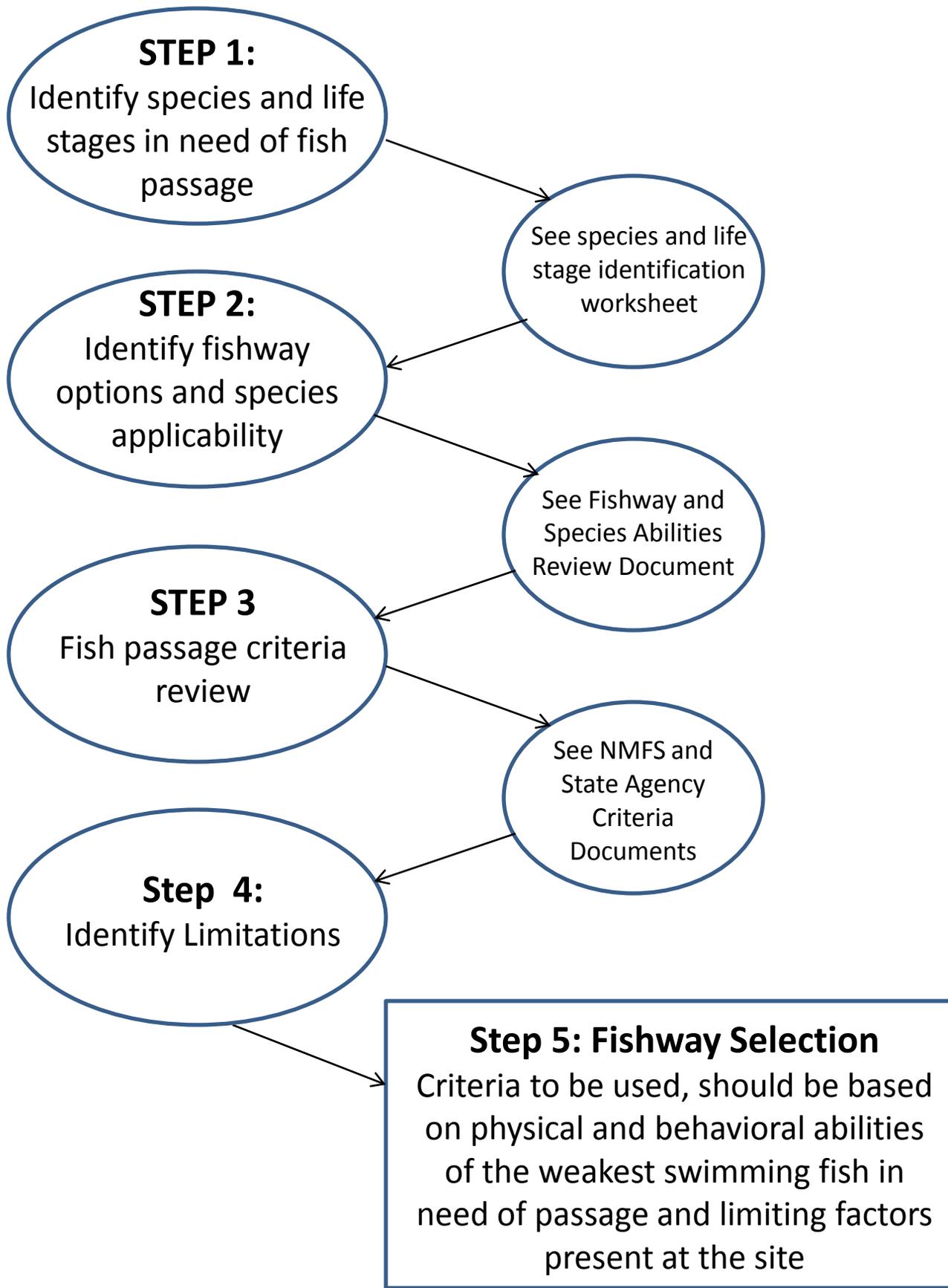


# FSOC

## Upstream Fish Passage Guidance Document



FSOC Upstream Passage Assessment Criteria

Ex: Feed Canal

Species Presence	CHF	CHS	STS	BT	Suckers
Life History Present	2	2	3	2	2
ESA Status	1	1	2	2	1
Abundance	3	3	3	1	3
Habitat Type	3	2	3	2	2
Habitat Connectivity Need - JV	0	0	2	0	0
Habitat Connectivity Need - AD	1	3	2	3	0
<b>Total</b>	<b>10</b>	<b>11</b>	<b>15</b>	<b>10</b>	<b>8</b>

