Table A-1. HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	Juveniles: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>Eggs and alevins</u>: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. <u>Juveniles</u>: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.

Table A-1 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chinook Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-2. HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-2 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coho Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-3. HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered substrate composition and stability		Year round	Permanent	Continuous		limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.		
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.

Table A-3 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Chum Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-4. HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-4 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pink Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-5. HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Operations									
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles;	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the	May affect survival at egg, alevin, and juvenile life-history stages. May affect

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered channel geometry	availability and suitability	Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal	Adults	and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	spawning productivity.
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-5 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Sockeye Salmon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-6. HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-6 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Steelhead.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-7. HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	Juveniles: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-7 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Coastal Cutthroat Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-8. HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-8 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Bull Trout and Dolly Varden.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-9. HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles	Eggs and alevins, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential redd scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Alevins Juveniles	Alevins and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and alevins. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and alevins. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and alevins; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and alevins; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased redd dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and alevins; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and alevins; Adults			

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and alevins; Juveniles; Adults	Eggs and alevins: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of redds) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-9 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Westslope Cutthroat and Redband Trout.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-10. HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-10 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pygmy Whitefish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-11. HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-11 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential egg sedimentation, resulting in smothering and decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-11 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-11 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-11 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-11 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	<u>Juveniles</u>: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-11 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered stream bank and shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry	n/a	n/a	n/a	n/a				
	Altered substrate composition and stability	n/a	n/a	n/a	n/a				

Table A-11 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympic Mudminnow.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-12. HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and alevin life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and alevin survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and alevin survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	Juveniles: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Changes in channel morphology, flow velocity, and substrate composition can alter substrate composition and stability, leading to decreased incubation success and alevin survival. Juveniles: Altered channel geometry, flow velocity, and substrate composition can result in decreased rearing habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival. Adults: Changes in channel morphology may lead to alteration of the migratory corridor and a reduction in suitable resting habitat, leading to increased stress and decreased spawning success. Changes in substrate composition and stability resulting from altered channel geometry and flow velocity may lead to decreased spawning success (e.g., through reduction in suitable spawning locations and/or increased scour and/or sedimentation of eggs) if potential spawning habitat is affected.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival at egg, alevin, and juvenile life-history stages. May affect spawning productivity.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				

Table A-12 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Umatilla and Leopard Dace, Lake Chub, Mountain Sucker, and Mottled Sculpin.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Juveniles; Adults	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Juveniles: Loss of access to favorable upstream or downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats. Juveniles may be denied the ability to migrate downstream in certain circumstances. Juveniles may also exert excess energy and incur injury attempting to navigate a barrier condition. These stressors may lead to decreased survival, growth, and fitness. Adults: Loss of access to suitable spawning habitats will result in decreased spawning productivity. Attempts to navigate barrier conditions may lead to excess exertion and possible injury. These combined stressors may lead to decreased survival and decreased spawning fitness and productivity. All exposed life-history stages: Partial barriers to fish passage may impose selection pressures that affect the diversity of the affected population. This in turn may affect the evolutionary fitness of the stock, with broad implications for population productivity and diversity.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, alevin, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-13. HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and ammocoetes; Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	Effects of underwater noise on lampreys are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Transforming adults; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Transforming adults; Adults	All life-history stages: Very little is known of the effects of pile-driving sounds on lamprey at any life-history stage.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	Effects of underwater noise on lampreys are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	All expose life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Mortality, injury, or stress from capture, handling, and relocation. Egg and ammocoetes relocation is impractical, likely leading to mortality. Adults and transforming adults: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of transforming adults and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults	Eggs and ammocoetes, transforming adults: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when transforming adults are present.	May cause direct mortality or injury at transforming adult life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential egg scour and/or sedimentation, resulting in decreased incubation success. Transforming adults: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and ammocoetes life-history stages; may affect transforming adult growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and ammocoetes; Transforming adults; Adults	Eggs and ammocoetes: Potential decreased egg incubation success and ammocoetes survival due to turbidity exposure and substrate disturbance. Transforming adults: Stress and behavioral modifications by rearing transforming adults exposed to sediment pulses, migration delay, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at transforming adult life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	n/a	n/a	Lamprey are not dependent on invertebrates for prey. Therefore this stressor will have no effect.
		Loss of habitat access (during construction and maintenance or coffer dam placement)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Potential decreased egg incubation success and amocoetes survival due to water loss and stranding. Transforming adults: Barrier to migration, loss of habitat accessibility, stranding, migration delay, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Transforming adults; Adults	Transforming adults and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Direct injury or mortality from dredging entrainment. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct mortality or injury of eggs and amocoetes. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Amocoetes; Transforming adults; Adults	Amocoetes: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). May affect survival, growth, and fitness. Adults and transforming adults: Increased stress and exertion, leading to decreased survival and, in the case of adults, spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect survival, growth, and fitness across amocoetes, transforming adult, and adult life history stages. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Amocoetes; Transforming adults; Adults	All exposed life history stages: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following stranding in or discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause injury or mortality across amocoetes, transforming adult, and adult life history stages. Multiple stressors may lead to decreased survival and fitness across all exposed life history stages.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Turbidity sufficient to cause burial may lead to decreased survival of eggs and amocoetes. Transforming adults and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Eggs and amocoetes; Transforming adults; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	Transforming adults and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of transforming adults and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	All expose life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and amocoetes; Transforming adults; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased egg dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and amocoetes; Transforming adults; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Transforming adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and amocoetes; Adults			

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when Transforming adults occupy nearshore habitats for rearing)	Permanent	Continuous	Transforming adults	All exposed life history stages: The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Transforming adults		Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Transforming adults; Adults		Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Transforming adults		Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	Eggs and amocoetes: Turbidity sufficient to cause burial may lead to decreased survival of eggs and amocoetes. Transforming adults and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating Eggs and amocoetes. May affect transforming adult growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Eggs and amocoetes; Transforming adults; Adults	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Eggs and amocoetes; Transforming adults; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Transforming adults; Adults	Transforming adults and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of transforming adults and adults.

