Table 6-17. Summary of Effect of Turbidity and Sedimentation on Life Functions of Listed Fish

Activity/ Timing[a]	Mortality[b]	Gill Damage[c]	Stress[c]	Avoidance	Migration Delay[c]	Foraging/ Predation[d]	Spawning[e]
Debris Removal 11/1 – 2/28	No	Not likely	Not likely	Likely (~300 ft, 4-6 hrs, ~4x/day)	Not likely	Likely	Likely (~300 feet)
Impact installation 9/15 – 4/15	No	Not likely	Not likely	Likely (25 ft, ~1 hr/day)	Not likely	Likely	Likely (~25 feet)
Vibratory installation year-round	No	Not likely	Not likely	Likely (25 ft, ≤24 hr/day)	Not likely	Likely	Likely (~25 feet)
Pile/cofferdam removal year-round	No	Not likely	Not likely	Likely (minimal, ≤24 hr/day)	Not likely	Likely	Likely (minimal)
Drilled shafts year-round	No	Not likely	Not likely	Not likely (contained)	Not likely	Likely	Not likely (contained)
Demolition year-round	No	Not likely	Not likely	Likely (minimal, ~8-10 hr/day)	Not likely	Likely	Likely (minimal)
Barges, shallow water year-round	No	Not likely	Not likely	Likely <300 feet	Not likely	Likely	Likely (<300 feet)

a All activities to occur within 4-year in-water constriction period.
b Turbidity will not reach levels known to cause mortality.
c Exposure unlikely due to avoidance, dilution, turbidity refugia, and limited extent and duration of effect.
d Effect likely but not quantifiable.
e Applies to eulachon only.

Table 6-18 summarizes the species and life stages of fish that could potentially be exposed to turbidity and sedimentation in the Columbia River and North Portland Harbor.

Table 6-18. Fish Species Potentially Exposed to Project-Generated Turbidity in the Columbia River and North Portland Harbor

	Life Stage				
Species	Spawning	Incubation	Rearing	Juvenile Outmigration	Migrating/ Holding Adults
Chinook					
LCR ESU			X	X	X
UCR Spring-Run ESU			X	X	X
UWR ESU				X	X
SR Fall-Run ESU				X	X
SR Spring/Summer-Run ESU				X	X
Steelhead					
LCR DPS			X	X	X
MCR DPS				X	X
UWR DPS				X	X
UCR DPS				X	X
SR DPS				X	X

Species	Spawning	Incubation	Rearing	Juvenile Outmigration	Migrating/ Holding Adults
	Life Stage				
Sockeye					
SR ESU				X	X
Coho					
LCR ESU			X	X	X
Chum					
CR ESU			X	X	X
Bull Trout *(exposure is discountable due to extremely low numbers in action area)*					
CR DPS					X[a]
Green Sturgeon *(exposure is discountable due to extremely low numbers in action area)*					
Southern DPS					X[a]
Eulachon					
Southern DPS	X	X		X	X

a Includes subadults.

Figure 4-1 and Figure 4-2 show when these species are likely to be present in the portions of Columbia River and North Portland Harbor likely to be exposed to elevated turbidity.

Summary of Effects to Listed Species

Bull trout and green sturgeon could potentially be exposed to turbidity effects, but due to extremely low numbers of these species in the very limited areas subject to elevated turbidity, exposure is discountable.

Adult and juvenile salmon and steelhead (Table 6-18) are likely to be exposed to elevated turbidity, but not at levels likely to cause mortality, gill damage, stress, or migratory delay. Turbidity may reach levels that could cause temporary avoidance of the areas within the discrete mixing zones and timelines outlined in Table 6-16 and Table 6-17. This is likely an adverse effect.

Adult and larval eulachon are likely to be exposed to elevated turbidity in the same manner as described for salmon and steelhead. Additionally, turbidity and sedimentation may have adverse effects on spawning and potential spawning habitat, but these effects will be limited to discrete areas, representing a miniscule proportion of available spawning habitat. Turbidity is not expected to interfere with migration of larval eulachon, which do not have volitional movement.

6.1.5.3 Contaminated Sediments

State and federal databases have identified upland sites in the project area or immediate vicinity that are known or suspected to contain contaminated media (Parcel Insight 2009). Parcel Insight (2009) compiled information from all of the regulatory databases related to chemical contamination in the project area, including: the federal Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database, Oregon State Environmental Cleanup Site Information (ECSI) database, Oregon and Washington State Leaking Underground Storage Tank (LUST) database, and Oregon State Hazardous Materials (HAZMAT) database. DEQ suspects that four sites in the project area may contain contaminated sediments due to their proximity to the contaminated upland sites and due to available information about past activities on the sites (Parcel Insight 2009).

