Partition Pool d=0.8'
56.3		103.44	8.49	94.95	95.15		Sixth Weir d=0.2'
58.0		103.44	9.65	93.79	94.69		Sixth Partition Pool d=0.9'
58.6		103.44	8.92	94.52	94.72		Seventh Weir d=0.2'
60.5		103.44	10.09	93.35	94.25		Seventh Partition Pool d=0.9'
61.2		103.44	9.34	94.10	94.30		Eigth Weir d=0.2'
62.9		103.44	10.48	92.96	93.81		Eigth Partition Pool d=0.85'
63.5		103.44	9.80	93.64	93.84		Ninth Weir d=0.2'
65.4		103.44	10.93	92.51	93.36		Ninth Partition Pool d=0.85'
65.8		103.44	10.20	93.24	93.44		Tenth Weir d=0.2'
67.0		103.44	11.06	92.38	92.43		Outlet Invert d=0.05
71.2		103.44	14.92	88.52	91.72		Max. Pool Depth=3.2'
110.5		103.44	12.02	91.42	91.62		TW Control d=0.2'
		103.44	10.64	92.80			Active Channel Margin
		103.44	10.58	92.86			Active Channel Margin

FAIRFAX CREEK - Bolinas Avenue ID# MR-080

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	5.32						Temporary Bench Mark-TBM
12.0		105.32	1.03	104.29		0.94%	Inlet Invert
470.0		105.32	5.32	100.00	100.05		Outlet Invert d=0.05'
	4.19		5.32				Turning Point - On TBM
475.0		104.19	10.89	93.30	96.10		Max. Pool Depth=2.8'
490.0		104.19	8.19	96.00	96.10		TW Control d=0.1'
		104.19	6.91	97.28			Active Channel Margin
		104.19	6.75	97.44			Active Channel Margin

SLEEPY HOLLOW CREEK #1 - Deer Hollow Road ID# MR-081

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	4.23						Temporary Bench Mark-TBM
48.0		104.23	5.03	99.20		-0.81%	TW Control of 1st resting habitat
71.7		104.23	5.93	98.30			Pool before inlet
72.7		104.23	4.83	99.40		0.84%	Inlet Invert
100.0		104.23	5.06	99.17			Outlet Invert
110.5		104.23	6.00	98.23			Middle Apron/Bedrock
115.0		104.23	10.28	93.95		34.80%	Bottom Apron/Bedrock
119.0		104.23	14.23	90.00	92.65		Max. Pool Depth=2.65'
140.5		104.23	10.95	93.28			TW Control
171.0		104.23	13.02	91.21		6.79%	Downstream Slope
		104.23	10.16	94.07			Active Channel Margin
		104.23	10.07	94.16			Active Channel Margin
		104.23	9.68	94.55			Active Channel Margin

SLEEPY HOLLOW CREEK #2 - Fawn Drive ID# MR-082

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	4.09						Temporary Bench Mark-TBM
22.0		104.09	2.39	101.70		4.35%	TW Control of 1st resting habitat
38.1		104.09	4.93	99.16	101.01		Pool before inlet d=1.85'
38.8		104.09	1.99	102.10			Inlet Invert- LB high point on concrete
38.8		104.09	1.96	102.13			Inlet Invert- RB high point on concrete
38.8		104.09	3.12	100.97		4.21%	Inlet Invert- Thalweg
87.7		104.09	5.18	98.91			Outlet Invert- Thalweg
91.0		104.09	5.94	98.15	98.75		Max depth within 5' of outlet=0.6'
95.5		104.09	6.25	97.84	98.74		Max. Pool Depth=0.9'
128.0		104.09	4.57	99.52			TW Control
160.0		104.09	5.35	98.74		2.44%	Downstream Slope

TAILWATER CROSS-SECTION at Station 128.0'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
8.0		104.09	2.36	101.73			LB on bank
16.5		104.09	3.86	100.23			LB ACM
22.8		104.09	4.57	99.52			TWC
25.7		104.09	4.37	99.72			In Channel- Gravel Bar
32.2		104.09	4.69	99.40			Bottom of Wall

SLEEPY HOLLOW CREEK #3 - Butterfield Road ID# MR-083

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
	3.51						Temporary Bench Mark-TBM
7.0		103.51	3.60	99.91		0.47%	TW Control of 1st resting habitat
33.0		103.51	4.65	98.86	99.46		Pool before inlet d=0.6'
45.7		103.51	3.51	100.00			Inlet Invert- Sides/high points
45.7		103.51	3.78	99.73		0.81%	Inlet Invert- Thalweg
121.0		103.51	4.39	99.12			Outlet Invert
127.5		103.51	5.00	98.51			Max. Pool Depth=0
132.6		103.51	4.82	98.69			TW Control
187.7		103.51	4.57	98.94		-0.45%	Downstream Slope

TAILWATER CROSS-SECTION at Station 132.6'

Station (ft)	BS (+)	HI	FS (-)	Elevation (ft)	WS	Slope	Station Description, Comments
5.0		103.51	1.32	102.19			LB on rock wall
7.0		103.51	3.01	100.50			LB ACM
8.0		103.51	4.59	98.92			LB bottom of wall
12.3		103.51	4.82	98.69			Thalweg
27.6		103.51	3.07	100.44			RB ACM
28.3		103.51	0.13	103.38			RB Midwall

APPENDIX B:

HYDROLOGY AND PASSAGE EVALUATIONS

CORTE MADERA CREEK STREAM CROSSING LOCATIONS: WATERSHED HYDROLOGY

ID#	Stream Name	Road Name	Drainage Area (mi.^{2})	Length of Anadromy (ft)	Mean Annual Precipitation (in/yr)	H Altitude Index (Thousand ft)	Potential Evapotranspiration rate (in/yr)
R-01	Ross Creek #1	Park Drive	2.81	5,200	40	1	42
R-02	Ross Creek #2	Norwood Avenue	2.78	3,800	40	1	42
R-03	Ross Creek #3	Not a road	2.69	950	40	1	42
R-04	Ross Creek #4	Unnamed walking path in city park	2.67	800	40	1	42
SA-01	San Anselmo Creek #1	Creek Park weir - Adjacent to SFD Blvd.	13.10	63,600	40	1	42
SA-02 aka MR-078	San Anselmo Creek #2	Saunders Avenue	9.48	33,200	40	1	42
SA-03	San Anselmo Creel #3 1 of 3	Center Blvd/Lansdale Avenue	9.34	31,200	40	1	42
SA-03	San Anselmo Creel #3 2 of 3	Center Blvd/Lansdale Avenue	9.34	31,200	40	1	42
SA-03	San Anselmo Creel #3 3 of 3	Center Blvd/Lansdale Avenue	9.34	31,200	40	1	42
SA-04 aka MR-079	San Anselmo Creek #4	Pastori Avenue	8.70	28,900	40	1	42
SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	4.41	14,000	40	1	42
SA-06	San Anselmo Creek #6 aka Canyon Creek	Canyon Road	3.38	8,300	40	1	42
SH-01	Sleepy Hollow Creek #1	Taylor Street	3.60	26,000	36	1	42
SH-02	Sleepy Hollow Creek #2	Saunders Avenue	3.57	25,600	36	1	42
SH-03	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	3.47	24,800	36	1	42
SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	3.44	24,000	36	1	42
SH-05	Sleepy Hollow Creek #5	Morningside Avenue	3.40	23,700	36	1	42
SH-06	Sleepy Hollow Creek #6	Broadmore Avenue	3.33	23,000	36	1	42
SH-07	Sleepy Hollow Creek #7	Arroyo Avenue	3.07	21,000	36	1	42

CORTE MADERA CREEK STREAM CROSSING LOCATIONS: WATERSHED HYDROLOGY

ID#	Stream Name	Road Name	Drainage Area ($mi.^2$)	Length of Anadromy (ft)	Mean Annual Precipitation (in/yr)	H Altitude Index (Thousand ft)	Potential Evapotranspiration rate (in/yr)
SH-08 aka MR 081	Sleepy Hollow Creek #8	Deer Hollow Road	2.44	17,000	36	1	42
SH-09 aka MR 082	Sleepy Hollow Creek #9	Fawn Drive	2.34	16,100	36	1	42
SH-10 aka MR 083	Sleepy Hollow Creek #10	Butterfield Road	1.99	13,000	36	1	42
SH-11	Sleepy Hollow Creek #11	Not a crossing - Raven dam	1.97	12,000	36	1	42
FX-01 aka MR-080	Fairfax Creek #1	Fairfax-Bolinas Road	3.56	10,800	38	1	42
FX-02	Fairfax Creek #2	Scenic Road	3.13	8,800	38	1	42
FX-03	Fairfax Creek #3	Olema Road	2.75	8,000	38	1	42
FX-04	Fairfax Creek #4	Not a road - dam	2.22	5,500	38	1	42
FX-05	Fairfax Creek #5	Sir Francis Drake Blvd.	2.04	3,500	38	1	42

CORTE MADERA CREEK - HYDRAULIC CAPACITY ESTIMATES

Site ID#	Stream Name	Road Name	Crossing Type	Culvert Size (ft) (D, H x W, or R x S)	Crossing Length (ft)	Inlet Type	Culvert Flow Capacity (cfs) @ HW/D=1	Drainage Area (mi^2)	Mean Annual Precipitation (in/yr)	Elevation @ 10% (ft)	Elevation @ 85% (ft)	Altitude Index (10^{-3} ft)	Q_5 (cfs)
FX-01 aka MR-080	Fairfax Creek #1	Fairfax-Bolinas Road	Concrete Box	6.35 X 9.9	458.0	Wingwall	465.0	3.56	38	340	1,180	1.0	427.4
FX-02	Fairfax Creek #2	Scenic Road	Concrete Box	11.1 x 14.0	40.0	Headwall	1,302.0	3.13	38	150	880	1.0	381.1
FX-03	Fairfax Creek #3	Olema Road	Concrete Box	10.3 x 14.0	44.0	Wingwall	1,302.0	2.75	38	150	880	1.0	339.7
FX-04	Fairfax Creek #4	Not a road - Olema Dam	Dam	N/A	16.0	N/A	N/A	2.22	38	150	880	1.0	280.7
FX-05	Fairfax Creek #5	Sir Francis Drake Blvd.	SSP circular pipe	8.0	174.6	Wingwall	372.0	2.04	38	150	880	1.0	260.4
R-01	Ross Creek #1	Park Drive	Concrete arch w/inlet apron	14.0 x 16.2	39.0	Wingwall	>1,500	2.81	40	120	1,050	1.0	362.8
R-02	Ross Creek #2	Norwood Avenue	Concrete arch w/flat floor	14.0 x 20.0	19.5	Headwall	>1,600	2.78	40	200	1,380	1.0	359.3
R-03	Ross Creek #3	Not a road	Utility pipe xing channel	N/A	3.0	N/A	N/A	2.69	40	150	880	1.0	349.0
R-04	Ross Creek #4	Unnamed walking path in city park	Bridge w/concrete apron	3.6 x 24.4	72.5	Headwall	488.0	2.67	40	150	880	1.0	346.7
SA-01	San Anselmo Creek #1	Creek Park weir - Adjacent to SFD Blvd.	Concrete weir with apron	N/A	29.5	N/A	N/A	13.10	40	150	880	1.0	1427.8
SA-02 aka MR-078	San Anselmo Creek #2	Saunders Avenue	Bridge w/fish ladder	15.0 X 37.0	59.6	Wingwall	6,400.0	9.48	40	340	1,180	1.0	1070.7
SA-03	San Anselmo Creek #3	Center Blvd/Lansdale Avenue	Two-bay box into concrete arch	10.2 x 30.0	282.2	Headwall	2,430.0	9.34	40	150	880	1.0	1056.6
SA-04 aka MR-079	San Anselmo Creek #4	Pastori Avenue	Concrete Box w/fish ladder	12.0 X 37.0	25.3	Wingwall	4,550.0	8.70	40	150	900	1.0	991.9
SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	Concrete Box	14.0 x 17.9	47.0	Headwall	2,060.0	4.41	40	150	880	1.0	541.8
SA-06	San Anselmo Creek #6 aka	Canyon Road	Bridge w/fish ladder	11.4 x 28.0	53.6	Wingwall	2,996.0	3.38	40	150	880	1.0	427.6
SH-01	Sleepy Hollow Creek #1	Taylor Street	Concrete arch culvert w/flat floor	10.4 x 12.2	30.7	Wingwall	*800.0*	3.60	36	150	880	1.0	410.9
SH-02	Sleepy Hollow Creek #2	Saunders Avenue	Concrete arch culvert w/flat floor	12.0 x 10.0	42.7	Headwall	*800.0*	3.57	36	150	880	1.0	407.9
SH-03	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	Concrete arch w/concave floor	9.9 x 9.5	60.3	Headwall	*800.0*	3.47	36	150	880	1.0	397.7

