HIGH-HEAD BYPASS DESIGN PARAMETERS		
	2011 NMFS Criteria	**HHB Proposed Guideline**
BYPASS ENTRANCE		
General	The screen and bypass must work in tandem to move out-migrating salmonids (including downstream migrant adult salmonids such as steelhead *kelts*, if present) to the bypass outfall with a minimum of injury or delay.	Same as NMFS
Holding/ Handling	No criteria listed for piped bypass	Holding and handling should be avoided; if unavoidable all steps should be taken to minimize holding and handling.
Debris management and prevention	No criteria listed for piped bypass	Before the bypass entrance all practical means must be used to remove as much debris as possible, especially large debris that may cause blockage. Debris management systems must not pose a threat of injury to fish or delay fish entry.
Access	Access for inspection and debris removal must be provided at locations in the *bypass system* where debris accumulations may occur.	The entire bypass system must be designed to be dewatered and inspected visually either through direct access (e.g. ports or an open channel) or remote equipment. The system also must be designed to allow for the removal of any debris within the bypass.
Channel Acceleration/ Deceleration	To ensure that fish move quickly through the bypass channel (i.e., the conveyance from the terminus of the screen to the bypass pipe), the rate of increase in velocity between any two points in the bypass channel should not decrease and should not exceed 0.2 fps per foot of travel.	Any increase must be <= 0.2 fps per foot of travel to ensure an acceleration profile that reduces risk of fish rejecting the bypass entrance. Deceleration between the capture point and bypass entrance may be necessary for: • debris removal • transition from free surface to full flow conduit at entrance • Passage monitoring (e.g. PIT detection or Vaki counter) • Additional dewatering upstream of a conduit entrance

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BYPASS LAYOUT and CONDUIT		
Vertical Conduit, Bifurcations, and Merges	Fish should not be pumped within the bypass system. Fish must not be allowed to free-fall within a pipe or other enclosed conduit in a bypass system. Downwells must be designed with a free water surface, and designed for safe and timely fish passage by proper consideration of turbulence, geometry, and alignment.	Free-fall within a pipe or other enclosed conduit in a bypass system should be avoided if possible. Downwells and convergence/divergence sections must be designed for safe and timely fish passage, considering turbulence, geometry, and alignment.
Pressure	In general, *bypass flow*s in any type of conveyance structure should be open channel. If required by site conditions, pressures in the bypass pipe must be equal to or above atmospheric pressures. Pressurized to non-pressurized (or vice-versa) transitions should be avoided within the pipe. Bypass pipes must be designed to allow trapped air to escape.	Pressure should be >= 7.2 psi (abs) (~ 0.5 atm) Avoid pressure change rates > -500 psi/sec (ref. Abernathy et. al 2002).
Bends	Bends should be avoided in the layout of bypass pipes due to the potential for debris clogging and turbulence. The ratio of bypass pipe center-line radius of curvature to pipe diameter (R/D) must be greater than or equal to 5. Greater R/D may be required for super-critical velocities (see Section 11.9.3.8).	The ratio of bypass pipe center-line radius of curvature to pipe diameter (R/D) >=5. Use of bends should be minimized in the layout of bypass pipes due to the potential for debris clogging and turbulence. R/D ratio should be maximized and consider the conduit shape and canting of the conduit to minimize turbulence and keep fish centered in the water volume.

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Diameter/ Geometry	The bypass pipe diameter or open channel bypass geometry should generally be a function of the *bypass flow* and slope, and should be chosen based on achieving the velocity and depth criteria in Sections 11.9.3.8 and 11.9.3.9.	Hydraulics and flow will set geometry and diameter. Bypass pipes and flumes diameter or width >= 12" to reduce risk of debris blockage and accommodate adult sized fish.
Depth of Water in Bypass Conduit	The design minimum depth of free surface flow in a bypass pipe should be at least 40% of the bypass pipe diameter, unless otherwise approved by NMFS.	Depth for sub-critical free surface flow in bypass pipes >= 40% of the diameter. For larger pipe diameters, depths less than 40% could still provide safe conditions depending on fish size, velocity, alignment and the roughness of the conduit.
Velocity	The design bypass pipe velocity should be between 6 and 12 fps for the entire operational range. If higher velocities are approved, special attention to pipe and joint smoothness must be demonstrated by the design. To reduce silt and sand accumulation in the bypass pipe, pipe velocity must not be less than 2 ft/s.	Bypass velocities should be >= 6 fps to ensure fish are conveyed quickly through the system and to minimize holding and delay. For high-head bypass design there may be a need for velocities to exceed the NMFS guidance for maximum velocity (12 fps). Examples of fish conveyance structures where fish safely travel at velocities >50 fps: Bonneville B2 corner collector, Wanapum Dam bypass, Green Peter bypass conduit and many spillways and natural fishways. Anytime velocities exceed the established NMFS criteria designs must carefully consider conduit alignment, risk of shear, how the water and fish are decelerated and uniformity of flow.

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Closure Valves/Flow Control	Closure valves of any type should not be used within the bypass pipe unless specifically approved based on demonstrated fish safety.	Same as NMFS with addition of: Other means of flow control, such as manipulating pipe elevations or the use of overflow weirs may need to be considered.
Deceleration/ Acceleration	No criteria listed for piped bypass	Whenever fish laden water exceeds 30 fps there is an increased risk of fish being exposed to strain rates greater than 500 cm/s/cm ΔY= 1.8cm. Therefore designs that exceed 30 fps should use computer and physical models, or testing under prototype conditions to evaluate any potential injury to fish.
BYPASS OUTFALL		
		Design should follow NMFS criteria. If deviation necessary, model/prototype testing would be required.