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and amocoetes; Transforming adults; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities. Maintain mechanical components to prevent leakage and/or spills.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and amocoetes; Transforming adults; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Effects of stressor exposure are expected to be negligible relative to the effects of intake/diversion related channel modifications and water withdrawals.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased egg dissolved oxygen; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and amocoetes; Transforming adults; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Transforming adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Transforming adults; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and amocoetes; Adults			

Table A-13 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Brook, River, and Pacific Lamprey.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and amocoetes; Transforming adults; Adults		Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Transforming adults; Adults		Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Transforming adults; Adults		Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	

Table A-14. HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	All exposed life-history stages: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae, juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential egg scour and/or sedimentation, resulting in decreased incubation success. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to turbidity exposure and substrate disturbance. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	Juveniles: Short-term reduction in foraging opportunity, increased competition, decreased growth and fitness.	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile life-history stage.

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to migration, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; egg smothering decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Juveniles	Juveniles: Juvenile migration and dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles;	All exposed life history stages: Thermal stress, physiological injury or mortality from acute temperature exposure	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality.

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles;	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; egg smothering; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	n/a	n/a	n/a	n/a	Riverine systems supporting sturgeon spawning and larval rearing are expected to be insensitive to the potential hydraulic and geomorphic effects of off-channel fish screens.	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				

Table A-14 (continued). HPA HCP Fish Screen Exposure and Response Matrix for White and Green Sturgeon.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to downstream dispersal imposing the following stressors: ▪ Inability to access otherwise suitable rearing habitats ▪ Increased predation exposure	Seasonal to year-round (depending on the nature of the barrier condition)	Permanent	Continuous	Larvae; Juveniles;	The effects of fish screens on passage conditions are usually minor in comparison to the effects of the flow control or diversion structure. However, off-channel screens can create effects on fish passage through several mechanisms. Should these stressors occur, the following effects may be realized: Larvae and juveniles: Impaired dispersal to favorable downstream rearing habitats will increase competition for remaining suitable areas, and force individuals to occupy marginal habitats.	Require assessment of the hydraulic effects of the project before permitting and require consideration of the full range of fish passage needs in design. Incorporate monitoring and maintenance requirements into the HPA.	May affect survival at egg, larval, and juvenile life-history stages. May affect adult survival and spawning productivity. May affect population productivity and diversity.
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness of rearing juveniles. Decreased habitat complexity caused by reduced LWD density can affect the availability and suitability of adult resting and spawning and juvenile rearing habitat. Decreased habitat complexity may have additional effects on food web productivity.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	May affect juvenile survival, growth, and fitness. May affect adult spawning fitness and productivity.

Table A-15. HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at all life-history stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Mortality, injury, or stress from capture, handling, and relocation. Egg relocation is impractical, likely leading to mortality. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully. Juveniles: Increased competition once relocated, reduced growth and fitness, and increased predation exposure. Adults: Delayed migration resulting in decreased fitness and spawning success.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Injury or mortality from entrainment or impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	May cause direct mortality or injury at juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Potential dispersal to unfavorable rearing areas. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Stream bed disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Stress, injury, decreased feeding success. Juveniles: Stress and behavioral modifications by rearing juveniles exposed to sediment pulses, migration delay, reduced foraging opportunities, and increased predation risk. Adults: Stress and behavioral modifications by adults exposed to sediment pulses. Potential migration delay, leading to reduced spawning productivity.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	May affect growth and fitness at larval and juvenile life-history stage. May affect adult fitness and spawning productivity.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles	This effect is not expected to be significant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or exclusion removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Adults	Adults: Decreased access to potential spawning habitat.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect adult spawning fitness and productivity.

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Larvae; Juveniles; Adults	Larvae and juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance, decreased foraging success. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; egg smothering; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Riverine								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Eggs and larvae; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Marine and Lacustrine								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>Larvae</u>: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Visual and physical disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered ambient noise levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Bank/shoreline/channel disturbance, resulting in increased sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Exposure to toxic chemicals from accidental spills	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	Fish removal, relocation, and exclusion	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment in pumps or impingement on pump screens	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Altered current and circulation conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Stream bed disturbance, increased turbidity (associated with site rewatering)	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Localized alteration in invertebrate abundance	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	n/a	n/a	n/a	n/a	n/a	n/a	n/a
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	n/a	n/a	n/a	n/a	Off-channel screen systems are not expected to be in operation during periods when eulachon and smelt spawning are present	n/a	n/a
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	n/a	n/a	n/a	n/a		n/a	n/a

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to direct mortality and decreased survival of eggs and larvae. Adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Increased water temperatures	Thermal stress	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	Decreased DO levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Adults	Adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect juvenile survival and fitness. May affect adult survival and spawning productivity.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Eggs and larvae; Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered stream bank and shoreline stability	Increased suspended solids; egg smothering; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	n/a	n/a	n/a	n/a	Riverine systems supporting eulachon and smelt spawning are expected to be insensitive to the potential hydraulic and geomorphic effects of off-channel fish screens.	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to downstream dispersal imposing the following stressors: ▪ Inability to access otherwise suitable rearing habitats ▪ Increased predation exposure	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-15 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Eulachon and Longfin Smelt.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-16. HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Eggs and Larvae; Juveniles; Adults	<u>Eggs and larvae:</u> Injury or mortality from mechanical injury. <u>Juveniles and adults</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause egg and larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>Eggs and larvae</u>: Injury or mortality probable during dewatering, capture and relocation impractical. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-16 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life history stages: Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae: Potential decreased egg survival due to temperature effects. Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life history stages: See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to dispersal, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.

Table A-16 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

Table A-16 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-16 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>Larvae</u>: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-16 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			

Table A-16 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Surf Smelt and Sand Lance.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry	n/a	n/a	n/a	n/a				
	Altered substrate composition and stability	n/a	n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-17. HPA HCP Fish Screen Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Rupture of egg membrane. ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Eggs and Larvae; Juveniles; Adults	<u>Eggs and larvae:</u> Injury or mortality from mechanical injury. <u>Juveniles and adults</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause egg and larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.

Table A-17 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Injury or mortality probable during dewatering, capture and relocation impractical. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life history stages: Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles	Eggs and larvae: Potential decreased egg survival due to temperature effects. Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	All exposed life history stages: See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to dispersal, loss of habitat accessibility, stranding, migration delay, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality. Adults: Potential migration barrier and delay, leading to reduced spawning productivity, foraging success. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.

Table A-17 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	Eggs and larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of eggs and larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating eggs and larvae. May affect juvenile growth and fitness and adult productivity and spawning success.