Key				
Factors	1	2	3	0
Life History Present	Resident or rearing 1+ smolt	Migratory (adult or JV)	Multiple	N/A
ESA Status	Non-listed	Threatened	Endangered	N/A
Abundance	Limited		Substantial	N/A
Habitat Type Upstream	Rearing	Spawning	Both	N/A
Habitat Connectivity Need - JV	Rearing habitat good downstream	Rearing habitat available upstream	Rearing habitat poor downstream and available upstream	No Need
Habitat Connectivity Need - AD	Good spawning habitat available downstream	Spawning habitat available upstream	Spawning habitat unavailable downstream and available upstream	No Need

Fish Passage Facility (upstream) Species Suitability				
Species/Lifestage	Passage Facilities	Physical Ability	Behavioral Factors	Criteria
<b>Adult:</b> Chinook salmon ( <i>Oncorhynchus tshawytscha</i> ) Coho Salmon ( <i>Oncorhynchus kisutch</i> ) Steelhead ( <i>Oncorhynchus mykiss</i> ) Sockeye ( <i>Oncorhynchus nerka</i> ) Cutthroat Trout-sea run ( <i>Oncorhynchus clarki</i> )	Vertical Slot, Pool and Weir, Pool and Chute, Ice harbor, Half Ice Harbor, baffled chute, stream simulation, rock weirs, roughened channels, stream simulation road-stream crossing, appropriately designed hydraulic road-stream crossing	Prolonged Swimming Speeds: 2 fps - 7.5 fps Burst swimming speeds: 10 fps - 20 fps	Good leapers, will readily jump if presented with a barrier. Require strong attraction flows.	12" jump heights, 2 fps in transport channels, 8 fps at transition points (slots, orifices, weir crests), 4 ft/lbs energy in resting pools
<b>Adult:</b> Chum Salmon ( <i>Oncorhynchus keta</i> )	Vertical slot, roughened channel, stream simulation, ice harbor, half ice harbor, baffled chute, stream simulation road-stream crossing, appropriately designed hydraulic road-stream crossing	Prolonged Swimming Speeds: @ 5 fps Burst Swimming Speeds: @ 8 fps	These fish do not leap. Even the smallest features that require a fish to leap to pass can be barriers to adult chum.	0" jump heights- fishway must be swim through. Fish cannot pass through fishways which require leaping to pass. 4ft/lbs energy in resting pools
<b>Adult:</b> Redband/Rainbow Trout ( <i>Oncorhynchus mykiss</i> ) Cutthroat Trout-resident/fluvial ( <i>Oncorhynchus clarki</i> )	Vertical Slot, Pool and Weir, Pool and Chute, Ice harbor, Half Ice Harbor, baffled chute, stream simulation, rock weirs, roughened channels, stream simulation road-stream crossing, appropriately designed hydraulic road-stream crossing	Prolonged swimming speeds: 1.6 fps - 4 fps Burst Swimming Speeds: 3.3 fps - 9.8 fps (depending on body size)	Fish are good leapers and will readily do so. Leaping ability is not as strong as adult salmon/steelhead. For smaller fish, fishways with small jumps may work better than swim-through style due to weaker swimming ability.	6-12" jump heights, 2 fps in transport channels, 4 ft/lbs of energy in resting pools.
<b>Adult:</b> Bull Trout ( <i>Salvelinus confluentus</i> ) Mountain whitefish ( <i>Prosopium willamsoni</i> )	Vertical Slot, Pool and Weir, Pool and Chute, Ice harbor, Half Ice Harbor, baffled chute, stream simulation, rock weirs, roughened channels, stream simulation road-stream crossing, appropriately designed hydraulic road-stream crossing	Prolonged swimming speeds: 1.3 fps - 2.8 fps Burst Swimming Speeds: @ 2.6 fps for whitefish, no ranking for bull trout burst speeds	Fish will leap, but these species tend to orient to the bottom of the water column and do not like to come to the surface. Swim through fishway with low velocities (small pool-pool differentials) or stream simulation and roughened channels work best.	6-12" jump heights, 2 fps in transport channels, 4 ft/lbs of energy in resting pools.