CORTE MADERA CREEK - HYDRAULIC CAPACITY ESTIMATES

Site ID#	Stream Name	Q_{10} (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Crossing sized for Recurrence Interval (cfs)	Comments
FX-01 aka MR-080	Fairfax Creek #1	559.2	704.5	849.8	949.2	5 - 10	
FX-02	Fairfax Creek #2	499.3	629.8	759.8	848.6	>=50	>100-yr recurrence interval
FX-03	Fairfax Creek #3	445.6	562.7	678.9	758.2	>=50	>100-yr recurrence interval
FX-04	Fairfax Creek #4	369.0	467.1	563.5	629.4	>=50	Not sized because site is a dam.
FX-05	Fairfax Creek #5	342.6	434.0	523.5	584.7	10 - 25	
R-01	Ross Creek #1	476.3	601.7	726.7	812.0	>=50	>100-yr recurrence interval
R-02	Ross Creek #2	471.8	596.1	719.9	804.5	>=50	>100-yr recurrence interval
R-03	Ross Creek #3	458.3	579.3	699.6	781.8	>=50	Not sized because site is a 18" diameter utility pipe crossing the stream channel.
R-04	Ross Creek #4	455.3	575.6	695.1	776.7	10 - 25	
SA-01	San Anselmo Creek #1	1,845.9	2,296.4	2,773.2	3,099.0	>=50	Not sized because site is a concrete weir across the stream channel.
SA-02 aka MR-078	San Anselmo Creek #2	1,388.7	1,733.2	2,093.1	2,339.0	>=50	>100-yr recurrence interval
SA-03	San Anselmo Creek #3	1,370.6	1,710.9	2,066.1	2,308.9	>=50	Sized slightly >50-yr.
SA-04 aka MR-079	San Anselmo Creek #4	1,287.6	1,608.5	1,942.4	2,170.6	>=50	>100-yr recurrence interval
SA-05	San Anselmo Creek #5	708.1	890.6	1,075.5	1,201.9	>=50	>100-yr recurrence interval
SA-06	San Anselmo Creek #6 aka	560.3	706.6	853.3	953.6	>=50	>100-yr recurrence interval
SH-01	Sleepy Hollow Creek #1	537.0	676.1	814.7	909.5	25 - 50	From nomograph: 800 cfs is capacity of a 8.3' x 12.8'
SH-02	Sleepy Hollow Creek #2	533.1	671.2	808.8	902.9	25 - 50	From nomograph: 800 cfs is capacity of a 8.3' x 12.8'
SH-03	Sleepy Hollow Creek #3	519.9	654.8	789.1	880.8	>=50	From nomograph: 800 cfs is capacity of a 8.3' x 12.8'

CORTE MADERA CREEK - HYDRAULIC CAPACITY ESTIMATES

Site ID#	Stream Name	Road Name	Crossing Type	Culvert Size (ft) (D, H x W, or R x S)	Crossing Length (ft)	Inlet Type	Culvert Flow Capacity (cfs) @ HW/D=1	Drainage Area (mi^2)	Mean Annual Precipitation (in/yr)	Elevation @ 10% (ft)	Elevation @ 85% (ft)	Altitude Index (10^{-3} ft)	Q_5 (cfs)
SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	Concrete arch culvert w/flat floor	7.0 x 15.2	32.3	Headwall	*800.0*	3.44	36	150	880	1.0	394.6
SH-05	Sleepy Hollow Creek #5	Morningside Avenue	Concrete Box	7.7 x 14.0	70.0	Wingwall	840.0	3.40	36	150	880	1.0	390.6
SH-06	Sleepy Hollow Creek #6	Broadmore Avenue	Concrete Box	7.5 x 14.0	50.0	Wingwall	840.0	3.33	36	150	880	1.0	383.4
SH-07	Sleepy Hollow Creek #7	Arroyo Avenue	Open-bottom arch	9.4 x 13.8	39.8	Wingwall	*900.0*	3.07	36	150	880	1.0	356.6
SH-08 aka MR-081	Sleepy Hollow Creek #8	Deer Hollow Road	Concrete Box	11.8 X 13.0	27.3	Wingwall	1,560.0	2.44	36	150	300	1.0	290.7
SH-09 aka MR-082	Sleepy Hollow Creek #9	Fawn Drive	Concrete Box	8.5 X 13.0	48.9	Wingwall	897.0	2.34	36	150	180	1.0	280.1
SH-10 aka MR-083	Sleepy Hollow Creek #10	Butterfield Road	Concrete Box	6.15 X 11.8	75.3	Wingwall	519.0	1.99	36	150	1,050	1.0	242.5
SH-11	Sleepy Hollow Creek #11	Not a crossing - Raven Dam	Dam	N/A	14.7	N/A	N/A	1.97	36	150	880	1.0	240.3