Table A-17 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Eggs and larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Eggs and larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Eggs and larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-17 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>Larvae</u>: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-17 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Pacific Herring.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-18. HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Larvae; Juveniles; Adults	<u>Larvae:</u> Injury or mortality from mechanical injury. <u>Juveniles and adults</u>: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause egg and larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>Adults and juveniles</u>: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	<u>Larvae</u>: Injury or mortality probable during dewatering, capture and relocation impractical. <u>Adults and juveniles</u>: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-18 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life history stages: Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae: Potential decreased egg survival due to temperature effects. Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life history stages: See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles;	Larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to dispersal, loss of habitat accessibility, stranding, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.

Table A-18 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, and increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

Table A-18 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Larvae; Juveniles	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles			
	Altered groundwater–surface water exchange	Reduced available suitable rearing habitat	Year-round	Permanent	Continuous	Larvae;			

Table A-18 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects of screens are expected to be insignificant relative to the effects of intakes or diversions they are associated with.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Altered dispersal patterns	Altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>Larvae</u>: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid potential effects on larval dispersal patterns. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-18 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Lingcod.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-19. HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Larvae; Juveniles	Larvae: Injury or mortality from mechanical injury. Juveniles and adults: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause egg and larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles	Juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae: Injury or mortality probable during dewatering, capture and relocation impractical. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-19 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life history stages: Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae: Potential decreased egg survival due to temperature effects. Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during egg and larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life history stages: See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows. Avoid work during egg incubation periods.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles;	Larvae: Potential decreased egg incubation success and larval survival due to water loss and stranding. Juveniles: Barrier to dispersal, loss of habitat accessibility, stranding, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	Juveniles: Decreased foraging opportunity due to short-term reduction in prey abundance. Decreased growth and fitness. All life-history stages: See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May affect juvenile survival, growth, and fitness. See effects for related stressors on all life-history stages under Water Quality Modifications.

Table A-19 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, and increased predation exposure.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.

Table A-19 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	<u>All expose life-history stages:</u> Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Larvae; Juveniles	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Adults			

Table A-19 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	Effects of screens are expected to be insignificant relative to the effects of intakes or diversions they are associated with.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Altered dispersal patterns	Altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>Larvae</u>: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid potential effects on larval dispersal patterns. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-19 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Hake, Pacific Cod, and Pollock.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-20. HPA HCP Fish Screen Exposure and Response Matrix for Rockfish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles; Adults	All exposed life-history stages: Stressor response dependent on noise magnitude and project-specific environmental conditions; may range from: ▪ Fatal injury from barotrauma or permanent auditory tissue damage limiting to survival ▪ Increased predation risk and decreased foraging success due to auditory masking and/or temporary hearing threshold effects that increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and prey ▪ Increased exertion due to behavioral responses (e.g., startle and flight) and habitat avoidance, leading to decreased growth and fitness.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable. Conduct construction and maintenance work within a dewatered exclusion area where practicable.	May affect survival at larval, juvenile, and adult stages, depending on project-specific noise intensity and receptor exposure. May cause direct mortality or injury.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Larvae; Juveniles; Adults	Larvae: Injury or mortality from mechanical injury. Juveniles and adults: Startle responses, increased stress. Behavioral avoidance of affected habitats while disturbance is ongoing.	Limit disturbance-causing activities to in-water work windows when affected species is least likely to be present.	May cause larval injury or mortality. May affect juvenile and adult behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	Adults and juveniles: Auditory masking or temporary hearing threshold effects may increase risk of predation and/or decrease foraging efficiency due to decreased ability to sense predators and/or prey.	Promote use of equipment equipped with antinoise/antivibration technology where practicable.	May affect survival, growth, and fitness due to avoidance behavior, decreased foraging success, and increased predation risk.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae: Injury or mortality probable during dewatering, capture and relocation impractical. Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Risk of mortality from stranding if fish cannot be captured and relocated successfully.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness, and adult spawning productivity.

Table A-20 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Rockfish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	All exposed life history stages: Injury or mortality from pump entrainment or screen impingement.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval and juvenile mortality.	May cause direct mortality or injury at larval and juvenile life-history stage. Injury and stress may affect survival, growth, and fitness.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae: Potential for larval dispersal to unsuitable rearing areas, increased predation/starvation risk. Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life-history stages; may affect juvenile growth and fitness; may affect adult spawning productivity.
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	All exposed life history stages: See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Effects are expected to be insignificant.	Limit area of dewatering to the greatest extent practicable.	Effects are expected to be insignificant.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles	Larvae and juveniles: Potential decreased larval survival due to water loss and stranding. Barrier to dispersal, loss of habitat accessibility, reduced foraging opportunities, increased predation risk. Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect growth and fitness at juvenile life-history stage, survival at all life-history stages, adult spawning fitness and productivity.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles	Juveniles: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles	These effects are expected to be insignificant at the scale of construction related activities expected.	Avoid turbidity effects above background levels.	These effects are expected to be insignificant at the scale of construction related activities expected.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.

Table A-20 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Rockfish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae Juveniles	Larvae and juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from entrainment through bypass systems. Increased predation risk from temporary disorientation following discharge from bypass systems. Direct injury or mortality from screen impingement or bypass system entrainment. Mortality from entrainment into intake system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Turbidity sufficient to cause fine sediment embeddedness may lead to decreased survival of larvae. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may cause behavioral alteration (e.g., avoidance responses) leading to increased territoriality, reduced foraging opportunity, increased predation exposure, and altered migration behavior. Adults: Reduction in suitable spawning habitat (due to substrate embeddedness) and reduced spawning success.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae. May affect juvenile growth and fitness and adult productivity and spawning success.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-20 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Rockfish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Larvae; Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	May affect behavior and distribution. May affect survival, growth, and fitness during juvenile rearing for intermediate-term period.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Adults			

Table A-20 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Rockfish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>Larvae</u>: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-20 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Rockfish.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-21. HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Veliger larvae; Juveniles, Adults	All life history stages: Visual disturbance is not expected to have significant effects. Physical disturbance may lead to mechanical injury or mortality.	Avoid project siting in oyster habitat.	May cause direct injury or mortality.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Veliger larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.	Effect of increased ambient noise level on Olympia oyster is a data gap.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae; Juveniles; Adults	Veliger larvae, juveniles: Removal and relocation may be impractical. Stranding and exposure may lead to mortality. Adults: Temporary behavioral effects may occur as a result of relocation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows.	May cause juvenile and larval mortality. May alter adult behavior, with insignificant effects on fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae	Veliger larvae: Injury or mortality may occur as a result of pump entrainment, or impingement on intake screens.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval mortality.	May cause larval injury or mortality.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Veliger larvae	Veliger larvae: May affect dispersal and retention in areas favorable for rearing.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life-history stages.

