CDFW FISH PASSAGE DESIGN CRITERIA/GUIDANCE AND DESIGN-REVIEW PROCESS

PRESENTED BY:

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PART XII

FISH PASSAGE DESIGN AND IMPLEMENTATION

Fisheries Engineering Checklist

Streamlining Fisheries Engineering Review

The lists provided below identify the information necessary for California Department of Fish and Wildlife (CDFW) fisheries engineering staff to complete reviews of project designs for fish passage and screening projects at water diversions. The lists were developed using CDFW (2000 and 2001) and National Marine Fisheries Service (NMFS) (1997 and 2001) screening criteria and new CDFW information on fish passage design (2009). CDFW and NMFS screening criteria, and California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife are available online. [1]

Included are lists of information necessary for the adequate review of fish screens, fish ladders, boulder weirs, rock chutes, roughened channels, and at grade diversions. Use of these lists by CDFW staff will streamline the engineering review process and ensure that projects provide sustainable fish protection and passage. The project applicant should submit this information with the design plans. If a listed item is considered unnecessary, the rationale for excluding it should be provided by the project applicant. Conversely, while these lists attempt to cover the key parameters for most projects, there may be site-specific opportunities to provide better fish passage and that cannot be easily translated into a simple checklist (e.g., avoidance of predation habitat).

Fish Screens: *See current CDFW and NMFS screening criteria, and California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife.*

1. Target species and life stages to be protected at proposed screening site (e.g. will steelhead rainbow trout fry be present?) (NMFS pg. 4-5).
2. Fish screen structure placement (e.g., on-stream, in-canal, in-reservoir, or pumped) (NMFS pg. 3).
3. Evidence of infeasibility of on-stream screen if an in canal screen is selected. Types of evidence would include, but not be limited to: coarse bed load, severely eroding banks, excessive channel velocities, etc.
4. Records of diversion flows **and** stream flows, including maximums and minimums, during irrigation season (NMFS pg. 2).
5. Stream flow vs. depth rating curve at diversion intake (NMFS pg. 2).
6. Description of fish screen openings, including porosity and dimensions of round, square, or slotted openings (NMFS pg. 5-6).
7. Applicable approach velocity and sweeping velocity criteria (NMFS pg. 4-5).
8. Fish screen area calculation performed in accordance with CDFW Fish Screening Criteria (6/19/00).

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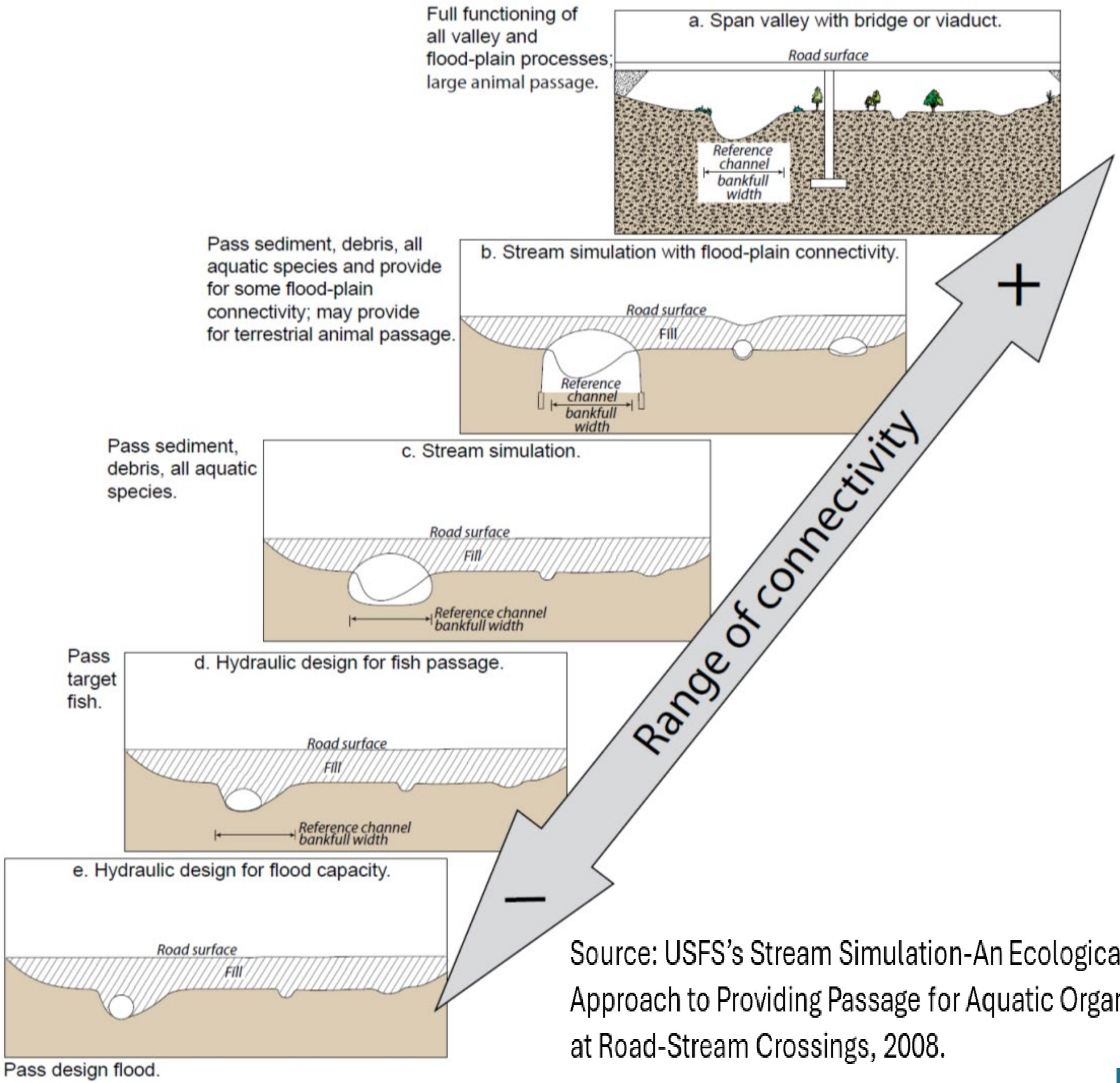
[1] Current CDFW and NMFS screening criteria, and California Salmonid Stream Habitat Restoration Manual, 3rd edition, California Department of Fish and Wildlife are available at the following links:

- http://www.dfg.ca.gov/fish/Resources/Projects/Engin/Engin_ScreenCriteria.asp
- http://swr.nmfs.noaa.gov/hcd/fishscrn.pdf
- http://www.dfg.ca.gov/fish/REsources/HabitatManual.asp

Order of Preference

- Eliminating a stream-road crossing
- Free-span bridge sized to pass 100-year flow and the continuity of geomorphic processes
- Bottomless arched culvert sized to span the bankfull channel plus room for banklines
- Stream simulation
- Geomorphic based roughened channels
- Rock weirs (or other types of drop structures)
- Culvert not sized to span the bankfull channel
- Technical fishway

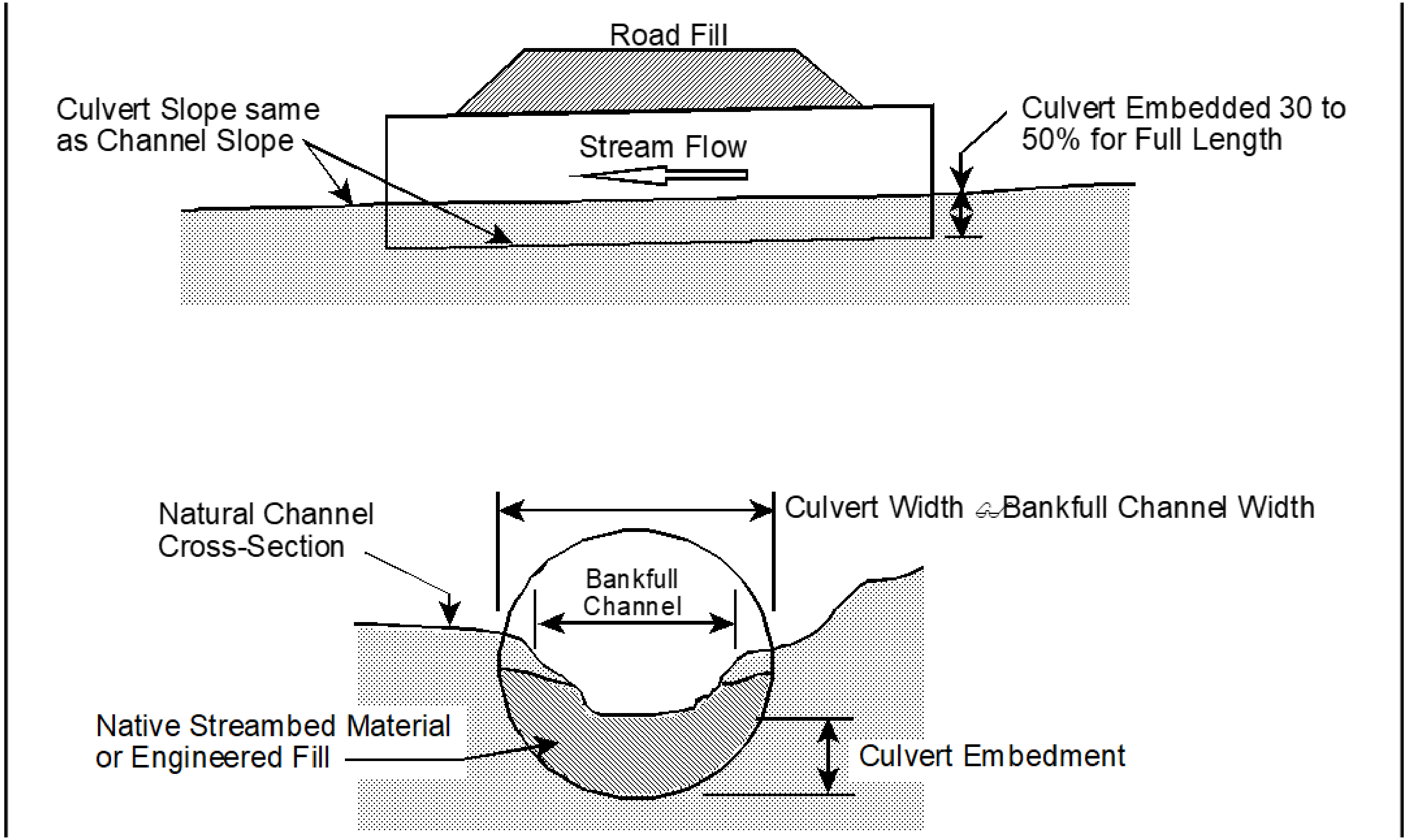


Source: USFS's Stream Simulation-An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings, 2008.

Hierarchy of Connectivity Solutions

- Full Span Bridge Solutions
  - Span the historically active floodplain or channel migration zone to minimize interference between infrastructure and channel processes; and optimize both terrestrial and aquatic species passage.
- Geomorphic Design Option
  - Stream Simulation
- Hydraulic Design Option
  - Profile Control using drop structures
  - Geomorphic based roughened channels
  - Baffle Retrofits
  - Fishways

Stream Simulation Design Option



- Reference Reach: Match slope, substrate size, channel bed mobility, geomorphic cross-sectional area, width and depth, bedform morphology

Stream Simulation Design Examples

- Stuart Creek/Bouverie Preserve Dam Removal
- San Ysidro
- Fort Goff Creek at State Route 96 Crossing in Siskiyou County