- Schooner Boat Works Pier 99 is a marine repair facility located on the south bank of North Portland Harbor, east of I-5. The facility appears in the ECSI and CERCLIS databases. Metals and petroleum products were detected in on-site soils. Groundwater and sediment at the site have not yet been analyzed. Considering the types of activities conducted at the site and the length of time that these activities occurred, other potential site contaminants may include: organotoxins, toxic metals (such as arsenic, lead, cadmium, chromium, mercury, and zinc), volatile organic compounds, semi-volatile organic compounds, and PCBs. Additionally, regulatory agencies have received complaints about this site releasing materials into the water (Parcel Insight 2009).
- Diversified Marine is a second marine repair facility located on the south bank of North Portland Harbor, west of the I-5 bridge. This facility also appears in the Oregon State HAZMAT and ESCI databases and in the federal CERCLIS database. As for Pier 99, regulatory agencies have received complaints about the Diversified Marine site releasing materials into the water. The record of Pollution Complaints and Spill Reports suggests that on-site activities could have contaminated the site soils and nearby sediments with any of a variety of contaminants used in boat building, maintenance, and repair. These contaminants may include paint chips, toxic metals (such as copper oxide, organotins, lead, cadmium, chromium, mercury, and zinc), petroleum constituents (such as benzene, toluene, ethylbenzene, and polycyclic aromatic hydrocarbons [PAHs]), and organic contaminants such as phthalates, pentachlorophenol, chlorinated solvents, and PCBs (Parcel Insight 2009).
- The site of a former landfill is located on Hayden Island near the Columbia River shoreline and to the west of I-5 at the current location of the Thunderbird Hotel. This unregulated landfill was located in a seasonal lake basin and probably operated between 1950 and 1970, after which it was covered with a 7- to 8-foot layer of clean fill. In 1989, an ARCO gas station that later opened on the eastern edge of the former landfill initiated a study and detected gasoline contamination in the groundwater. Borings also revealed a layer of landfill debris beneath clean fill. The DEQ LUST program (file #26-89-0149) requested a Corrective Action Plan from ARCO, leading to pump-and-treat remediation that began operating in August 1990. Groundwater samples from eight monitoring wells contained dissolved metals, which are most likely a result of leachate percolating through unknown solid wastes in the unsaturated zone (Parcel Insight 2009). Because there is a high connectivity between the groundwater and the Columbia River in this location, it is suspected that metals could be present in the river sediments immediately adjacent to the site.
- The former site of the Boise-Cascade Lumber Mill is located in Vancouver on the north shore of the Columbia River, about 1,500 feet to the west of the I-5 bridge and to the west of the Red Lion Hotel. Based on the industrial history and type of activities conducted on the site, it is possible that these contaminants may have impacted nearby sediments in the Columbia River. However, the USACE performed in-water sediment sampling near the site, but did not detect contaminated sediments (USACE 2008b, 2009).

The project will implement several measures to prevent the mobilization of contaminated sediments in the project area. First, the project will complete a Phase I Environmental Site Assessment or each acquired property that could reasonably contain contaminated materials. The Phase I Environmental Site Assessment may identify possible contamination based on the site history, a visual inspection of the site, and a search of federal and state databases of known or suspected contamination sites. If there is evidence of contamination, a Phase II Environmental Site Assessment may be performed to pinpoint the location of the contaminated sediments as well as to measure the extent and concentration of the contaminants. The Phase II Environmental Site Assessment will also identify the specific areas recommended for remedial action.

The project will implement BMPs to ensure that the project either: 1) avoids areas of contaminated sediment or 2) enables responsible parties to initiate cleanup activities for contaminated sediments occurring within the project construction areas. The exact BMPs are not yet determined, but the contractor will be required to develop mitigation and remediation measures in accordance with ODOT and WSDOT standard specifications and all state and federal regulations. The plan will also comply with all regulatory criteria related to contaminated sediments. There will be coordination with regulatory agencies such as DEQ and Ecology on the assessment of site conditions and the cleanup of contaminated sediments. If contaminated sediments are removed from the site, they will be disposed of at a permitted upland disposal site.

Because the project will identify the locations of contaminated sediments and use BMPs to ensure that they do not become mobilized, there is little risk that listed species will be exposed to contaminated sediments. This aspect of the project is not likely to adversely affect any listed species.

6.1.6 Avian Predation

Project-related in-water and overwater structures may have an effect on avian predation in the CRC action area. Such structures may include the temporary work platforms/bridges, tower cranes, oscillator support platforms, barges, and cofferdams, as well as the permanent new bridge spans.

Avian predation is known to be a factor that limits salmon recovery in the Columbia River basin (NMFS 2008e). Throughout the basin, birds congregate near man-made structures and eat large numbers of migrating juvenile salmonids (Ruggerone 1986, Roby et al. 2003, and Collis et al. 2002 cited in NMFS 2008e). Basin wide, avian predation is high enough to constitute a substantial portion of the mortality rate of several runs of salmon and steelhead (Roby et al. 2003 cited in NMFS 2008e). Predation rates are particularly high in impoundments upstream of dams, dam bypass systems, and dredge spoil islands (NMFS 2008e). Additionally, local environmental factors may exacerbate avian predation. In particular, mainstem dams in the lower Columbia detain suspended sediments, a condition that has increased water clarity, potentially enhancing the foraging success of predaceous birds (NMFS 2008e).