Fish Passage Facility (upstream) Species Suitability				
Species/Lifestage	Passage Facilities	Physical Ability	Behavioral Factors	Criteria
<b>Adult:</b> Sucker species ( <i>Catostomus spp.</i> )	Vertical slot, roughened channel, stream simulation, ice harbor, half ice harbor, baffled chute, stream simulation road-stream crossing, appropriately designed hydraulic road-stream crossing	Prolonged swim speeds: @ 1.5 fps -2.5 fps Burst Swim Speeds: @ 6 fps	Fish are relatively weak swimmers, though have a decent burst when need be. Sucker species do not and cannot leap. Fishways must be swim through, stream simulation or roughened channel	0" jump heights- fishway must be swim through. Fish cannot pass through fishways which require leaping to pass. 2 fps in transport channels, maximum 4 fps in fishways (including discrete transitions) 4ft/lbs energy in resting pools
<b>Adult:</b> Lamprey species ( <i>Lampetra spp.</i> )	roughened channel, stream simulation, lamprey specific fishway (lamp ramp)	Prolonged swim speeds: .5 fps -1.3 fps Burst Swim Speeds: @ 2.8 fps	Fish are weak swimmers and cannot/do not leap. Back eddies, 90 degree corners, and moderate to high velocities can block fish passage. Require a wetted smooth surface or very slow velocities in order to pass.	0" jump heights, max velocities of < 2 fps. Specialized criteria for lamprey include ramp heights, angles, velocity of water over surfaces, no corners
<b>Juvenile:</b> Chinook salmon ( <i>Oncorhynchus tshawytscha</i> ) Coho Salmon ( <i>Oncorhynchus kisutch</i> ) Steelhead ( <i>Oncorhynchus mykiss</i> ) Redband/Rainbow Trout ( <i>Oncorhynchus mykiss</i> ) Cutthroat Trout ( <i>Oncorhynchus clarki</i> )	Vertical Slot, Pool and Weir, Pool and Chute, Ice harbor, Half Ice Harbor, baffled chute, stream simulation, rock weirs, roughened channels, stream simulation road-stream crossing, appropriately designed hydraulic road-stream crossing	Prolonged swim speeds: .5 fps -2.1 fps Burst Swim Speeds: ( no or limited data for juvenile burst speeds)	Fish are good leapers and will readily do so. Leaping ability is not as strong as adult salmon/steelhead. For smaller fish, fishways with small jumps may work better than swim-through style due to weaker swimming ability.	6" to 9" jump heights (depending on agency criteria), 2 fps in transport channels, 2-4 ft/lbs of energy in pools
<b>Juvenile/sub-adult:</b> Bull Trout ( <i>Salvelinus confluentus</i> )	Vertical Slot, Pool and Weir, Pool and Chute, Ice harbor, Half Ice Harbor, baffled chute, stream simulation, rock weirs, roughened channels, stream simulation road-stream crossing, appropriately designed hydraulic road-stream crossing	Prolonged swim speeds: 1.5 fps -1.7 fps Burst Swim Speeds: (no or limited data for juvenile burst speeds)	Leaping ability/willingness is fairly unknown. Fairly weak swimmers. Best passage is through roughened channel or stream simulation. Other fishways should be low velocity/low head, or small jump heights	6" jump heights, 2 fps in transport channels, 2-4 ft/lbs energy in pools