Table A-21 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All exposed life history stages: See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	This stressor is not expected to have any significant effect on this species.	n/a	No significant effects expected.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	All exposed life history stages: May affect habitat suitability for this species, leading to effects on survival, growth and fitness.	Avoid project siting in sensitive habitats	May affect survival, growth and fitness.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Veliger larvae; Juveniles; Adults	These effects are expected to be insignificant at the scale of construction related activities expected.	Avoid turbidity effects above background levels.	These effects are expected to be insignificant at the scale of construction related activities expected.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Veliger larvae; Juveniles; Adults	All life history stages: No significant effects are expected from visual and physical disturbance related to operations. The effects of anthropogenic noise on this species is a data gap.	Avoid project siting in oyster habitat.	Expected effects are insignificant or unknown.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Veliger Larvae	Veliger larvae: Injury and or mortality from entrainment into intake systems or impingement on screens.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen.	May cause larval injury or mortality.
	Water Quality Modifications								
	Elevated suspended sediments	Smothering, decreased feeding effectiveness, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	Veliger larvae: Turbidity sufficient to impact feeding effectiveness may lead to decreased survival of larvae. May affect larval settlement. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may affect feeding effectiveness.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect larval survival of incubating larvae. May affect juvenile and adult growth and fitness.

Table A-21 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All exposed life history stages: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause mortality or affect survival and fitness of all exposed life history stages.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Veliger larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	The effects of this stressor at expected magnitudes are expected to be insignificant.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Adults			

Table A-21 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Veliger larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Veliger larvae	<u>Veliger larvae</u>: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-21 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Olympia Oyster.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-22. HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on this species is a data gap.	Effect of increased ambient noise level on Northern abalone is a data gap.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Larvae; Juveniles, Adults	All life history stages: Visual disturbance is not expected to have significant effects. Physical disturbance may lead to mechanical injury or mortality.	Avoid project siting in abalone habitat.	May cause direct injury or mortality.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Larvae; Juveniles, Adults	All life-history stages: Effect of anthropogenic sound is a data gap.	Effect of increased ambient noise level on Northern abalone is a data gap.	Effect of increased ambient noise level on Northern abalone is a data gap.
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All life-history stages: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause mortality.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect survival of incubating larvae and juveniles. May affect juvenile productivity and adult productivity.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modifications.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae; Juveniles; Adults	Larvae, juveniles: Removal and relocation may be impractical. Stranding and exposure may lead to mortality. Adults: Temporary behavioral effects may occur as a result of relocation.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows.	May cause juvenile and larval mortality. May alter adult behavior, with insignificant effects on fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Larvae: Injury or mortality may occur as a result of pump entrainment, or impingement on intake screens.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present. Use low velocity Hidtrostal pumps for dewatering to limit larval mortality.	May cause larval injury or mortality.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Larvae	Larvae: May affect dispersal and retention in areas favorable for rearing.	Limit alteration of flow conditions to minimal area.	May affect survival during larval life-history stages.

Table A-22 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All exposed life history stages: See response to related stressors under Water Quality Modification.	Adhere to system-specific in-water work windows.	See effects for related stressors under Water Quality Modifications.
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	This stressor is not expected to have any significant effect on this species.	n/a	No significant effects expected.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a	n/a	n/a	n/a
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	All exposed life history stages: May affect habitat suitability for this species, leading to effects on survival, growth and fitness.	Avoid project siting in sensitive habitats	May affect survival, growth and fitness.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Larvae; Juveniles; Adults	These effects are expected to be insignificant at the scale of construction related activities expected.	Avoid turbidity effects above background levels.	These effects are expected to be insignificant at the scale of construction related activities expected.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Larvae; Juveniles; Adults	All life history stages: No significant effects are expected from visual and physical disturbance related to operations. The effects of anthropogenic noise on this species is a data gap.	Avoid project siting in abalone habitat.	Expected effects are insignificant or unknown.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Larvae	Larvae: Injury and or mortality from entrainment into intake systems or impingement on screens.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen.	May cause larval injury or mortality.
	Water Quality Modifications								
	Elevated suspended sediments	Smothering, decreased feeding effectiveness, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	Larvae: Turbidity sufficient to impact feeding effectiveness may lead to decreased survival of larvae. May affect larval settlement. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes). Moderate to high turbidity may affect feeding effectiveness.	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect larval survival of incubating larvae. May affect juvenile and adult growth and fitness.

Table A-22 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All exposed life history stages: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause mortality or affect survival and fitness of all exposed life history stages.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Larvae; Juveniles; Adults	All expose life-history stages: Construction and operation may lead to introductions of toxic substances through accidental spills or other pathways. Impoundments may attract increased recreational vessel activity, creating a pathway for chronic exposure to hydrocarbons and other contaminants. Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Northern abalone are expected to be relatively insensitive to riparian vegetation modification. Further, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	The effects of this stressor at expected magnitudes are expected to be insignificant.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Larvae; Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Larvae; Adults			

Table A-22 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Larvae; Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>Larvae</u>: Larval dispersal to favorable rearing habitats may be delayed by screen and or bypass configuration. This may lead to effects on growth and fitness that could effect survival	Carefully site screen intakes and bypass systems to avoid migration delay effects. Ensure that approach and bypass attraction velocity criteria are suitable for the species in question.	May affect growth and fitness at juvenile life history stage, with potential effects on survival.
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-22 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Northern Abalone.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-23. HPA HCP Fish Screen Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	n/a	Habitats used by this species are restricted to a narrow band littorine and riparian terrestrial vegetation and is therefore not exposed to aquatic impacts from fish screen construction. Impacts associated with project siting are associated with intake or diversion.	n/a	n/a
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	n/a		n/a	n/a
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	n/a		n/a	n/a
		Bank/shoreline disturbance resulting in increased suspended sediments.	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
	Dewatering and handling	Removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Nearshore disturbance, increased turbidity (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Localized alteration in invertebrate abundance	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	n/a		n/a	n/a

Table A-23 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	All exposed life history stages: May affect habitat suitability for this species. Loss of obligate *Salicorna* spp. habitat would be expected to decrease survival, growth, and fitness.	Avoid project siting in sensitive habitats	May affect survival, growth and fitness.
		Entrainment of benthic organisms, increased suspended solids, resuspension of contaminated sediments	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	n/a	Habitats used by this species are restricted to a narrow band littorine and riparian terrestrial vegetation and is therefore not exposed to aquatic impacts from fish screen operation.	n/a	n/a
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress and disorientation from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	n/a		n/a	n/a
	Water Quality Modifications								
	Elevated suspended sediments	Smothering, decreased feeding effectiveness, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	n/a	n/a	n/a	n/a
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	n/a	n/a	n/a	n/a
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: May cause injury, mortality or physiological effects on organisms exposed to pollutants at littorine fringe.	Employ appropriate BMPs during construction to avoid accidental spills and/or minimize their extent. Require a spill control and containment plan for construction activities. Encourage improved management of recreational uses to limit introductions of toxic substances from these sources.	May cause injury or mortality. May affect survival, growth, and fitness at all exposed life-history stages.