The effects of overwater structures on interactions between salmonids and avian predators are widely recognized but have not been the subject of extensive study (Carrasquero 2001). In a 2001 literature review Carrasquero (2001) determined that there is no quantitative or qualitative evidence that docks, piers, boathouses, or floats either increase or decrease predation on juvenile salmonids. Additionally, the review found no studies related to predator-caused mortality specifically associated with overwater structures. Caspian terns, double-crested cormorants, and various gull species are the principal avian predators in the Columbia River basin (NMFS 2000b cited in NMFS 2008e). Populations in the basin have increased as a result of nesting and feeding habitats caused by the creation of dredge spoil islands, reservoir impoundments, and tailrace bypass outfalls (Roby et al. 2003). However, no studies have demonstrated the use of overwater structures by predaceous birds (Carrasquero 2005).

The overwater structures in the CRC action area are not likely to attract large concentrations of avian predators as do such features as nesting islands, impoundments, or tailraces. Nevertheless, because avian predators are known to congregate on overwater structures and because the project will increase the number of available perches, it is possible that the avian predation rates could increase to some extent within the project area. Specifically, the new bridges could create a permanent increase in the number of perches available. Additionally, the work platforms/bridges, tower cranes, oscillator support platforms, and barges will temporarily increase the number of perches available in the Columbia River and North Portland Harbor. Presumably, avian predation may occur during the overlap of: 1) when overwater structures are present in the project area (Figure 6-17, Figure 6-18, and Figure 6-19) and 2) when juvenile fish are present in the project area (see Figure 4-2); however, it is impossible to quantify how many individual fish will be affected.

6.2 INDIRECT EFFECTS TO FISH

Indirect effects are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur. Two elements of the CRC project are likely to result in indirect effects. Increased area of PGIS and consequent increase in stormwater runoff will cause ongoing effects to the action area water bodies. Increased capacity of the highway system and LRT network could potentially lead to changes in land use or traffic patterns for years to come.

6.2.1 Stormwater Effects on Water Quality and Water Quantity

The project area currently contains 217 acres of PGIS and will add a net 21 acres, resulting in a post-project net total of 238 acres. This section discusses the effect of project-related PGIS and stormwater runoff on all of the action area water bodies: Columbia River, North Portland Harbor, Columbia Slough, and Burnt Bridge Creek.

The CRC project occurs within several different state and local jurisdictions, each of which has different stormwater treatment standards. The CRC project team agreed to incorporate the most restrictive water quality requirements of all these standards, as embodied in the ODOT stormwater BMP selection tool (ODOT 2008). The selection tool requires that the project incorporate the highest practicable levels of stormwater treatment and outlines a process for selecting the BMPs that fulfill this requirement. Stormwater treatment facilities must also adhere to design standards. The ODOT standards require water quality treatment for 50 percent of the 2-year 24-hour event. Flow control standards require that the project does not result in an increase in sediment-transporting flows in the receiving water body between a lower and an upper endpoint. In western Oregon, the lower endpoint is 42 percent of the 2-year event. The upper endpoint is either the channel-topping event for streams that are not incised or only slightly incised or the 10-year flow event for streams that are moderately or severely incised (ODOT 2009).

The BMP selection tool was developed as a collaborative effort between ODOT, FHWA, NMFS, and other resource agencies. The final selection of the design storms and elements of the BMP selection tool were consensus decisions among these agencies. Incorporation of the tool meets NMFS requirements for ESA consultations related to stormwater (ODOT 2009). Once the team selected the BMPs, they compared the design standards with state and municipal agency stormwater criteria to ensure that the BMPs incorporated the most restrictive requirements. Table 6-19 outlines the jurisdictional stormwater treatment standards used on this project. The sizing and detailed design of individual water quality facilities will meet or exceed the specific requirements of the state or local agency that has jurisdiction over that facility. For example, treatment facilities within the WSDOT right-of-way will be sized and designed in accordance with the WSDOT Highway Runoff Manual.

Table 6-19. Jurisdictional Stormwater Treatment Requirements

Jurisdiction	Water Quality Design Criteria	Flow Design Criteria
ODOT	Treat 85% of the cumulative runoff.	Not applicable. Flow control not required for receiving water bodies in this portion of the action area.
Ecology (applies to WSDOT right-of-way and City of Vancouver)	Treat 91% of the runoff volume over the period of simulation.	Columbia River – Not applicable. Flow control not required this water body. Burnt Bridge Creek - discharge must be reduced to pre-development (forested) flow rates from 50% of the 2-year to the 50-year peak flow.
City of Portland	Treat 90% of the average annual runoff.	Not applicable. Flow control not required for receiving water bodies in this portion of the action area.