## FSOC Fishway Description and Fish Use

Fish Use (see species applicability sheet)	Fishway Type	Description	Positives	Negatives
<p><b>Works well for:</b>                      *Adult Chinook, Coho, Sockeye, Chum, Steelhead, Bull Trout, mountain whitefish, cutthroat, Redband/rainbow trout</p> <p><b>May work for (depending on configuration):</b>                      *Sucker species,                      *Juvenile Chinook, Coho, Steelhead, Bull Trout, cutthroat, rainbow/redband                      *Lamprey spp.</p>	<b>Vertical Slot</b>	Swim through fishway that provides resting pools and slots that fish need to use a quick "burst" to swim through. The invert of each slot is set at a given height difference from that of the slot directly upstream.	<ul style="list-style-type: none"> <li>*Self adjusting/self regulating</li> <li>*Provides resting areas (pools)</li> <li>*Swim through fishway that does not require a fish to leap</li> <li>*Passage can occur at any depth in the water column</li> </ul>	<ul style="list-style-type: none"> <li>*Slots can catch debris</li> <li>*Slot velocities and pool re-circulation can be difficult for weaker swimming fish</li> <li>*Large footprint and expensive</li> <li>*Uses lots of water so small stream application is difficult</li> </ul>
<p><b>Works well for:</b>                      *Adult and juvenile Chinook, Coho, Sockeye, Chum Salmon, Steelhead, cutthroat, Redband/rainbow trout                      *Bull Trout adults</p> <p><b>May work for (depending on configuration):</b>                      *Mountain whitefish                      *Bull Trout sub-adults</p> <p><b>Does not wor for:</b>                      *Sucker spp. , Chum Salmon, Lamprey spp.</p>	<b>Pool and Weir<sup>1</sup></b>	Fishway that utilizes plunging flow over weirs, separated by energy dissipation pools. Each weir is set at a given height differential from the weir directly up or down stream. Fish pass by leaping over each weir.	<ul style="list-style-type: none"> <li>*Can be designed to provide passage at a wide range of flows</li> <li>*Can be designed to use the least amount of water (great for low flow passage)</li> <li>*Provides resting areas</li> <li>*Most debris passes over top of weirs</li> <li>*Simple in design, less engineering than other fishways</li> </ul>	<ul style="list-style-type: none"> <li>*Requires manual adjustment of each weir if water surface elevations up and/or downstream change</li> <li>*Gravel and sediment can settle in pools</li> <li>*Fish are required to leap in order to pass, which could lead to increased chance of injury</li> </ul>

## FSOC Fishway Description and Fish Use

Fish Use (see species applicability sheet)	Fishway Type	Description	Positives	Negatives
<p><b>Works well for:</b>                      *Adult and juvenile Chinook, Coho, Sockeye, Steelhead, cutthroat, Bull Trout, Redband/rainbow trout, mountain whitefish</p> <p><b>Does Not Work For:</b>                      *Chum salmon and Sucker spp. (when in plunging flow regime)                      *Lamprey spp.</p>	<p><b>Pool and Chute<sup>1</sup></b></p>	<p>Hybrid fishway with both plunging flow and streaming flow at certain flows (namely the mid to higher flows). Primarily acts as a pool and weir at low flows. Works well for applications with limited project space and the structure spans the entire channel.</p>	<ul style="list-style-type: none"> <li>*Potentially small footprint (does not need to dissipate energy during high flows)</li> <li>*Potentially two methods of fish passage (leap over, or swim through) at certain flows.</li> <li>*Works at wide range of flows</li> <li>*Self adjusting</li> <li>*Strong attraction flow (when channel spanning)</li> </ul>	<ul style="list-style-type: none"> <li>*High turbulence during high flows</li> <li>*Limited resting areas for fish</li> <li>*Attraction can be an issue if not channel spanning</li> <li>*High degree of engineering needed to decipher plunging/streaming flow regime and correlate to fish passage</li> <li>*Passage provided at top of the water column only</li> <li>*Ladder must be straight (no turns)</li> <li>*Best for low head applications (&lt;5-6 ft.)</li> </ul>
<p><b>Works well for:</b>                      *Adult Chinook, Coho, Sockeye, Steelhead, cutthroat, Bull Trout, Redband/rainbow trout, mountain whitefish</p> <p><b>May work for (dependant on configuration and velocities):</b>                      * Chum, Sucker spp.                      * Juvenile Chinook, coho, steelhead, bull trout, redband/rainbow, cutthroat</p> <p><b>Does not work for:</b>                      *Lamprey spp.</p>	<p><b>Baffled Chute (denil and steeppass)</b></p>	<p>Baffled flumes that are designed to control depth and velocities by baffle dimensions and configuration. Baffles create turbulence that break up velocities for fish to swim through.</p>	<ul style="list-style-type: none"> <li>*Small and economical</li> <li>*Swim-through fishway which can provide "sweet spot" for passage</li> <li>*Steeppasses are portable and can be used at traps and in temporary capacities</li> <li>*Can be placed in steep configurations, gaining a lot of height in a short horizontal distance</li> </ul>	<ul style="list-style-type: none"> <li>*Very susceptible to debris</li> <li>*Cannot be used in locations where chute is downstream passage route</li> <li>*Due to high velocities, requires resting pools in larger installations</li> <li>*May use large quantities of water (depending on design)</li> <li>*Steeppass typically limited to temporary uses</li> </ul>