Table A-23 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	May affect habitat suitability for this species. Loss of obligate *Salicorna* spp. habitat would be expected to decrease survival, growth, and fitness. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	The effects of this stressor at expected magnitudes are expected to be insignificant.
	Altered shoreline stability	Increased suspended solids; nest disturbance; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Adults			

Table A-23 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered wave energy	Change in habitat structure and habitat suitability; reduced food web complexity, habitat availability, and suitability	Year-round (with stressor exposure occurring in spring and summer when juveniles occupy nearshore habitats for rearing)	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on sediment supply, longshore drift patterns, and wave energy and current patterns.	May affect survival, growth, and fitness at juvenile life-history stage. Decreased fitness may affect survival and productivity during ocean migration life-history phase.
	Altered current velocities		Year-round (with variable effects depending on site-specific current dynamics and project configuration)	Permanent	Intermittent				
	Altered substrate composition and stability		Year-round (beginning with project installation and becoming more pronounced over time	Permanent	Continuous				
	Altered groundwater-surface water exchange		Year-round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	During intake operation.	Permanent	Continuous	Larvae	<u>n/a</u>	n/a	n/a
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dewatering and handling	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Dredging and fill	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Operations								
	Visual, physical, and noise related disturbance	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Entrainment and impingement	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-23 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Newcomb's Littorine Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Water Quality Modifications								
	Increased suspended solids	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Increased water temperatures	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered dissolved oxygen levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered pH levels	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Introduction of toxic substances (PAHs, metals, organic pollutants)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered shoreline stability	n/a	n/a	n/a	n/a	n/a			
	Altered allochthonous inputs	n/a	n/a	n/a	n/a	n/a			
	Altered habitat complexity	n/a	n/a	n/a	n/a	n/a			
	Altered groundwater–surface water exchange	n/a	n/a	n/a	n/a	n/a			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Altered channel geometry		n/a	n/a	n/a				
	Altered substrate composition and stability		n/a	n/a	n/a				
	Ecosystem Fragmentation								
	Passage barriers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table A-24. HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	The effects of exposure to this stressor are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses (withdrawal into shell), delayed feeding. Behavioral avoidance of affected habitats while disturbance is ongoing.	No specific recommendations	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juvenile capture and relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Risk of entrainment for these species is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles</u>: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. <u>Adults</u>: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>Juveniles and adults</u>: Stress and behavioral modifications when exposed to sediment pulses, reduced foraging effectiveness.	Adhere to system-specific in-water work windows. Avoid work during sensitive spawning periods.	May affect juvenile and adult growth and fitness at juvenile life-history stage.

Table A-24 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juvenile and adults: Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May cause injury or mortality in all exposed life history stages.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	All life-history stages: Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	All exposed life history stages: The effects of operational stressors on these species are a data gap.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	Effects of stressor exposure are unknown.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Juveniles; Adults	All exposed life history stages: Injury or mortality from impingement on or entrainment through the screen. Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Stress from passage through bypass systems.	Evaluate flow through velocities and screen mesh characteristics for potential effects on these species.	May cause injury or mortality. May affect survival, growth, and fitness.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Spire snails belong to the Hydrobiidae, a family of snails having gills. The gill tissue is sensitive to injury or clogging by elevated suspended sediment levels. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect adult and juvenile survival, growth and fitness.

Table A-24 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All expose life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Stressor magnitude expected to be limited and the effects of exposure attributable to fish screens insignificant.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults			

Table A-24 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	The effects of exposure to this stressor are unknown.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Juveniles; Adults	<u>All exposed life-history stages</u>: Startle responses (withdrawal into shell), delayed feeding. Behavioral avoidance of affected habitats while disturbance is ongoing.	No specific recommendations	May affect behavior.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	The effects of underwater noise on spire snail and giant Columbia River limpet are a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All exposed life-history stages</u>: See responses to related stressors under Water Quality Modifications.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modifications.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	<u>All expose life-history stages:</u> Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	See effects for related stressors under Water Quality Modifications.

Table A-24 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Adults and juveniles: Mortality, injury, or stress from capture, handling, and relocation. Juvenile capture and relocation is impractical, likely leading to mortality.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts.	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Risk of entrainment for these species is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles: Altered habitat suitability, increased stress, increased competition, decreased growth and fitness. Adults: Delayed migration, increased stress, decreased spawning fitness.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Stress and behavioral modifications when exposed to sediment pulses, reduced foraging effectiveness.	Adhere to system-specific in-water work windows. Avoid work during sensitive spawning periods.	May affect juvenile and adult growth and fitness at juvenile life-history stage.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Loss of habitat access (during construction and maintenance or dam removal)	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juvenile and adults: Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May cause injury or mortality in all exposed life history stages.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: Decreased growth and fitness due to loss a food resources (scouring of periphyton caused by bed disturbance).	Limit area of dewatering to the greatest extent practicable.	May affect growth and fitness at juvenile and adult life history stage.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	All life-history stages: Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.