The majority of the water quality facilities proposed for the CRC project use infiltration as the primary mechanism for water quality treatment and flow control. Depending on the infiltration rates available at a particular site, these facilities may be able to provide an even higher level of stormwater treatment than what is required.

6.2.1.1 General Effects of Stormwater on Fish

In general, addition of impervious surface to a watershed has the potential to affect listed fish by altering water quality in the receiving water bodies. Stormwater runoff flows over the roadway, picking up contaminants from impervious surfaces and delivering them to the roadside drainage system and eventually to surface water bodies (Pacific EcoRisk 2007). Sources of these contaminants include vehicles, atmospheric deposition, roadway maintenance, and pavement wear (Pacific EcoRisk 2007).

The addition of PGIS increases the level of vehicle-generated pollutants deposited on the roadway and delivered to surface waters. Common pollutants present in stormwater runoff include total suspended solids, nutrients, oil and grease, other fluids associated with automobiles, PAHs, agricultural chemicals used in highway maintenance, total zinc, dissolved zinc, total copper, dissolved copper, and other metals (NMFS 2008j). These pollutants are known to be toxic to fish (Everhart et al. 1953; Sprague 1968; Hecht et al. 2007; Sandahl et al. 2007; Johnson et al. 2009) and have potential adverse effects on salmon and steelhead, even at ambient levels

(Loge et al. 2006, Hecht et al. 2007, Johnson et al. 2007, Sandahl et al. 2007, Spromberg and Meador 2006, all cited in NMFS 2008j). These contaminants are persistent in the aquatic environment, traveling long distances in solution or adsorbed onto suspended sediments. Alternatively, they may also persist in streambed substrates, mobilizing during high-flow events (Anderson et al. 1996, Alpers et al. 2000a, 2000b, all cited in NMFS 2008j). Some of these pollutants may also persist in the tissues of juvenile salmonids, resulting in long-term interference with important life functions such as olfaction, immune response, growth, smoltification, hormonal regulation, reproduction, cellular function, and physical development (Fresh et al. 2005, Hecht et al. 2007, LCREP 2007b all cited in NMFS 2008j). The addition of PGIS may also increase the levels of contamination in surface waters, degrading water quality and causing further harm to fish.

The following sections provide more detail about the types of contaminants found in stormwater runoff and their likely effects on fish.

Contaminant Levels and Effects on Fish

There have been no comprehensive studies performed about the types and concentrations of pollutants found in stormwater runoff emanating from the project area. However, Herrera (2007) prepared a white paper on the types and concentrations of contaminants found in untreated runoff in western Washington, an area with climate and traffic volumes comparable to the action area. No such study exists in Oregon, and therefore, this study represents the most comprehensive review of the characteristics of stormwater runoff applicable to the CRC project area. The study reported that typical contaminants found in stormwater runoff included TSS, metals, nutrients, and organic compounds. Additionally, stormwater runoff had levels of oxygen demand corresponding to detectable levels of these pollutants.

Geosyntec (2008) performed a comprehensive study of contaminant concentrations in treated stormwater runoff in western Washington. The results of both studies are presented in the subsections below in order to characterize the likely pollutant levels in stormwater runoff in the CRC project area and the risk that listed fish are exposed to toxic levels of contaminants in the CRC action area.

Total Suspended Solids

TSS has the potential to harm fish by causing gill tissue damage, physiological stress, altered behavior, and degradation of aquatic habitat (Pacific EcoRisk 2007). The level of effect generally depends on the characteristics of the particles, with hard angular particles causing more damage than softer, smoother ones. Given the short-term duration of most precipitation events, exposure of individual fish to such effects is likely to be limited in space and time (Pacific EcoRisk 2007). However, chronically high levels of TSS may cause long-term degradation of habitat (such as spawning redds) or may reduce the productivity of the benthic communities that make up the food web of numerous fish species.

Herrera (2007) reported mean TSS concentration levels of 93 mg/L in untreated runoff in western Washington, with maximum concentrations of 900 mg/L. Stormwater treatment BMPs reduced TSS levels significantly such that post-treatment median concentration ranged from 6 to 20.5 mg/L (Geosyntec 2008).

There are several criteria for levels of TSS likely to harm aquatic organisms or habitats. Neither Oregon nor Washington offer numeric guidance for TSS. However, EPA guidance classifies impairment to aquatic habitat or organisms as follows:

- < 10 mg/L – Impairment is improbable
- < 100 mg/L – Potential impairment
- > 100 mg/L – Impairment probable.

The National Academy of Sciences (NAS) (1973) offers the following:

- < 25 mg/L – High level of protection to aquatic community
- 25–80 mg/L – Moderate level of protection
- 80–400 mg/L – Low level of protection
- > 400 mg/L – Very low level of protection

In the absence of site-specific data about ambient turbidity levels in the receiving water body, the timing and duration of TSS concentrations, and the characteristics of the suspended particles, it is difficult to draw a clear line between TSS concentrations and harm to fish. However, the data show that stormwater treatment facilities significantly reduce TSS concentrations, and, in comparison to the NAS standard, potentially to levels that offer a high level of protection to the aquatic community. In comparison to the EPA threshold, stormwater runoff treatment may reduce TSS concentrations to the low end of the potential impairment standard (Pacific EcoRisk 2007).