- San Lorenzo River at State Route 9 Crossing – currently in design
- Neefus Gulch at Appian Way (NF Navarro River)
- Kenny Creek (SF Eel River)
- Morrison Gulch (tributary to Jacoby Creek and Humboldt Bay)
- Scott Bar Mill Creek Fish Passage Improvement Project (Scott River)
- Gulch C (along the Skunk Train railway, Noyo River)
- First Slough at 14th St. (tributary to Humboldt Bay)

Hydrology / Design Flow for Fish Passage

High Design Flow

Species/Life Stage	Percent Annual Exceedance Flow	Percentage of 2-yr Recurrence Interval Flow[1]
Adult Anadromous Salmonids	1%	50%
Adult Non-Anadromous Salmonids	5%	30%
Juvenile Salmonids	10%	10%
Native Non-Salmonids	5%	30%
Non-Native Species	10%	10%

1. If flow duration data is not available, the values shown for Percentage of 2-yr recurrence interval flow may be used.

Low Design Flow

Species/Life Stage	Percent Annual Exceedance Flow	Alternate Minimum Flow (cfs)[2]
Adult Anadromous Salmonids	50%	3
Adult Non-Anadromous Salmonids	90%	2
Juvenile Salmonids	95%	1
Native Non-Salmonids	90%	1
Non-Native Species	90%	1

2. If the percent annual exceedance flow is less than the alternative minimum flow, use the alternative minimum flow. Also, if flow duration data is not available, the alternative minimum flow may be used.

Anadromous Salmonid Criteria

Parameter	Adult	Juvenile
Depth	1.0 ft	0.5 ft
Velocity	2.0 - 6.0 ft/s*	1.0 ft/s
Jump Height	1.0 ft	0.5 ft

* - velocity criteria dependent on length between salmonid resting areas.