## FSOC Fishway Description and Fish Use

Fish Use (see species applicability sheet)	Fishway Type	Description	Positives	Negatives
<p><b>Works well for:</b>                      *Adult and juvenile Chinook, Coho, Sockeye, Steelhead, cutthroat, Bull Trout, Redband/rainbow trout, mountain whitefish</p> <p><b>May work for (dependant on configuration):</b>                      *Lamprey spp.</p> <p><b>Does not work for:</b>                      *Chum salmon, sucker spp.</p>	<p><b>Rock Weirs</b></p>	<p>"Nature" like fishway that utilizes boulders to create wiers and pools, much like a pool/weir or pool/chute fishway to provide passage. Typically fish are required to leap over weirs to pass, but generally both streaming and plunging flow regimes exist at certain flows.</p>	<ul style="list-style-type: none"> <li>*Natural in appearance</li> <li>*Dependant on design/flow, can provide both swim through and/or leap over passage.</li> <li>*Provides stream grade control</li> <li>*Can be partial width or channel spanning, though channel spanning is far preferred do to attraction and stability considerations</li> </ul>	<ul style="list-style-type: none"> <li>*Must be designed, engineered, constructed carefully and correctly</li> <li>*Longevity can be a concern, especially if rocks are not sized/designed correctly</li> <li>*Generally requires maintenance (debris removal, rock replacement)</li> <li>*Combination of sizing rock to withstand flood flows and provide passage sometimes does not pencil out</li> <li>*Low flow fish passage is a concern (sub-surface flow)</li> <li>*May not work downstream of reservoirs where fines settle out, or in any location devoid of fines.</li> </ul>

## FSOC Fishway Description and Fish Use

Fish Use (see species applicability sheet)	Fishway Type	Description	Positives	Negatives
<p><b>Works well for:</b> *All species and lifestages in need of passage (depending on design/configuration, gradient, velocities, depths)</p>	<p><b>Roughened Channel</b></p>	<p>"Nature" like fishway that utilizes natural aspects of a stream, such as riffles and pools, to provide passage. Typically, roughened channels are "over-steepened" and "over roughened" as compared to the natural gradient and rock size.</p>	<ul style="list-style-type: none"> <li>*Natural in appearance</li> <li>*Utilizes "natural" stream hydrology to provide passage</li> <li>*Allows for natural function and passage of sediment</li> <li>*Can be partial width or channel spanning, though channel spanning is far preferred do to attraction considerations</li> </ul>	<ul style="list-style-type: none"> <li>*Difficult to construct, need a high level of design/engineering to be successful</li> <li>*If not designed/constructed correctly, both fish passage and longevity are at risk</li> <li>*Requires a lot of rock and streambed materials. Sometimes at a high cost.</li> <li>*Only applicable in low head installations (5ft - 6ft or less)</li> <li>*May not work downstream of reservoirs where fines settle out, or in any location devoid of fines.</li> </ul>
<p><b>Works well for:</b> *Adult and juvenile Chinook, Coho, Sockeye, Chum, Steelhead, cutthroat, Bull Trout, Redband/rainbow trout, mountain whitefish</p> <p><b>May work for (but likely problematic due to orifice velocities):</b> *Sucker spp. , Lamprey spp</p>	<p><b>Ice Harbor and Half Ice Harbor</b></p>	<p>Fishway that utilizes both pool and weir, as well as submerged orifice. Full ice harbor has partition between two weirs/orifices. Half ice harbor is full ice harbor cut in half (partition on one side, one weir w/ orifice on the other). Passage through this fishway is through either leaping over the weir or swimming through the orifice.</p>	<ul style="list-style-type: none"> <li>*Offers two routes of passage for fish that may prefer to either leap over the weir or burst through the orifice.</li> <li>*Best used at sites with good water supply and consistent reservoir and forebay levels.</li> </ul>	<ul style="list-style-type: none"> <li>*Large footprint</li> <li>*Requires a lot of water and stable flows</li> <li>*Submerged orifices are prone to plugging and are hard to clean</li> </ul>