Section 6.1.5.2 provides a more detailed review of the effects of suspended sediment on fish.

Metals

The main sources of metals in stormwater runoff include friction in engine and suspension systems, attrition of brake pads and tires, and rust and corrosion of automobile body parts. Other sources include guardrail plating, vehicle emissions, impurities in de-icing compounds, and atmospheric deposition (Herrera 2007). Metals may occur as particulates or dissolved ions (Pacific EcoRisk 2007). Metals in highway runoff are often correlated with levels of suspended sediments because they either occur as particulates or are bound to the surfaces of other solids. Zinc, copper, and chromium show a particularly high correlation with TSS concentrations (Herrera 2007). In general, factors that affect levels of solids in the water column will also affect the levels of metals; however, due to the varied behavior of metals under different environmental conditions, this relationship is very complex (Pacific EcoRisk 2007).

Herrera (2007) reported the following metals in untreated stormwater runoff: antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, vanadium, and zinc. About half of these (arsenic, antimony, barium, cobalt, molybdenum, nickel, and vanadium) occurred at levels well below any known thresholds for toxicity to aquatic organisms, and therefore, the authors deemed that these metals were not pollutants of concern for listed fish. Thus, only cadmium, chromium, copper, lead, mercury, and zinc will be addressed further in this discussion.

Cadmium: Herrera (2007) reported median concentrations of 1.2 µg/L in untreated stormwater runoff, with maximum concentrations of 2.80 µg/L. Treated stormwater runoff contained much lower concentrations, with median concentrations ranging from 0.05 to 0.20 µg/L (Geosyntec 2008). Median cadmium levels in treated stormwater were well below freshwater acute criteria. They were also below chronic water quality criteria and EPA Genus Mean Acute Values (GMAVs), that is, values specific to fish genera *Oncorhynchus* and *Salvelinus.* However, some of the upper 95th percentile values for treated stormwater exceeded freshwater acute and chronic criteria, indicating that, despite undergoing treatment, stormwater runoff may still contain cadmium at levels that could potentially harm listed fish (Pacific EcoRisk 2007).

Studies have indicated that chronic levels of cadmium at 0.5 µg/L for 30 days may have sublethal effects on bull trout, including interference with prey selection and prey capture efficiency (Riddell et al. 2005, cited in Pacific EcoRisk 2007). However, this concentration would not likely persist in highway runoff for such an extended period of time (Pacific EcoRisk 2007).

Chromium: Herrera (2007) reported median concentrations of 12.7 µg/L of total chromium in untreated highway runoff, with maximum concentrations of 17.9 µg/L. No data were presented for treated highway runoff (Geosyntec 2008). These values were well below the GMAV Cr (III) and Cr (IV) values for *Oncorhynchus* and *Salvelinus*, which ranged from 9,669 to 69,000 µg/L. The values were also well below the chronic and acute freshwater criteria for Cr (III) (64.4 to 628.6 µg/L), indicating that stormwater runoff does not contain Cr (III) at levels likely to harm listed fish (Pacific EcoRisk 2007).

Measured maximum values of total chromium did, however, exceed the freshwater acute (15 µg/L) and chronic criteria (10 µg/L) for Cr (IV). The measured median concentration is within the acute criterion, but exceeds the chronic criterion. This indicates that while typical chromium levels in untreated stormwater effluent may not cause direct injury or mortality to listed fish, there may be toxic effects on food chain organisms (Pacific EcoRisk 2007).

There were no direct data measuring chromium concentrations in treated runoff. However, it is presumed that levels in treated runoff would be much less than for untreated runoff. While it is reasonable to assume that chromium concentrations in treated runoff will be below levels likely to directly harm listed fish, it is uncertain as to whether concentrations are toxic to food chain organisms (Pacific EcoRisk 2007).

Copper: Herrera (2007) reported median concentrations of 5.18 µg/L for dissolved copper and 24.4 µg/L for total copper in untreated stormwater runoff in western Washington. Median concentrations of dissolved copper in treated effluent ranged from 4.4 to 10 µg/L (Geosyntec 2008). Regardless of whether the samples originated from treated or untreated stormwater, concentrations were in exceedance of freshwater acute criteria, but were below GMAVs for salmon and bull trout (Pacific EcoRisk 2007).

Although dissolved copper concentrations in stormwater runoff may not typically occur at levels likely to cause lethal toxicity to salmonids, sub-lethal toxicity is of great concern. Salmonids may avoid waters with copper concentrations at 2.3 µg/L (Sprague 1964). Dissolved copper is known to interfere with olfaction in fish, even at very low levels. Reduced olfactory ability interferes with important life functions, such as prey location, predator avoidance, mate recognition, contaminant avoidance, and migration. Baldwin et al. (2003) observed that an increase of 2.3 µg/L above background levels reduced olfactory response in salmonids by 25%. Sandahl et al. (2007) observed 50% reduction in olfactory response and 40% reduction in predator avoidance when dissolved copper levels were 2.0 µg/L above background levels of 0.3 µg/L.