CORTE MADERA CREEK - HYDRAULIC CAPACITY ESTIMATES

Site ID#	Stream Name	Q_{10} (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Crossing sized for Recurrence Interval (cfs)	Comments
SH-04	Sleepy Hollow Creek #4	516.0	649.9	783.1	874.2	>=50	From nomograph: 800 cfs is capacity of a 8.3' x 12.8'
SH-05	Sleepy Hollow Creek #5	510.7	643.3	775.2	865.4	>=50	Close to 100-yr.
SH-06	Sleepy Hollow Creek #6	501.4	631.7	761.3	849.8	>=50	Close to 100-yr.
SH-07	Sleepy Hollow Creek #7	466.8	588.6	709.3	791.8	>=50	Used flow between larger and small sized arches on nomograph.
SH-08 aka MR-081	Sleepy Hollow Creek #8	381.4	482.0	580.8	648.4	>=50	>100-yr recurrence interval
SH-09 aka MR-082	Sleepy Hollow Creek #9	367.6	464.8	560.1	625.2	>=50	>100-yr recurrence interval
SH-10 aka MR-083	Sleepy Hollow Creek #10	318.7	403.7	486.4	543.0	>=50	Close to 100-yr.
SH-11	Sleepy Hollow Creek #11	315.9	400.1	482.2	538.3	>=50	Not sized because site is a dam.

Corte Madera Creek - Summary of Fish Passage Analysis for Existing Passage Conditions

Stream Xing Location Information			Fish Passage Criteria Flows (cfs)				Fish Passage Criteria Flows (cfs)				Fish Passage Criteria Flows (cfs)			
ID#	Stream Name	Road Name	Lower Q50% or 3 cfs	Upper Q1%	%Passable	Range of Passable Flows (c.f.s.)	Lower Q90% or 2 cfs	Upper Q5%	%Passable	Range of Passable Flows	Lower Q95% or 1 cfs	Upper Q10%	%Passable	Range of Passable Flows
R-01	Ross Creek #1	Park Drive	3.0	78.3	**10%**	71.0 - 78.0	2.0	20.3	**0%**	N/A	1.0	8.8	**0%**	N/A
R-02	Ross Creek #2	Glenwood Avenue	3.0	77.4	**100%**	3.0 - 77.4	2.0	20.0	**100%**	2.0 - 20.0	1.0	8.7	**100%**	1.0 - 8.7 c.f.s
R-03	Ross Creek #3	Drop over a utility pipe	3.0	74.9	**100%**	3.0 - 74.9	2.0	19.4	**50%**	N/A	1.0	8.4	**0%**	N/A
R-04	Ross Creek #4	Unnamed walking path in city park	3.0	74.4	**0%**	N/A	2.0	19.3	**0%**	N/A	1.0	8.4	**0%**	N/A
SA-01	San Anselmo Creek #1	Creek Park weir - Adjacent to SFD Blvd.	3.0	364.8	**100%**	3.0 - 364.8	2.0	94.5	**100%**	2.0 - 94.5 c.f.s.	1.0	41.1	**80%**	8.0 - 41.1 c.f.s.
SA-02 aka MR-078	San Anselmo Creek #2	Saunders Avenue	3.0	264.0	**0%**	N/A	2.0	68.4	**0%**	N/A	1.0	29.8	**0%**	N/A
SA-03	San Anselmo Creel #3 1 of 3	Center Blvd/Lansdale Avenue	3.0	260.1	**0%**	N/A	2.0	67.3	**0%**	N/A	1.0	29.3	**0%**	N/A
SA-03	San Anselmo Creel #3 2 of 3	Center Blvd/Lansdale Avenue	3.0	260.1	**0%**	N/A	2.0	67.3	**0%**	N/A	1.0	29.3	**0%**	N/A
SA-03	San Anselmo Creel #3 3 of 3	Center Blvd/Lansdale Avenue	3.0	260.1	**0%**	N/A	2.0	67.3	**0%**	N/A	1.0	29.3	**0%**	N/A
SA-04 aka MR-079	San Anselmo Creek #4	Pastori Avenue	3.0	242.3	**6%**	N/A	2.0	62.7	**0%**	N/A	1.0	27.3	**0%**	N/A
SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	3.0	122.8	**57%**	55.0 - 122.8	2.0	31.8	**0%**	N/A	1.0	13.8	**0%**	N/A
SA-06	San Anselmo Creek #6 aka Canyon Creek	Canyon Road	3.0	94.1	**50%**	N/A	2.0	24.4	**0%**	N/A	1.0	10.6	**0%**	N/A
SH-01	Sleepy Hollow Creek #1	Taylor Street	3.0	100.3	**37%**	64.0 - 100.0 c.f.s.	2.0	26.0	**0%**	N/A	1.0	11.3	**0%**	N/A
SH-02	Sleepy Hollow Creek #2	Saunders Avenue	3.0	99.4	**66%**	35.8 - 99.4 c.f.s.	2.0	25.7	**0%**	N/A	1.0	11.2	**0%**	N/A
SH-03	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	3.0	96.6	**86%**	9.7 - 94.3 c.f.s.	2.0	25.0	**82%**	3.1 - 22.1 c.f.s.	1.0	10.9	**67%**	3.1 - 9.8 c.f.s.
SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	3.0	95.8	**47%**	52.3 - 95.8 c.f.s.	2.0	24.8	**0%**	N/A	1.0	10.8	**0%**	N/A
SH-05	Sleepy Hollow Creek #5	Morningside Avenue	3.0	94.7	**75%**	25.6 - 94. 7 c.f.s.	2.0	24.5	**55%**	12.1 - 24.5	1.0	10.7	**0%**	N/A
SH-06	Sleepy Hollow Creek #6	Broadmore Avenue	3.0	92.7	**68%**	31.9 - 92.7	2.0	24.0	**0%**	N/A	1.0	10.5	**0%**	N/A
SH-07	Sleepy Hollow Creek #7	Arroyo Avenue	3.0	85.5	**100%**	All flows	2.0	22.1	**100%**	All flows	1.0	9.6	**100%**	All flows
SH-08 aka MR-081	Sleepy Hollow Creek #8	Deer Hollow Road	3.0	68.0	**0%**	N/A	2.0	17.6	**0%**	N/A	1.0	7.7	**0%**	N/A
SH-09 aka MR-082	Sleepy Hollow Creek #9	Fawn Drive	3.0	65.2	**0%**	N/A	2.0	16.9	**0%**	N/A	1.0	7.3	**0%**	N/A
SH-10 aka MR-083	Sleepy Hollow Creek #10	Butterfield Road	3.0	55.4	**37%**	36.0 - 55.4	2.0	14.3	**0%**	N/A	1.0	6.2	**0%**	N/A
SH-11	Sleepy Hollow Creek #11	Not a crossing - Raven dam	3.0	54.9	**0%**	N/A	2.0	14.2	**0%**	N/A	1.0	6.2	**0%**	N/A
FX-01 aka MR-080	Fairfax Creek #1	Fairfax-Bolinas Road	3.0	99.1	**0%**	N/A	2.0	25.7	**0%**	N/A	1.0	11.2	**0%**	N/A
FX-02	Fairfax Creek #2	Scenic Road	3.0	87.2	**90%**	11.8 - 87.2	2.0	22.6	**94%**	3.2 - 22.6	1.0	9.8	**74%**	3.2 - 9.7
FX-03	Fairfax Creek #3	Olema Road	3.0	76.6	**59%**	33.5 - 76.6	2.0	19.8	**10%**	17.9 - 19.8	1.0	8.6	**0%**	N/A
FX-04	Fairfax Creek #4	Not a road - Olema dam	3.0	61.8	**0%**	N/A	2.0	16.0	**0%**	N/A	1.0	7.0	**0%**	N/A
FX-05	Fairfax Creek #5	Sir Francis Drake Blvd.	3.0	56.8	**78%**	5.4 - 47.3	2.0	14.7	**34%**	2.0 - 5.7	1.0	6.4	**0%**	N/A