Table A-24 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	Juveniles: Increased stress and exertion, avoidance of otherwise suitable habitats (intermittent stressors). Habituation to auditory masking effects, leading to increased predation exposure and decreased foraging efficiency. May affect survival, growth, and fitness. Adults: Increased stress and exertion, leading to decreased survival and spawning fitness.	Select screen designs that employ passive clearing where practicable. Where mechanical screens and debris clearing systems are necessary, select designs that limit mechanical noise.	May affect juvenile survival, growth, and fitness. May affect adult survival and spawning productivity.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Juveniles	Juveniles: Increased stress and exertion when avoiding entrainment/impingement, leading to decreased survival, growth, and fitness. Direct injury or mortality from impingement on screens or in debris clearing mechanisms, or entrainment in bypass or trash collection systems with cleared debris. Mortality from entrainment into diversion system.	Employ conservative design parameters as necessary to avoid entrainment or impingement of the smallest, weakest swimming species likely to be exposed to the screen. Site bypass system outfalls at locations that deter predator loitering and reduce risk of predation.	May cause juvenile injury or mortality. May affect juvenile survival, growth, and fitness.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Spire snails belong to the Hydrobiidae, a family of snails having gills. The gill tissue is sensitive to injury or clogging by elevated suspended sediment levels. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect adult and juvenile survival, growth and fitness.
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	Adults and juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality. May affect survival, growth, and fitness.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality. May affect survival, growth and fitness.

Table A-24 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect survival, growth and fitness.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Stressor magnitude expected to be limited and the effects of exposure attributable to fish screens insignificant.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			

Table A-24 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Giant Columbia River Limpet and Great Columbia River Spire Snail.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth and fitness at all exposed life history stages.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Passage barriers	Complete or partial barriers to upstream or downstream fish passage imposing the following stressors: ▪ Inability to access otherwise suitable rearing or spawning habitats ▪ Energy exertion or injury during attempts to navigate barrier condition ▪ Increased predation exposure ▪ Run-timing, size, or life-history specific barrier conditions that impose a selection pressure on the affected population	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness. The magnitude of this stressor resulting from fish screen operation is expected to be insignificant.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	Effects of stressor exposure are expected to be insignificant.

Table A-25. HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
In-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	All life-history stages: The effect of construction noise on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater= native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	This is a data gap for these species. However, effects on host fish species for glochidia larvae will affect population productivity of this species. This indirect effect applies to all stressors.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	All life-history stages: The effect of visual and physical disturbance on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/ antivibration technology where practicable.	The effects of exposure to this stressor are unknown.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	All life-history stages: The effect of altered ambient noise levels on California floater and western ridged mussels is a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia: Capture and removal of larvae impractical, high likelihood of larval mortality. Adults and juveniles: Adults appear insensitive to handling stress, however inadvertent dispersal when relocated can affect population productivity. Juvenile sensitivity to handling stress unknown. These species are also sensitive to effects on host fish.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows	May cause larval mortality. May affect adult population productivity. Effects on host fish may also affect population productivity.

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia: High likelihood of mortality from pump entrainment or impingement on screen filters. Juveniles and adults: Risk of entrainment for juveniles and adults is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	High likelihood of larval mortality from entrainment or impingement. The effects of juvenile and adult exposure to this stressor are expected to be low. Effects on host fish will indirectly affect population productivity.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: Potential downstream sedimentation, resulting in decreased downstream habitat suitability, decreased dissolved oxygen levels, reduced food resource availability, and reduced suitable habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect survival in all life stages.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows.	May affect survival at juvenile and adult life-history stages.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	See effects for related stressors under Water Quality Modifications.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. Juvenile and adults: Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	May affect survival in all life stages.
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochida; Juveniles; Adults	Glochidia: Direct injury or mortality from dredge entrainment. Juveniles and adults: Effects of stressor exposure vary from mortality due to mechanical injury, burial and starvation, to behavioral alteration depending on nature of dredging activity. Inadvertent dispersal may affect population productivity. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications. Effects on host fish may also lead to indirect effects on population productivity.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	All life-history stages: Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	All exposed life history stages: The effects of operational stressors on these species are a data gap.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	Effects of stressor exposure are unknown.
	Entrainment and impingement	Stress, exertion, mechanical injury from impingement; stress from entrainment through bypass systems; entrainment losses from ineffective screening.	During screen operation	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Entrainment through screens is likely, leading to mortality. However this effect is attributable to the diversion and limitations of screen design, rather than the screen itself. Juveniles and adults: Being sessile benthic species, mussels are expected to be insensitivity to these stressors once attached to the substrate.	Evaluate flow through velocities and screen mesh characteristics for potential effects on these species.	No effect expected.
	Water Quality Modifications								
	Elevated suspended sediments	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Gill tissue in these species is sensitive to injury or clogging by elevated suspended sediment levels. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect adult and juvenile survival, growth and fitness.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Limit nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May affect survival and fitness of juveniles and adults.
	Introduction of toxic substances	Intoxication, physiological injury	Dependent on contributing mechanism of impact	Temporary to long-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	All expose life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Require TESC plan for all construction and maintenance activities.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Stressor magnitude expected to be limited and the effects of exposure attributable to fish screens insignificant.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Juveniles; Adults			

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	<u>All exposed life history stages:</u> The effects of in-channel screens on hydraulic and geomorphic conditions are expected to be negligible in most circumstances. Larger permanent in-channel screen structures have the potential to impose some effects, but as these structures are integrated with the diversion or intake structures they are associated with, the effects are ascribed to those structures rather than the screens.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	Effects from in-channel screens are expected to be insignificant relative to the influence of the associated flow control structure and water withdrawal.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Delayed migration, altered dispersal patterns	Delayed migration or altered dispersal to suitable habitats, retention in areas unfavorable for rearing.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Off-Channel Screens									
	Construction and Maintenance Activities								
	Equipment operation and materials placement	Increased underwater noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Glochidia larvae; Juveniles; Adults	<u>All life-history stages</u>: The effect of construction noise on California floater and western ridged mussels at any life-history stage is a data gap. Any potential impact would likely occur on the host fish species for the glochidia larvae (California floater= native minnows; western ridge = coldwater stream fish such as trout and salmon).	Avoid pile-driving noise in excess of impact thresholds established by NOAA Fisheries and USFWS in habitats used by species. Limit pile driving to in-water work windows. Use double-confined bubble curtain to reduce sound pressure, or work within confined or dewatered work areas. Encourage use of vibratory hammers and wooden pilings where practicable.	<u>This is a data gap for these species.</u> However, effects on host fish species for glochidia larvae will affect population productivity of this species. This indirect effect applies to all stressors.
		Visual and physical disturbance	During project construction and maintenance activities	Temporary	Interannual to decadal (during construction and maintenance)	Glochidia larvae; Juveniles, Adults	<u>All life-history stages</u>: The effect of visual and physical disturbance on California floater and western ridged mussels is a data gap.	Although little is known on the effects of anthropogenic sounds on California floater and western ridged mussels, it is prudent to avoid/minimize cavitation to limit noise intensity. Promote use of equipment equipped with antinoise/ antivibration technology where practicable.	The effects of exposure to this stressor are unknown.
		Altered ambient noise levels	During project construction and maintenance activities	Temporary (auditory masking) to short-term (hearing threshold effects)	Interannual to decadal (during project construction and maintenance)	Juveniles; Adults	<u>All life-history stages</u>: The effect of altered ambient noise levels on California floater and western ridged mussels is a data gap.	Employ appropriate BMPs to insulate surface waters from equipment noise and vibration occurring over extended periods.	The effects of exposure to this stressor are unknown.