The above data indicate that stormwater runoff contains dissolved copper at levels that may cause sublethal effects in salmonids. However, it is important to note that site-specific conditions, such as the presence of dissolved organic carbon, can reduce the bioavailability of dissolved copper and mitigate for the negative effect on olfaction (Pacific EcoRisk 2007). Therefore, even though a given highway system may discharge dissolved copper at these levels, it is not possible to definitively conclude that this causes harm to fish in every setting (Pacific EcoRisk 2007).

Lead: Herrera (2007) reported median and maximum dissolved lead concentrations at 3.2 µg/L in untreated runoff. BMPs markedly reduced dissolved lead concentrations; median post-treatment concentrations ranged from 0.1 to 2.2 µg/L. Regardless of treatment, dissolved lead levels in runoff were well below acute criteria (16.3 µg/L), indicating that stormwater runoff does not contain dissolved lead at levels likely to kill listed fish or prey organisms. In some cases, median concentrations for treated runoff exceeded chronic freshwater criteria (0.64 µg/L). However, the authors note that exposure to chronic levels of dissolved lead is unlikely due to the short duration of most runoff events (Pacific EcoRisk 2007).

Lead is also under investigation as a potential endocrine disruptor in fish. Isidori et al. (2007, cited in Pacific EcoRisk 2007) found potential estrogen receptor sensitivity at lead concentrations as low as 0.0004 µg/L. There are no data, however, that provide a direct evidence of actual endocrine disruption in fish at such low levels. The issue warrants more study (Pacific EcoRisk 2007).

Mercury: Herrera (2007) reported median concentrations of 0.02 µg/L for total mercury in untreated stormwater runoff in western Washington. There were no data for mercury concentrations typically found in treated stormwater (Pacific EcoRisk 2007). Total mercury concentrations were well below acute criteria and GMAVs for Hg(II) and were also below acute criteria for total mercury. These values indicate that mercury concentrations in stormwater runoff do not pose a risk to listed fish or their prey (Pacific EcoRisk 2007). Total mercury did, however, exceed chronic criteria, but Pacific EcoRisk (2007) concludes that chronic exposure to elevated levels of mercury is unlikely.

Organic mercury is of particular concern to listed fish due to its propensity to bioaccumulate in the aquatic environment. Pacific EcoRisk (2007) caution that it is impossible to extrapolate organic mercury levels or bioaccumulation rates from existing highway runoff sampling data. Nevertheless, the authors note that organic mercury is still an issue for listed fish, in particular where runoff flows into lentic systems that accumulate organic mercury.

Zinc: Herrera (2007) reported median dissolved zinc concentrations of 39 µg/L in untreated stormwater (with maximum concentrations of 394 µg/L). In the same study, median total zinc concentrations in untreated stormwater measured 116 µg/L (with maximum concentrations of 394 µg/L). Treated stormwater showed somewhat reduced levels of dissolved zinc, with median concentrations ranging from 7.5 to 41 µg/L (Geosyntec 2008). All of the dissolved zinc levels, whether for treated or untreated stormwater, were well below GMAVs for salmon and steelhead (931.3 µg/L) and bull trout (2,100 µg/L). However, some dissolved zinc concentrations exceeded acute freshwater quality criteria (40 µg/L) and chronic freshwater criteria (36.5 µg/L), indicating that direct lethal effects to listed fish and their prey species may occur after exposure to stormwater runoff, even after it has undergone water quality treatment (Pacific EcoRisk 2007). As with dissolved copper, it is important to note that site-specific conditions may reduce bioavailability of dissolved zinc and mitigate for its toxicity in fish-bearing waters.

Dissolved zinc may also have sublethal effects on salmonids. Sprague (1968) reported that salmonids may avoid waters with zinc concentrations of 5.6 µg/L above background levels of 3 to 13 µg/L. Geosyntec (2008) reported that dissolved zinc concentrations in both treated and untreated stormwater exceeded these levels.

<u>Nutrients</u>

Nutrients are chemicals that promote growth in organisms. Nutrients are of concern to listed fish in that they may cause excessive algal growth in fish-bearing waters, which may in turn reduce dissolved oxygen available to fish or may outcompete food organisms for space in streambed substrate (Pacific EcoRisk 2007). Nutrient levels are not necessarily correlated with traffic levels and may be more closely tied to other land use practices (Pacific EcoRisk 2007). Chief sources of nutrients in highway runoff include atmospheric deposition, vehicle exhaust, and fertilizer applications on the adjacent right-of-way (Herrera 2007). The nutrients of highest concern include nitrogen (in the form of ammonia and nitrate/nitrite) and phosphorous (in the form of orthophosphate and total phosphorous).