APPENDIX B: CORTE MADERA CREEK - FISH PASSAGE ASSESSMENT: FISHXING RESULTS

CORTE MADERA CREEK - FISHXING PROGRAM SUMMARY TABLE

FishXing File Name	Site ID#	Stream Name	Road Name	Xing Length (ft)	QLp - low passage	QHp - high passage	Percent Passable	Barriers at QLp	Barriers at QHp
FX-02 Adults.xng	FX-02	Fairfax Creek	Scenic Road	40.0	3 cfs	87.2 cfs	89.50%	Depth	NONE
FX-02 Residents.xng	FX-02	Fairfax Creek	Scenic Road	40.0	2 cfs	22.6 cfs	94.10%	Depth	NONE
FX-02 Juveniles.xng	FX-02	Fairfax Creek	Scenic Road	40.0	1 cfs	9.8 cfs	73.90%	Depth	Leap; Depth; EB
FX-03 Adults.xng	FX-03	Fairfax Creek	Olema Road	44.0	3 cfs	76.6 cfs	58.6%	Depth	EB
FX-03 Residents.xng	FX-03	Fairfax Creek	Olema Road	44.0	2 cfs	19.8 cfs	10.1%	Leap; Depth	V
FX-03 Juveniles.xng	FX-03	Fairfax Creek	Olema Road	44.0	1 cfs	8.6 cfs	0.0%	Leap; Depth	V
FX-05 Adults.xng	FX-05	Fairfax Creek	Sir Francis Drake Blvd.	174.6	3 cfs	56.8 cfs	77.9%	Depth	NONE
FX-05 Residents.xng	FX-05	Fairfax Creek	Sir Francis Drake Blvd.	174.6	2 cfs	14.7 cfs	33.6%	NONE	NONE
FX-05 Juveniles.xng	FX-05	Fairfax Creek	Sir Francis Drake Blvd.	174.6	1 cfs	6.4 cfs	0.0%	Leap; Depth; EB	NONE
R-01 Adults.xng	R-01	Ross Creek	Park Drive	39.0	3 cfs	78.3 cfs	9.5%	Depth	NONE
R-02 Adults.xng	R-02	Ross Creek	Norwood Avenue	19.5	3 cfs	77.4 cfs	100.0%	NONE	NONE
R-02 Residents.xng	R-02	Ross Creek	Norwood Avenue	19.5	2 cfs	20 cfs	100.0%	NONE	NONE
R-02 Juveniles.xng	R-02	Ross Creek	Norwood Avenue	19.5	1 cfs	8.7 cfs	100.0%	NONE	NONE
R-03 Adults.xng	R-03	Ross Creek	Drop over Utility Pipe	N/A	3 cfs	74.9 cfs	28.5%	Depth; Pool	Depth; V
SA-01.xng	SA-01	San Anselmo Creek	Weir w/apron in Creek Park	29.5	3 cfs	364.8 cfs	86.6%	Depth	V
SA-05 Adults.xng	SA-05	San Anselmo Creek	Fairfax-Bolinas Road	47.0	3 cfs	122.8 cfs	56.6%	Depth	NONE
SA-05 Residents.xng	SA-05	San Anselmo Creek	Fairfax-Bolinas Road	47.0	2 cfs	31.8 cfs	0.00%	Depth	Depth; V
SA-05 Juveniles.xng	SA-05	San Anselmo Creek	Fairfax-Bolinas Road	47.0	1 cfs	13.8 cfs	0.0%	Leap; Depth	NONE
SH-01 Adults.xng	SH-01	Sleepy Hollow Creek	Taylor Street	30.7	3 cfs	100 cfs	37.10%	Depth	V
SH-02 Adult.xng	SH-02	Sleepy Hollow Creek	Saunders Avenue	42.7	3 cfs	99.4 cfs	65.90%	Depth	EB
SH-02 resident.xng	SH-02	Sleepy Hollow Creek	Saunders Avenue	42.7	3 cfs	25.7 cfs	0.00%	Depth	V
SH-02 juveniles.xng	SH-02	Sleepy Hollow Creek	Saunders Avenue	42.7	3 cfs	11.2 cfs	0.00%	Depth; EB	EB
SH-03 Adult.xng	SH-03	Corte Madera Creek	Sir Francis Drake Blvd.	60.3	3 cfs	96.6 cfs	86.10%	Depth	NONE
SH-03 Resident.xng	SH-03	Corte Madera Creek	Sir Francis Drake Blvd.	60.3	2 cfs	25 cfs	86.20%	Depth	V
SH-03 Juveniles.xng	SH-03	Corte Madera Creek	Sir Francis Drake Blvd.	60.3	1 cfs	10.9 cfs	67.30%	Depth	Depth; V
SH-04 Adults.xng	SH-04	Sleepy Hollow Creek	Mountain View Avenue	32.3	3 cfs	95.8 cfs	46.80%	Depth	NONE
SH-04 Residents.xng	SH-04	Sleepy Hollow Creek	Mountain View Avenue	32.3	2 cfs	24.8 cfs	0.00%	Depth	NONE
SH-04 Juveniles.xng	SH-04	Sleepy Hollow Creek	Mountain View Avenue	32.3	1 cfs	10.8 cfs	0.00%	Depth; EB	Depth; EB
SH-05 Adults.xng	SH-05	Sleepy Hollow Creek	Morningside Avenue	70.0	3 cfs	94.7 cfs	75.40%	Depth	NONE
SH-05 Residents.xng	SH-05	Sleepy Hollow Creek	Morningside Avenue	70.0	2 cfs	24.5 cfs	55.30%	Depth	Leap; EB
SH-05 Juveniles.xng	SH-05	Sleepy Hollow Creek	Morningside Avenue	70.0	1 cfs	10.5 cfs	0.00%	Depth	Leap; Depth; EB
SH-06 Adults.xng	SH-06	Sleepy Hollow Creek	Broadmoor Avenue	50.0	3 cfs	92.7 cfs	67.80%	Depth	Leap; Pool
SH-06 Residents.xng	SH-06	Sleepy Hollow Creek	Broadmoor Avenue	50.0	2 cfs	24 cfs	0.00%	Leap; Depth	
SH-06 Juveniles.xng	SH-06	Sleepy Hollow Creek	Broadmoor Avenue	50.0	1 cfs	10.5 cfs	0.00%	Leap; Depth	
SH-11 Adults.xng	SH-11	Sleepy Hollow Creek	Raven Dam	N/A	3 cfs	200 cfs	0.00%	Leap; Depth; Pool	

APPENDIX C:

STREAM CROSSING RANKING MATRICES

CORTE MADERA CREEK - RANKING MATRIX - DFG SCORING

	RANKING MATRIX for CORTE MADERA CREEK STREAM CROSSINGS USING REVISED ADULT PASSAGE CRITERIA - Prolonged speed = 8ft/sec, Burst speed/Exit Velocity = 16ft/sec. Min. depth = 0.5ft.														
INITIAL RANK	**Site ID#**	**Stream Name**	**Road Name**	**Presumed Species Diversity**	**Species Diversity Score**	**Extent of Barrier Score**	**Current Sizing Score**	**Current Condition Score**	**Crossing Score**	**Length of Potential Upstream Habitat**	**Habitat Quantity Score**	**Habitat Quality Modifier**	**Total Habitat Score**	**TOTAL SCORE**	**Comments**
#1	SA-02 aka MR-078	San Anselmo Creek #2	Saunders Avenue	Steelhead	2	15	0	0	0.0	33,200	10.0	0.5	5.00	22.0	Ineffective fish ladder - replace or retrofit. Literature review confirmed it fails to meet Denil fish ladder specs.
#2	FX-01 aka MR-080	Fairfax Creek #1	Fairfax-Bolinas Road	Steelhead	2	15	4	0	2.0	10,800	9.6	0.25	2.40	21.4	Outlet is perched 4 ft. Culvert is 450' long. Top restoration priority to allow steelhead the option to recolonize Fairfax Creek.
#3	R-01	Ross Creek #1	Park Drive	Steelhead	2	14	0	5	2.5	5,200	5.2	0.5	2.60	21.1	High priority for treatment due to both severity of barrier and poor structural condition of the crossing. Replace with open-bottom arch or bridge.
#4	SA-04 aka MR-079	San Anselmo Creek #4	Pastori Avenue	Steelhead	2	14	0	0	0.0	28,900	10.0	0.5	5.00	21.0	Adult passage is probably low. Site has an ineffective fish ladder. Literature review confirmed structure fails to meet Denil fish ladder specs.
#5	SA-06	San Anselmo Creek #6 aka Canyon Ck	Canyon Road	Steelhead	2	12	0	1	0.5	8,300	8.3	0.75	6.23	20.7	Site should be evaluated for fish passage due migration-level flows. Should also be inspected for maintainence during winter flows to clear debris.
#6	FX-04	Fairfax Creek #4	Not a road - Olema Dam	Steelhead	2	15	0	1	0.5	5,500	5.5	0.5	2.75	20.3	Complete barrier due to large drop over dam; however FX-01 should be treated 1st. Effective grade control will be a major issue at this location.
Tied #7	SH-11	Sleepy Hollow Creek #11	Not a crossing - Raven Dam	Steelhead	2	15	0	1	0.5	12,000	10.0	0.25	2.50	20.0	Complete barrier due to large drop over dam. SH-01 and SH-08 should be treated prior to SH-11. Grade control must be considered at this location.
Tied #7	SH-08 aka MR-081	Sleepy Hollow Creek #8	Deer Hollow Road	Steelhead	2	15	0	1	0.5	17,000	10.0	0.25	2.50	20.0	Outlet is perched 5.8 ft and spills over bedrock/concrete drop. SH-01 should be treated 1st.
Tied #7	SA-03	San Anselmo Creel #3	Center Blvd/Lansdale Avenue	Steelhead	2	15	1	0	0.5	31,200	10.0	0.25	2.50	20.0	Perched outlet and lack-of-depth over a long reach are passage problems.
Tied #8	SH-09 aka MR-082	Sleepy Hollow Creek #9	Fawn Drive	Steelhead	2	15	0	0	0.0	16,100	10.0	0.25	2.50	19.5	Lack-of-depth violation up to 30cfs, then excess velocity. Looks partially passable for adults.
Tied #8	SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	Steelhead	2	12	0	1	0.5	14,000	10.0	0.5	5.00	19.5	Primarily a lack-of-depth criteria violation.
#9	R-04	Ross Creek #4	Unnamed walking path in city park	Steelhead	2	15	3	0	1.5	800	0.8	0.5	0.40	18.9	Perched outlet and extensive inlet apron are problematic. Limited reach of habitat up to Pheonix Dam, yet is potentially vital juvenile refugia in summer months.