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
		Bank/shoreline/channel disturbance, resulting in increased sediments	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit area of disturbance to the greatest extent practicable. Follow established protocols for erosion control during construction.	See effects for related stressors under Water Quality Modification.
		Exposure to toxic chemicals from accidental spills	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All exposed life-history stages: See responses to related stressors under Water Quality Modification.	Limit spills to the greatest extent practicable. Follow established protocols for erosion control and chemical containment during construction.	See effects for related stressors under Water Quality Modification.
	Dewatering and handling	Fish removal, relocation, and exclusion	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia: Capture and removal of larvae impractical, high likelihood of larval mortality. Adults and juveniles: Adults appear insensitive to handling stress, however inadvertent dispersal when relocated can affect population productivity. Juvenile sensitivity to handling stress unknown. These species are also sensitive to effects on host fish.	Use protocols established by NOAA Fisheries and WDFW/WSDOT to avoid and minimize impacts. Adhere to in-water work windows	May cause direct injury or mortality of juveniles and adults. Stress may affect survival, growth, and fitness.
		Entrainment in pumps or impingement on pump screens	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia; Juveniles; Adults	Glochidia: High likelihood of mortality from pump entrainment or impingement on screen filters. Juveniles and adults: Risk of entrainment for juveniles and adults is currently unknown, but is anticipated to be low.	Install and maintain pump screens consistent with WDFW protocols. Adhere to system-specific in-water work windows; avoid use when juveniles are present.	The effects of exposure to this stressor are unknown.
		Altered flow conditions	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochidia larvae; Juveniles; Adults	All life-history stages: Potential downstream sedimentation, resulting in decreased downstream habitat suitability, decreased dissolved oxygen levels, reduced food resource availability, and reduced suitable habitat; decreased fitness, growth, and productivity.	Limit alteration of flow conditions to minimal area.	May affect adult and juvenile growth and fitness.
		Stream bed disturbance (associated with site rewatering)	During project construction and maintenance activities	Temporary	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	Juveniles and adults: Mortality from increased sedimentation.	Adhere to system-specific in-water work windows.	May affect juvenile and adult growth and fitness at juvenile life-history stage.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Juveniles; Adults	All life-history stages: See responses to related stressors under Water Quality Modifications.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering and rewatering.	May affect growth and fitness at juvenile and adult life history stage.
		Loss of habitat access (during construction and maintenance or dam removal)	n/a	n/a	n/a	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Potential decreased incubation success and survival due to water loss and stranding. Juvenile and adults: Stranding may lead to direct mortality.	Limit area of dewatering to the greatest extent practicable. Follow established protocols for dewatering. Perform slow dewatering activities to allow for movement into suitable habitats.	These species are non-migratory and insensitive to temporary barriers to passage.

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Dredging and fill	Alteration of bathymetry and substrate characteristics	During project construction and maintenance activities	Permanent	Interannual–decadal	Juveniles; Adults	Juveniles and adults: See responses described under Hydraulic and Geomorphic Modifications.	Avoid fill or, if unavoidable, restore currently filled or degraded shallow shoreline habitats.	See effects for related stressors under Hydraulic and Geomorphic Modifications.
		Localized decrease in periphyton coverage	During project construction and maintenance activities	Short-term	Interannual to decadal (depending on activity frequency)	Glochida; Juveniles; Adults	Glochidia: Direct injury or mortality from dredge entrainment. Juveniles and adults: Effects of stressor exposure vary from mortality due to mechanical injury, burial and starvation, to behavioral alteration depending on nature of dredging activity. Inadvertent dispersal may affect population productivity. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications. Effects on host fish may also lead to indirect effects on population productivity.
		Entrainment of benthic organisms, increased suspended solids	During project construction and maintenance activities	Temporary to short-term	Interannual–decadal	Juveniles; Adults	All life-history stages: Direct injury or mortality from dredge entrainment. See responses described for related stressors under Water Quality Modifications.	Avoid turbidity effects above background levels.	May cause direct injury or mortality. See effects for related stressors on all life-history stages under Water Quality Modifications.
	Operations								
	Visual, physical, and noise related disturbance	Increased stress, startle responses from intermittent stressors. Auditory masking.	During screen operation	Permanent	Intermittent to continuous	Juveniles; Adults	All exposed life history stages: The effects of operational stressors on these species are a data gap.	Where mechanical screens and debris clearing systems are necessary, select designs that produce minimal mechanical noise.	Effects of stressor exposure are unknown.
	Entrainment and impingement	Stress, exertion, mechanical injury, diversion to unsuitable habitats	During screen operation	Permanent	Continuous	Glochidia larvae; Juveniles; Adults	Glochidia larvae: Entrainment through screens is likely, leading to mortality. However this effect is attributable to the diversion and limitations of screen design, rather than the screen itself. Juveniles and adults: Being sessile benthic species, mussels are expected to be insensitivity to these stressors once attached to the substrate.	Evaluate flow through velocities and screen mesh characteristics for potential effects on these species.	No effect expected.
	Water Quality Modifications								
	Increased suspended solids	Increased substrate embeddedness, decreased sensory ability, gill clogging, gill abrasion	Dependent on contributing mechanism of impact	Temporary to short-term (dependent on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Gill tissue in these species is sensitive to injury or clogging by elevated suspended sediment levels. Juveniles and adults: Responses vary depending on stressor magnitude. Unavoidable extreme turbidity may cause physical injury and/or physiological effects (e.g., gill trauma, altered osmoregulation, blood chemistry changes).	Ensure project design avoids and/or minimizes habitat alterations leading to chronic bank instability. Avoid short-term turbidity effects above background levels to greatest extent practicable. Adhere to established protocols for managing sediment and turbidity.	May affect adult and juvenile survival, growth and fitness.