Ammonia: Herrera (2007) reported that untreated runoff contained median ammonia concentrations of 1.84 µg/L, with maximum concentrations of 2.66 µg/L. Geosyntec (2008) reported median ammonia concentrations in treated runoff at significantly lower levels, ranging from 0.03 to 0.08 µg/L. In surface waters, ammonia toxicity is highly variable, depending on ambient pH values; therefore, there is no one numeric acute toxicity criterion for ammonia. Acute toxicity is instead determined by using a complex numeric formula based on ambient pH. Using median highway runoff pH values (Herrera 2007), Pacific EcoRisk (2007) estimates acute toxicity for western Washington waters at 31.26 µg/L. In this case, ammonia found in both treated and untreated runoff is well below the estimated acute toxicity standards, indicating that ammonia levels in highway runoff do not occur at levels likely to kill listed fish.

Stormwater runoff may contain ammonia at levels that could cause sublethal effects to fish. Wicks et al. (2002, as cited in Pacific EcoRisk 2007) found that ammonia at concentrations of 0.02 to 0.08 µg/L may reduce the ability of coho to maintain their highest levels of swimming speed, potentially interfering with upstream migration.

Nitrate/Nitrite: Herrera (2007) reported that untreated runoff contained median nitrate/nitrite concentrations of 1.54 µg/L, with maximum concentrations of 2.99 µg/L. In the Geosyntec (2008) study, median concentrations of nitrate/nitrite in treated stormwater ranged from 0.20 to 0.70 µg/L. Both treated and untreated stormwater runoff has concentrations well below the 96-hour acute toxicity standard of nitrate to salmonids (ranging from 994 to 2342 mg/L). Additionally, levels were well below the 96-hour acute toxicity standard for nitrite (ranging from 110 to 1,700 mg/L). These data indicate that stormwater runoff is not a significant source of nitrate/nitrite in surface water bodies, at least not at levels that are likely to harm listed fish.

Phosphorus: Herrera (2007) reported that untreated runoff contained median orthophosphate concentrations of 0.10 mg/L, with maximum concentrations of 0.42 mg/L. The same study reported median total phosphorus levels of 0.19 mg/L, with maximum concentrations of 0.57 mg/L. The Geosyntec (2008) study noted that treated stormwater runoff contained median concentrations of 0.04 to 0.26 mg/L. There are no toxicity-based water quality criteria for phosphorus; however a Pacific EcoRisk (2007) review of the scientific literature concluded that 96-hour exposures to 90 to 1,875 mg/L of di-ammonium phosphate may cause acute harm to certain species of fish (including coho, Chinook, and trout). Given that these standards far exceed levels typically found in both treated and untreated runoff, stormwater does not appear to be a significant source of phosphorus to surface water bodies.

Petroleum Hydrocarbons

This category of pollutants includes vehicle emissions from fuels, such as oil and grease, total petroleum hydrocarbons (TPH), and PAHs. Sources of PAHs include asphalt sealing, vehicle emissions, oils, and atmospheric deposition (Herrera 2007). These contaminants correlate closely with traffic volumes. Additionally, these contaminants have a high affinity for particulates, and therefore they are highly correlated with concentrations of suspended solids. PAHs in streambed sediments have been shown to cause adverse impacts to benthic invertebrates, with potential implications to the prey base of listed fish (Pacific EcoRisk 2007).

Petroleum hydrocarbons include a large subset of compounds, generally occurring as mixtures of many different chemicals. Accordingly, petroleum hydrocarbons are evaluated in broad groupings such as oil and grease, total PAHs (the sum of numerous individual PAHs), and TTPH (the sum of individual petroleum hydrocarbons) (Pacific EcoRisk 2007).

Pacific EcoRisk (2007) examined the Herrera (2007) data regarding PAH concentrations in untreated stormwater runoff and concluded that concentrations of individual PAHs were well below freshwater acute values. This indicates that PAHs from stormwater runoff do not occur at levels that are toxic to listed fish or their prey base, even when the runoff is untreated. (No data were presented for treated runoff.) For total PAH, the study concluded that median concentrations were well below freshwater acute values, but maximum concentrations were high enough to warrant concern and continued monitoring.

Other studies demonstrate that PAH may cause toxicity in fish embryo-larval life stages (Incardona et al. 2004; Incardona et al. 2005; Incardona et al. 2006, all cited in Pacific EcoRisk 2007); however, no study presents the concentration levels at which this toxicity may occur. Pacific EcoRisk (2007) posits that this type of toxicity may occur at lower levels than the acute toxicity criteria presented above, and therefore this issue warrants further study.