#10	SH-01	Sleepy Hollow Creek #1	Taylor Street	Steelhead	2	13	1	1	1.0	26,000	10.0	0.25	2.50	18.5	Located near mouth of Sleepy Hollow Ck, treatment would allow good access up to Deer Hollow Rd. Retrofit w/weirs to raise tailwater elevation may be feasible.
#11	SH-10 aka MR-083	Sleepy Hollow Creek #10	Butterfield Road	Steelhead	2	13	0	1	0.5	13,000	10.0	0.25	2.50	18.0	Lack-of-depth is the primary criteria violation and actual passage is probably fairly high.

CORTE MADERA CREEK - RANKING MATRIX - DFG SCORING

INITIAL RANK	Site ID#	Stream Name	Road Name	Presumed Species Diversity	Species Diversity Score	Extent of Barrier Score	Current Sizing Score	Current Condition Score	Crossing Score	Length of Potential Upstream Habitat	Habitat Quantity Score	Habitat Quality Modifier	Total Habitat Score	TOTAL SCORE	Comments
#12	FX-03	Fairfax Creek #3	Olema Road	Steelhead	2	11	0	1	0.5	8,000	8.0	0.5	4.00	17.5	Lack-of-depth is the primary criteria violation and actual passage is probably fairly high.
#13	FX-05	Fairfax Creek #5	Sir Francis Drake Blvd.	Steelhead	2	9	3	5	4.0	3,500	3.5	0.5	1.75	16.8	Although passable for adults, extremely poor condition of the SSP pipe warrents replacement. Recommend a properly-sized open-bottom concrete arch.
#14	SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	Steelhead	2	12	0	0	0.0	24,000	10.0	0.25	2.50	16.5	Lack-of-depth is the only criteria violation for adults, slight v-shaped invert probably allows higher actual passage.
Tied #15	SH-02	Sleepy Hollow Creek #2	Saunders Avenue	Steelhead	2	11	1	0	0.5	25,600	10.0	0.25	2.50	16.0	Lack-of-depth is the only criteria violation for adults. Stream flow is also concentrated to RB and probably allows higher actual passage.
Tied #15	SH-06	Sleepy Hollow Creek #6	Broadmore Avenue	Steelhead	2	11	0	1	0.5	23,000	10.0	0.25	2.50	16.0	Lack-of-depth is the primary criteria violation and actual passage is probably fairly high.
#16	SH-05	Sleepy Hollow Creek #5	Morningside Avenue	Steelhead	2	8	0	0	0.0	23,700	10.0	0.25	2.50	12.5	Lack-of-depth is the only criteria violation for adults, slight v-shaped invert probably allows higher actual passage.
#17	R-03	Ross Creek #3	Utility pipe across channel in Natalie Coffin Park	Steelhead	2	7	0	0	0.0	950	1.0	0.5	0.48	9.5	Passsage was assessed only for drop over utlity pipe.
#18	FX-02	Fairfax Creek #2	Scenic Road	Steelhead	2	1	0	0	0.0	8,800	8.8	0.5	4.40	7.4	Site currently provides nearly unimpeded passage for all life stages of salmonids.
Tied #19	SA-01	San Anselmo Creek #1	Creek Park weir - Adjacent to SFD Blvd.	Steelhead	2	1	0	1	0.5	63,600	10.0	0.25	2.50	6.0	Site currently provides nearly unimpeded passage for all life stages of salmonids.
Tied #19	SH-03	Sleepy Hollow Creek #3	Sir Francis Drake Blvd.	Steelhead	2	1	1	0	0.5	24,800	10.0	0.25	2.50	6.0	Site currently provides nearly unimpeded passage for all life stages of salmonids.
#20	SH-07	Sleepy Hollow Creek #7	Arroyo Avenue	Steelhead	2	0	1	0	0.5	21,000	10.0	0.25	2.50	5.0	Site currently provides unimpeded passage for all life stages of salmonids.
#21	R-02	Ross Creek #2	Norwood Avenue	Steelhead	2	0	0	0	0.0	3,800	3.8	0.5	1.90	3.9	Site currently provides unimpeded passage for all life stages of salmonids.

