Estimation of Passage Flows for Anadromous Fish through Critical Riffles in Stevens and Coyote Creeks, Santa Clara County, California

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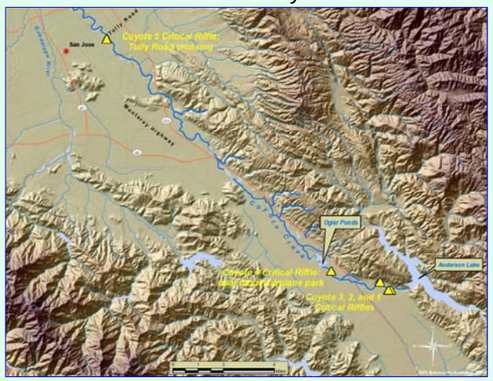
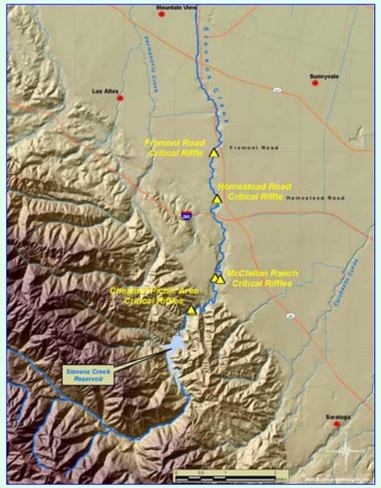
1. Summary

Field data collected for critical riffles located along Stevens and Coyote Creeks suggests that characterization of an underlying riffle hydraulic parameter, which we have termed "controlling depth", may prove to be a solid and cost-effective means of estimating salmonid passage flows through riffles with constrained geometries. Constrained geometries include those with confined widths, with large and irregular roughness elements on the bed (such as rip-rap), or with imposed and often steep slopes.

Critical Riffles on Coyote Creek



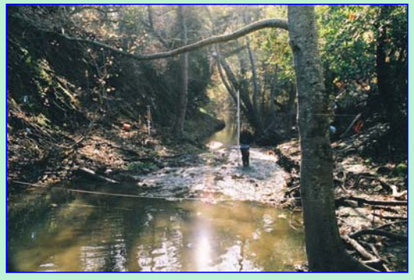
Critical Riffles on Stevens Creek



2. Project Overview

Working with the Santa Clara Valley Water District (Water District) and members of the Fisheries and Aquatic Habitat Collaborative Effort, Balance Hydrologics (Balance) estimated passage flows for anadromous fish through identified critical riffles on Stevens and Coyote Creeks in the Santa Clara Valley. Critical riffles were identified by fisheries consultant Stacey Li and Balance geomorphologists, and included naturally occurring bed structures which have the potential to act as passage impediments to migrating fish. Passage flow estimation for this project was based on meeting a modified version of the criteria developed by Thompson (1972) and was defined as that streamflow which would result in a water depth of 0.8 feet at one station along each cross-section established at all critical riffles. Results from this project are presently used by the Water District to regulate reservoir releases during migratory periods.

Homestead Road Critical Riffle



Coyote Critical Riffle 3

3. Methods

- Working with biologist Stacy Li, Balance scientists identified and selected 6 critical riffles along Stevens Creek and 5 critical riffles along Coyote Creek
- Following riffle selection, Balance scientists completed detailed level-surveys of each riffle and measured discharge and hydraulic characteristics through each riffle at measured flows.

Three lines of evidence used to estimate passage flows:

- HEC-RAS modeling: calibrated to observed controlling depth
- Back calculate Manning's "n" from field measurements & use back calculated "n" to iteratively solve for passage flow at each riffle
- Field verification measurements during storm events

Controlling Depth

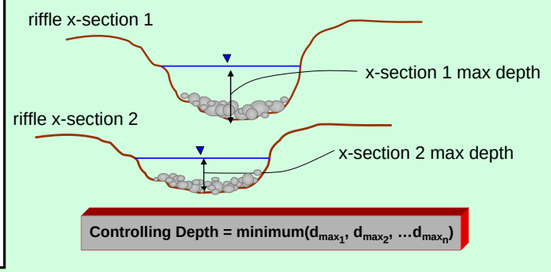
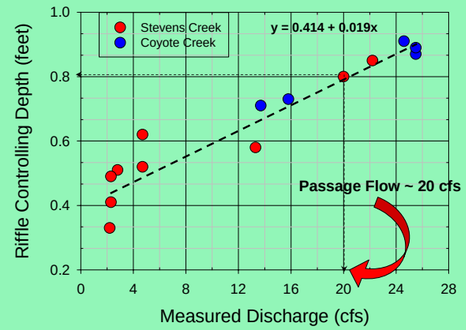


