

**11.6.1.7 Horizontal Screens:** Horizontal screens have been evaluated as experimental technology, because they operate fundamentally different than conventional vertically oriented screens. This fundamental difference relates directly to fish safety, because when inadequate flow depth exists with vertically oriented screens, there is no potential for fish to get trapped over the screened surface. In contrast, when water level on horizontal screens drops and most or all diverted flow goes through the screens, there is high likelihood that fish will become impinged and killed on the screened surface. In addition, if depths become shallow and flow rate is high over a horizontal screen, the resulting cross-section velocity may be too high to allow fish to swim away from the horizontal screen surface.

Unless specified differently below, general screen and bypass criteria and guidelines specified in section 11 apply for horizontal screens as well. Horizontal screens are considered biologically equivalent to conventional screens only if the following criteria and guidelines are achieved in design and operation:

**11.6.1.7.1 Design Development:** Since site-specific design considerations are required, NMFS engineers must be consulted throughout the development of the horizontal screen design.

**11.6.1.7.2 Hydrologic and Hydraulic Analysis:** The horizontal screen design process must include an analysis to verify that sufficient hydrologic and hydraulic conditions exist in the stream so as not to exacerbate a passage impediment in the stream channel (see Section 4.1), or in the off-stream conveyance, including the screen and bypass. This analysis must conclude that all criteria listed below can be achieved for the entire juvenile outmigration season, as defined by section 3. If the criteria listed below cannot be maintained per this design analysis, a horizontal screen design must not be used at the site. If this analysis concludes that removal of the bypass flow required for a horizontal screen from the stream channel results in inadequate passage conditions or unacceptable loss of riparian habitat, other screen design styles must be considered for the site and installed at the site if adverse effects are appreciably reduced.

**11.6.1.7.3 Screen Geometry:** Horizontal screens must be set at specific slopes and geometry consistent with prototypes approved by NMFS. The screen design must include reference material for an example prototype that confirms the adequacy of the design.

**11.6.1.7.4 Site Limitation:** Horizontal screens must not be installed spanning the entire width of stream or river channels, or in stream or river channels where hydraulic conditions on the screen cannot be maintained as specified below, or where the screen cannot be easily accessed for maintenance. Upstream fish passage must not be impeded by installation of a horizontal screen. In general, very few instream sites may be appropriate for installation of a horizontal screen.

**11.6.1.7.5 Flow Regulation:** For a horizontal screen to be installed, the site must have a good headgate, capable of maintaining sufficiently consistent diversion rates to allow a horizontal screen and bypass to operate within these criteria and guidelines.

**11.6.1.7.6 Channel Alignment:** Horizontal screens must be installed such that the approaching conveyance channel is completely parallel and in line with the screen channel (no skew) such that uniform flow conditions exist at the upstream edge of the screen. A straight channel should exist for at least twenty feet upstream of the leading edge of the horizontal screen, or up to two screen channel lengths if warranted by approach flow conditions in the conveyance channel. Flow conditions that require a longer approach channel include turbulent flow, supercritical hydraulic conditions, or uneven hydraulic conditions in a channel cross section. Horizontal screens must be installed such that a smooth hydraulic transition occurs from the approach channel to the screen channel (no abrupt expansion, contraction, or flow separation).

**11.6.1.7.7 Bypass Flow Depth:** For horizontal screens, the bypass flow must pass over the downstream end of the screen at a minimum depth of one foot.

**11.6.1.7.8 Bypass Flow Amount:** Bypass flow is used for transporting fish and debris across the plane of the screen and through the bypass conveyance back to the stream. Bypass flow amounts must be sufficient to continuously provide the hydraulic conditions specified in this section, and bypass conditions specified in section 11.9. In general, for diversion rates less than 100 cfs, about 15% of the total diverted flow should be used as bypass flow for horizontal screens. For diversion rates more than 100 cfs, about 10% of the total diverted flow should be used for bypass flow for horizontal screens. Small horizontal screens may require up to 50% of the total diverted flow as bypass flow. The amount of bypass flow must be approved by NMFS engineers.

**11.6.1.7.9 Diversion Shut-off:** If inadequate bypass flow exists at any time (per Sections 11.6.1.7.7 and 11.6.1.7.8), the horizontal screen design must include an automated means to shut off the diversion flow, or a means to route all diverted flow back to the originating stream.

**11.6.1.7.10 Sediment Removal:** The horizontal screen design must include means to simply and directly remove sediment accumulations under the screen, without compromising the integrity of the screen while water is being diverted.

**11.6.1.7.11 Screen Approach Velocity:** Screen *approach velocity* is calculated by dividing the maximum flow rate by the *effective screen area*, and must be less than 0.25 ft/s and uniform over the entire screen surface area (see section 15.2). The horizontal screen design must include *approach velocity* and *sweeping velocity* consistent with the prototype example submitted per 11.6.1.7.3. Recent prototype development has demonstrated that better self-cleaning of a horizontal

screen is achieved when the ratio of sweeping velocity and approach velocity exceeds 20:1, and *approach velocities* are less than 0.1 ft/s. If equipped with an automated mechanical screen cleaning system, screen *approach velocity* must be less than 0.4 ft/s and uniform over the entire screen surface area (see section 15.2).

**11.6.1.7.12 Screen Sweeping Velocity:** For horizontal screens, *sweeping velocity* must be maintained or gradually increase for the entire length of screen (see section 11.9.1.8). The design *sweeping velocity* must be consistent with the prototype example submitted per 11.6.1.7.3. Higher *sweeping velocities* may be required to achieve reliable debris removal and to keep sediment mobilized. *Sweeping velocity* should never be less than 2.5 ft/s, or an alternate minimum velocity based on an assessment of sediment load in the water diversion system.

**11.6.1.7.13 Screen Cleaning:** For passive horizontal screens, *approach velocity* and *sweeping velocity* must work in tandem to allow self cleaning of the entire screen face and to provide good bypass conditions. If the proposed design has not been demonstrated to have cleaning capability and hydraulic characteristics similar to a successful prototype, the screen design must include an automated screen cleaning system.

**11.6.1.7.14 Inspection, Maintenance and Monitoring:** Daily inspection and maintenance must occur of the screen and bypass to maintain operations consistent with these criteria. Post construction monitoring of the facility must occur for at least the first year of operation. This monitoring must occur whenever water is diverted, and include an inspection log (in table form) of date and time, water depth at the bypass, debris present on screen (including any sediment retained in the screen openings), fish observed over the screen surface, operational adjustments made, maintenance performed and the observer's name. A copy of the inspection log must be provided annually to the NMFS design reviewer, who will review operations and make recommendations for the next year of operation.