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Increased water temperatures	Thermal stress	Limited to stranding events in bypass channels	Long-term to permanent	Seasonal	Juveniles; Adults	Adults and juveniles: Altered growth and survival caused by temperatures outside optimal growth range and alteration of food web patterns. Direct mortality caused by exposure to temperatures in excess of tolerance thresholds.	Avoid/minimize disturbance of riparian vegetation. Maintain system-appropriate riparian buffer widths to the greatest extent possible.	May cause injury or mortality. May affect survival, growth, and fitness.
	Altered dissolved oxygen levels	Decreased DO levels	Limited to stranding events in bypass channels	Temporary to short-term (e.g., contaminant spill or discharge) to long-term (e.g., from eutrophication effects induced by the impoundment), dependent on contributing mechanism of impact	Intermittent to permanent (dependent on contributing mechanism of impact)	Juveniles; Adults	All exposed life history stages: Physiological injury or mortality from acute decreased DO exposure	Avoid large sediment pulses during construction where practicable.	May cause injury or mortality. May affect survival, growth and fitness.
	Altered pH levels	Interference with osmoregulation, respiratory distress, physiological injury.	Dependent on contributing mechanism of impact	Temporary to short-term (depending on contributing mechanism of impact)	Intermittent to interannual–decadal (dependent on contributing mechanism of impact)	Juveniles; Adults	Juveniles and adults: Physiological responses to pH levels outside of optimal thresholds, causing mortality or injury leading to reduced fitness.	Avoid nutrient inputs where practicable. Avoid in-water curing of concrete or discharge of concrete leachate to surface waters.	May cause direct mortality in acute events. May affect survival, growth and fitness.
	Introduction of toxic substances (PAHs, metals, organic pollutants)	Intoxication, physiological injury.	During discharge events	Long-term to permanent	Intermittent to continuous (concurrent with discharge events and actions of persistent pollutants)	Juveniles; Adults	All exposed life-history stages: Exposure to toxic substances may lead to direct mortality, or physiological injury limiting to survival, growth, and fitness.	Evaluate effluent potential to introduce toxic substances. Require or encourage use of upstream treatment measures prior to discharge. Coordinate enforcement of water quality standards with Ecology.	May affect survival, growth, and fitness at all exposed life-history stages.

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Riparian Vegetation Modifications								
	Altered shading, solar input, and ambient air temperature	Expansion of thermal regime (i.e., increased summer temperatures, decreased winter temperatures)	Year-round (pronounced in winter/summer during solar radiation and ambient temperature extremes)	Long-term to permanent (dependent on nature of riparian impacts).	Seasonal	Juveniles; Adults	Stressors related to extensive modification of riparian vegetation can impose a number of effects across all life-history stages. However, riparian modification resulting from fish screen development is expected to be limited in most cases. Development of bypass channels would be expected to cause more extensive riparian modification, however bypass system development is considered to be artificial channel creation, the effects of which are addressed in the Channel Modifications white paper (Herrera 2007b).	Select piped bypass system designs over creation of artificial bypass channels where practicable to avoid/minimize disturbance of riparian vegetation. Design bypass systems and outfalls for minimal riparian impact.	Stressor magnitude expected to be limited and the effects of exposure attributable to fish screens insignificant.
	Altered stream bank and shoreline stability	Increased suspended solids; decreased area of suitable spawning habitat; reduced habitat complexity (e.g., filling of pools)	Year-round (with specific stressors prominent during high flow conditions)	Intermediate-term to long-term (dependent on time required for riparian recovery)	Continuous to seasonal (dependent on specific stressor)	Juveniles; Adults			
	Altered allochthonous inputs	Reduced recruitment of terrestrially derived prey resources; reduced aquatic food web productivity due to reduction in organic matter inputs	Year-round	Permanent	Continuous	Juveniles; Adults			
	Altered habitat complexity	Reduced recruitment of large woody debris, affecting habitat structure, hydraulic and substrate complexity, and availability of organic substrate. Reduced food web productivity, reduced foraging opportunity, reduction in available cover, reduction in available spawning habitat (freshwater)	Year-round	Short-term to permanent (dependent on nature of activity)	Continuous	Juveniles; Adults			
	Altered groundwater–surface water exchange	Reduced available suitable spawning habitat; reduced gravel dissolved oxygen	Year-round	Permanent	Continuous	Eggs and larvae; Adults			
	Hydraulic & Geomorphic Modifications								
	Altered flow conditions	Change in habitat structure and habitat suitability, reduced food web complexity, and reduced spawning and rearing habitat availability and suitability	Year-round	Permanent	Continuous	Juveniles; Adults	Juveniles and adults: Altered channel geometry, flow velocity, and substrate composition can result in decreased habitat suitability, and changes in food web complexity. This may limit foraging opportunities and increase competition for suitable habitats, leading to decreased growth, fitness, and survival.	Carefully evaluate project siting and design and consider the magnitude of impact mechanisms produced by the project. Encourage selection of project designs that minimize effects on channel geometry, flow velocity, substrate composition, and groundwater exchange to the greatest extent practicable.	May affect survival, growth and fitness at all exposed life history stages.
	Altered channel geometry		Year-round (with stressor exposure occurring during high-flow events, fall through spring)	Permanent	Seasonal				
	Altered substrate composition and stability		Year round	Permanent	Continuous				
	Ecosystem Fragmentation								
	Passage barriers	Partial barriers to upstream or downstream passage of host fish.	Year-round	Permanent	Continuous	Glochidia larvae	Effects on host fish dispersal may affect the dispersal of larvae, affecting population productivity	Design fish screens to minimize passage related effects on host fish species.	May affect population productivity.

Table A-25 (continued). HPA HCP Fish Screen Exposure and Response Matrix for Western Ridged Mussel and California Floater.

Sub-activity Type	Impact Mechanism/ Submechanism	Exposure					Response to Stressor	Minimization Measures	Resulting Effects of the Submechanism
		Stressor	When	Duration	Frequency	Life-history Form			
	Modified downstream transport of woody debris and organic material	Decreased food web productivity, altered habitat complexity	Year-round	Permanent	Continuous	Juveniles; Adults	All exposed life-history stages: Reduced downstream transport of wood and organic material can alter food web productivity in downstream reaches, affecting survival, growth, and fitness. The magnitude of this stressor resulting from fish screen operation is expected to be insignificant.	Design diversion structure and fish screen to pass organic material and woody debris. Return entrained or impinged woody debris and organic material to the stream channel downstream of the screen and diversion structure.	Effects of stressor exposure are expected to be insignificant.