CORTE MADERA CREEK - RANKING MATRIX - MODIFIED HABITAT SCORING

		RANKING MATRIX for CORTE MADERA CREEK STREAM CROSSINGS USING REVISED ADULT PASSAGE CRITERIA - Prolonged speed = 8ft/sec, Burst speed/Exit Velocity = 16ft/sec. Min. depth = 0.5ft.														
"No Hab Limit" RANK	"Hab. Limit" RANK	Site ID#	Stream Name	Road Name	Presumed Species Diversity	Species Diversity Score	Extent of Barrier Score	Current Sizing Score	Current Condition Score	Crossing Score	Length of Potential Upstream Habitat	Habitat Quantity Score	Habitat Quality Modifier	Total Habitat Score	TOTAL SCORE	Comments
#1	#1	SA-02 aka MR-078	San Anselmo Creek #2	Saunders Avenue	Steelhead	2	15	0	0	0.0	33,200	33.2	0.5	16.60	33.6	Ineffective fish ladder - replace or retrofit. Literature review confirmed it fails to meet Denil fish ladder specs.
#2	#4	SA-04 aka MR-079	San Anselmo Creek #4	Pastori Avenue	Steelhead	2	14	0	0	0.0	28,900	28.9	0.5	14.45	30.5	Adult passage is probably low. Site has an ineffective fish ladder. Literature review confirmed structure fails to meet Denil fish ladder specs.
#3	Tied #7	SA-03	San Anselmo Creel #3	Center Blvd/Lansdale Avenue	Steelhead	2	15	1	0	0.5	31,200	31.2	0.25	7.80	25.3	Perched outlet and lack-of-depth over a long reach are passage problems.
#4	#10	SH-01	Sleepy Hollow Creek #1	Taylor Street	Steelhead	2	13	1	1	1.0	26,000	26.0	0.25	6.50	22.5	Located near mouth of Sleepy Hollow Ck, treatment would allow good access up to Deer Hollow Rd. Retrofit w/weirs to raise tailwater elevation may be feasible.
#5	Tied #7	SH-08 aka MR-081	Sleepy Hollow Creek #8	Deer Hollow Road	Steelhead	2	15	0	1	0.5	17,000	17.0	0.25	4.25	21.8	Outlet is perched 5.8 ft and spills over bedrock/concrete drop. SH-01 should be treated 1st.
#6	#2	FX-01 aka MR-080	Fairfax Creek #1	Fairfax-Bolinas Road	Steelhead	2	15	4	0	2.0	10,800	10.8	0.25	2.70	21.7	Outlet is perched 4 ft. Culvert is 450' long. Top restoration priority to allow steelhead the option to recolonize Fairfax Creek.
#7	Tied #8	SA-05	San Anselmo Creek #5	Fairfax-Bolinas Road	Steelhead	2	12	0	1	0.5	14,000	14.0	0.5	7.00	21.5	Primarily a lack-of-depth criteria violation.
#8	#3	R-01	Ross Creek #1	Park Drive	Steelhead	2	14	0	5	2.5	5,200	5.2	0.5	2.60	21.1	High priority for treatment due to both severity of barrier and poor structural condition of the crossing. Replace with open-bottom arch or bridge.
#9	Tied #8	SH-09 aka MR-082	Sleepy Hollow Creek #9	Fawn Drive	Steelhead	2	15	0	0	0.0	16,100	16.1	0.25	4.03	21.0	Lack-of-depth violation up to 30cfs, then excess velocity. Looks partially passable for adults.
#10	#5	SA-06	San Anselmo Creek #6 aka Canyon Ck	Canyon Road	Steelhead	2	12	0	1	0.5	8,300	8.3	0.75	6.23	20.7	Site should be evaluated for fish passage due migration-level flows. Should also be inspected for maintainence during winter flows to clear debris.
#11	Tied #7	SH-11	Sleepy Hollow Creek #11	Not a crossing - Raven Dam	Steelhead	2	15	0	1	0.5	12,000	12.0	0.25	3.00	20.5	Complete barrier due to large drop over dam. SH-01 and SH-08 should be treated prior to SH-11. Grade control must be considered at this location.
#12	#6	FX-04	Fairfax Creek #4	Not a road - Olema Dam	Steelhead	2	15	0	1	0.5	5,500	5.5	0.5	2.75	20.3	Complete barrier due to large drop over dam; however FX-01 should be treated 1st. Effective grade control will be a major issue at this location.
#13	#14	SH-04	Sleepy Hollow Creek #4	Mountain View Avenue	Steelhead	2	12	0	0	0.0	24,000	24.0	0.25	6.00	20.0	Lack-of-depth is the only criteria violation for adults, slight v-shaped invert probably allows higher actual passage.
#14	#9	R-04	Ross Creek #4	Unnamed walking path in city park	Steelhead	2	15	3	0	1.5	800	0.8	0.5	0.40	18.9	Perched outlet and extensive inlet apron are problematic. Limited reach of habitat up to Pheonix Dam, yet is potentially vital juvenile refugia in summer months.
#15	#11	SH-10 aka MR-083	Sleepy Hollow Creek #10	Butterfield Road	Steelhead	2	13	0	1	0.5	13,000	13.0	0.25	3.25	18.8	Lack-of-depth is the primary criteria violation and actual passage is probably fairly high.

APPENDIX C: CORTE MADERA CREEK - STREAM CROSSING RANKING MATRIX - "NO HABITAT LENGTH LIMIT" SCORING ON XINGS WITH BARRIER SCORES OF AT LEAST 12 POINTS