## FSOC Fishway Description and Fish Use

Fish Use (see species applicability sheet)	Fishway Type	Description	Positives	Negatives
<p>Works well for: *All species and lifestages in need of passage (depending on design/configuration, gradient, velocities, depths)</p>	<p><b>Stream Simulation</b></p>	<p>Fishway that matches existing "natural conditions" in the stream. Often used in side channels to provide passage around diversions or in barrier removals, stream simulation fishways match gradient, bed materials, depths, and velocities of the existing stream in the project vicinity.</p>	<p>*Provides fish passage at the same level that the stream provides naturally- i.e. the fish does not know it is in a fishway.</p>	<p>* Difficult to impossible to do in situations in which water surface elevations must be raised above natural conditions. For example, water surface must be raised to push water down an irrigation canal. *Large footprint *Expensive *High level of design time to survey reference reaches, and must be constructed carefully to include naturally features such as fines, low flow channel.</p>
<p><b>Road Stream Crossings- Culverts and Bridges</b></p>				
<p>Works well for: *All species and lifestages in need of passage (depending on design/configuration, gradient, velocities, depths)</p>	<p><b>Stream Simulation Bridge/ culvert</b></p>	<p>A bridge or culvert that spans the entire channel of the stream. Depending on agency criteria, the length of clear span will vary, but at minimum the crossing must clear span the entire channel. Also, features contained within the crossing must match the existing natural conditions in the stream. These features include gradient, jump heights, water depths, velocities, and bed materials.</p>	<p>*Provides fish passage at the same level that the stream provides naturally- i.e. the fish does not know it is in a fishway. *Preferred method of providing fish passage at road-stream crossings. *Minimal review time for permitting agencies</p>	<p>*Extensive in stream surveys needed to calculate active channel width, gradient, and bed material composition up and downstream of the crossing</p>

FSOC Fishway Description and Fish Use				
Fish Use (see species applicability sheet)	Fishway Type	Description	Positives	Negatives
<p>Works well for:</p> <p>*All species and lifestages in need of passage (depending on design/configuration, gradient, velocities, depths)</p>	<p><b>Hydraulic Bridge/Culvert</b></p>	<p>A bridge or culvert which does not qualify as "stream simulation," but the resulting hydraulic conditions the crossing provides meets the needs of the native migratory fish in need of passage. In order to meet hydraulic passage requirements, analysis must clearly show that the velocities, depths, and jump heights provided between the 95% and 5% exceedence flows (fish passage flows) meet the needs of the native migratory fish in need of passage.</p>	<p>*Can be less expensive than stream simulation (smaller structures)</p> <p>*Can provide good fish passage in certain situations. Particularly in failry lentic conditions, or in spring fed system with very stable flows.</p>	<p>* Loss of natural function. Smaller crossings do not allow for internal bed and banks to form, and to dissipate energies of flood flows.</p>

**There are many variations to each one of these fishways. These comments are general characterizations regarding performance and fish use, and**

1- Ladder may be designed with submerged orifice as well. An orifice requires additional water but allows fish to burst through the orifice lower in the water column. Submerged orifices are prone to plugging and are difficult to clean. They may not work well for fish with limited swimming capabilities.