Fish Ladders and Bypass Channels: 10-20% of River Flow

Design considerations for other species

Lamprey – rounded corners

Sturgeon: 3 foot depth, 5 foot width

Clear Lake Hitch: 0.5 foot depth, 5 ft/s velocity, no jump

Slower fish swimming species (Santa Ana sucker, stickleback, Arroyo chub): 0.5 foot depth, 1 f/s velocity, no jump

Energy Dissipation in Pools

- $V_m = \frac{\gamma * Q * h}{EDF}$
- Where:
  - V_m = effective pool volume of for dissipating energy (ft^3)
  - γ = Unit weight of water (62.4 lb/ft^3)
  - Q = flow entering pool (cfs)
  - H = hydraulic head of flow drop entering pool (ft)
  - EDF = energy dissipation factor

- For adult salmon and steelhead, use an ***EDF of 4*** foot-pounds per second per cubic foot of volume
- For shad and adult trout, use an ***EDF of 3*** foot-pounds per second per cubic foot of volume
- Pool lengths greater than 8 ft or deeper than 4 ft should not be consider in the calculation

Roughened Channels: EDF < 7

- rock ramps (generally sloped < 5%)
- chute and pool
- step-pool
- cascade

Roughened Channel Examples

- Deer Creek Irrigation District
- Little Shasta River Diversion near Montague
- GID Diversion near Montague
- Bonde Weir Removal near Palo Alto
- Paynes Creek
- Auburn Ravine at former Hemphill Dam site
- Budiselich and Central CA Traction RR on the Stockton Diverting Canal
- Gulch 7 step pool roughened channel
- Grub Creek Plane Bed Rock Ramp

Pool & Weir Design Criteria

Criterion	Value
Maximum Hydraulic Head Between Pools (H)	- 1 ft for adult salmonids - ½ ft for juvenile salmonids - ¾ ft for shad - Slightly higher values may be applied at entrance
Minimum Depth Over Baffles	- 1 ft is normal design criterion - Minimum of 6 inches or depth of target species, whichever is greater - 3 inches may be acceptable for leaping fish in fishways in small to moderate streams without flow control
Minimum Orifice Dimensions	- 12 in W x 15 in H - 15 in W x 18 in H recommended for salmon
Minimum Freeboard	- 3 ft
Minimum Pool Depth	- 3 ft to 8 ft depending on scale of river

Fish ladder entrances - importance for attraction flow and orientation

Fishway Entrance

- Often most difficult design element
- NFI = NFO
- Provides access to fish ladder
- Located at upstream-most point of fish passage
- Multiple entrances may be needed to accommodate the design flow range
- Generally delivers attraction jet into tailwater

- Entrance alignment is important
  - Perpendicular for low flows
  - Angled 30° for high flow
- Shape / Dimension
  - Overflow weir full width of fish way
  - Narrow weir with end contractions
  - Vertical slot
  - Orifice
- Consider rectangular port with width to height ratio of 0.6 to 1.25
- Smallest recommended port dimension is 30 inches

Design-review Process

Goals of design review process are to ensure that fish passage criteria are met and that project will maintain itself over time

Engage early – at alternatives analysis phase

Get good base topography of existing conditions early – on-line 1 m resolution LIDAR supplemented by total station/RTK for area that was inundated when LIDAR was flown

Include Basis of Design report:

- Geomorphic and Pre-Design Site Assessments
- Fish Passage Flows/Design Flow Analysis
- Water Crossing Design for project site constraints, if applicable
- Hydraulic Modeling (Recommend using 2D modeling rather than 1D modeling – will make it easier to meet velocity criteria because can look at continuous path through site rather than average cross-sectional velocities)
- Rock sizing calculations (including analysis/calculations/assumptions used in all in-channel engineered design features)

Design Review process example - DCID

Alternatives Analysis:

- Roughened Ramp
- Fish Ladder

Selected alternative was combination of roughened ramp and lowering diversion elevation due to high bedload on Deer Creek

DCID 30% Design

- Determining Fish Passage Flows: 32 (observed low flow minus diversion and bypass flow) and 2,680 cfs (1% exceedance)
- Hydraulic modeling to demonstrate meeting fish passage criteria at low and high fish passage flows
- Determining design elevation of diversion invert
- Boulders for roughness elements

DCID 65% Design

- Rock sizing for roughened ramp

DCID 90% Design

- Final details on plans
- Specifications
- Monitoring and maintenance plan
- Removing riprap from below the roughened ramp elevations to help maintain surface flow
- Maintaining a flume design for flow measurement in the diversion channel

DCID Post-project monitoring

- Topographic survey after high flows
- 2D modeling at low fish passage flow