Figure A: Measured Discharge vs. Riffle "Controlling Depth"



4. Data/Results

- The data collected from Stevens and Coyote Creeks suggest that "controlling depth" is a characteristic hydraulic metric of riffles that can be used to predict passage flow for salmonids. Further testing elsewhere may strengthen the relationship illustrated in Figure A enabling application of this method by fisheries managers elsewhere.
- HEC-RAS modeling, field-verification measurements, and manual calculations suggest passage flow values for studied riffles between 18 and 21 cfs – this result is re-produced very closely using the concept of "controlling depth" (see Figure A).
- The "controlling depth" concept as a means of estimating passage flows may be more robust and flexible than traditional hydraulic modeling for long-term riffle-specific monitoring because computations can be completed with measurements. made at non-passage flows including the late-summer base flows (see Figure A).
- The exponent of 0.39 relating discharge to controlling depth conforms very well with the value of 0.45 reported by Leopold and others (1964) for at-a-station hydraulic geometry characteristics (see Figure B)
- Application of Manning's "n" to characterize low-flow conditions in this project proved successful and the magnitude of roughness values used in this study conform well with flume and hydraulic data reported by Judd (1963) and Boyer (1954)

Figure B: Measured Discharge vs. Riffle "Controlling Depth"

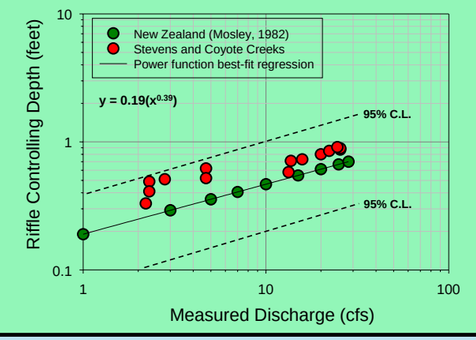
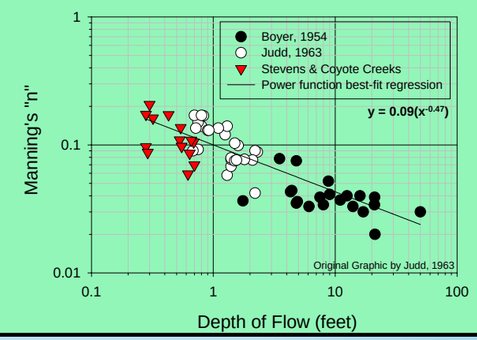


Figure C: Depth of Flow vs. Manning's "n"



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Regulated streams are ubiquitous throughout the western United States and play key roles in providing drinking water, flood protection and power generation for residents of the region's major urban centers. However, streamflow regulation also impacts anadromous fish by fundamentally changing the hydrology and sediment transport regimes of the affected watersheds and by introducing artificial migration barriers. These problems have long been recognized by the private and public sectors and, as a result, many local, state and federal agencies are actively engaged in managing reservoir releases for the benefit of anadromous fisheries.

Balance geomorphologists and engineers, working with local fisheries experts, evaluated passage conditions along Stevens and Coyote Creeks, two regulated streams in Santa Clara County. This study was part of a larger effort headed by the Santa Clara Valley Water District to measure the condition of habitat for chinook salmon, steelhead trout and other native fish species in several streams in the region. Field work and analyses focused on riffles in the middle reaches of each stream, which were identified as especially problematic for passage due to constrained geometric characteristics. Adequate passage conditions were based on meeting a modified version of the criteria developed by Thompson (1972) which stipulates 0.8 feet of depth over 25% of the total stream cross-sectional width or over a continuous 10% of the width. Balance provided a likely range of passage flows for each critical riffle based on three different methods: (1) manual measurements of streamflow during winter storms, (2) hydraulic modeling with HEC-RAS, and (3) iterative passage flow calculations utilizing Manning's and appropriate continuity equations.

Critical passage flows were identified for each stream and are compared to similar work at other locations, particularly results from Mosley (1982) in New Zealand. Results from this project have been used by the Santa Clara Valley Water District to make decisions regarding the magnitude of water releases from upstream reservoirs during periods of up-migration. The iterative flow calculation methodology shows promise as a useful tool for resource managers who may not have the budget or requisite technical resources needed to run HEC-RAS, conduct formal IFIM modeling, or establish gaging stations.