PCBs

PCB use has been banned in the United States since the 1970s (Herrera 2007). However, these compounds are highly persistent, and PCB residues still occur throughout the aquatic environment. PCBs are of particular concern for their propensity to bioaccumulate in fish (Yonge et al. 2002, as cited in Herrera 2007). Sources include atmospheric deposition, pesticides, and herbicides. Few data are available for PCBs concentrations in stormwater runoff. However, they have not been detected in stormwater runoff in western Washington (Zawlocki 1981 as cited in Herrera 2007). Pacific EcoRisk (2007) posits that PCBs are not believed to be a contaminant of concern in highway runoff in western Washington.

Oxygen Demand

Herrera (2007) reported that biological oxygen demand (BOD) median concentrations in untreated runoff were 40.3 mg/L, with maximum concentrations of 71.0 mg/L. For chemical oxygen demand (COD), median concentrations in untreated runoff were 106 mg/L, with maximum levels of 1,377 mg/L.

The State of Washington water quality standards mandate that if a stream has an ambient DO below the water quality criteria, then anthropogenic oxygen demand cannot lower the dissolved oxygen levels by more than 0.2 mg/L. Additionally, the State of Washington offers dissolved oxygen levels necessary for sustaining various salmonid life stages in freshwater, ranging from 6.5 to 9.5 mg/L. Site-specific conditions, such as water flow, turbulence, and ambient temperature, influence the degree to which stormwater runoff with high BOD or COD would result in reduced dissolved oxygen levels in a given surface water body. It is likely that mixing and turbulence in a stream would mitigate the effect of stormwater discharge with high oxygen demand, such that effects would be limited in spatial extent and duration. Nevertheless, Pacific EcoRisk (2007) posits that levels of BOD and COD found in stormwater runoff have the potential to reduce dissolved oxygen in surface water bodies, particularly in warm or lentic water bodies, although it is not possible to predict to what extent.

Factors Affecting Toxicity of Pollutants in Stormwater Runoff

Although stormwater runoff certainly contains contaminants that are known to be toxic to fish, it is difficult to predict what specific concentration levels are likely to cause harm. Water quality criteria are nearly always based on laboratory studies that used purified water to avoid confounding influences from other waterborne contaminants. Accordingly, these results may not reflect site-specific field conditions. Ambient water quality conditions may influence the bioavailability of contaminants, either increasing or decreasing the ability of the contaminant to enter fish tissues. A contaminant concentration that is toxic in one setting may not be toxic in another, depending on the site-specific factors that determine the bioavailability of the contaminant. Similarly, toxicity levels in actual water bodies may be much less than that encountered in a laboratory setting (Pacific EcoRisk 2007).

Suspended solids may bind to chemical contaminants in the water column, reducing their bioavailability to fish. Suspended clay particles have a high capacity for binding, with particular affinity for metals and polar organics (Li et al. 2004, Roberts et al. 2007; Sheng et al. 2002; all cited in Pacific EcoRisk 2007). Thus, presence of clay in the water column may reduce the toxicity of contaminants to fish. On the other hand, silica-based particles (such as sand) have little affinity for such contaminants, and therefore their presence in the water column is not likely to reduce toxicity of chemicals in the water column (Cary et al. 1987, cited in Pacific EcoRisk 2007).

Dissolved organic carbon may have a similar effect, binding to both metals and organics and reducing the potential toxicity of both to aquatic organisms (Newman and Jagoe 1994, cited in Pacific EcoRisk 2007).

Water hardness (particularly concentrations of calcium and magnesium) has an antagonistic relationship with metals, potentially hindering with the uptake of metals into gill tissue (Hollis et al. 2000, cited in Pacific EcoRisk 2007). Interestingly, water hardness does not appear to significantly limit the uptake of copper into fish olfactory tissues (MacIntyre et al. 2007, cited in

Pacific EcoRisk 2007). On the other hand, water hardness my increase the bioavailability of some PAHs and PCBs (Akkanen and Kukkonen 2001, cited in Pacific EcoRisk 2007).

The pH of water may affect the ionic charge of waterborne contaminants. In general, conditions that promote the ionic form of a contaminant will reduce the contaminant's bioavailability and its toxicity to fish.

Water Quantity

New PGIS also may also alter water quantity in the receiving water body. In general, addition of PGIS to a watershed increases the amount of runoff entering surface waters. This may cause changes in stream dynamics, including higher peak flow, reduced peak-flow duration, and more rapid fluctuations in the stream hydrograph. These changes may in turn lead to scour, potentially resulting in impacts to water quality and degradation of stream bed habitat. Increasing the amount of PGIS also decreases infiltration to groundwater, potentially reducing base flows in streams and decreasing the amount of water available during summer months.

6.2.1.2 General Effects to the Environmental Baseline in the CRC Action Area

The project will install numerous stormwater treatment facilities to provide flow control where required and to sequester pollutants before runoff enters any surface water body. It is important to note that even treated stormwater contains some level of pollutants. Most treatment facilities are not 100 percent efficient, and although they greatly reduce pollutant levels, they do not completely eliminate discharges of pollutants to receiving water bodies. Flow-through facilities, in particular, will discharge pollutants during most events. Certain kinds of infiltration facilities have outfalls that discharge untreated stormwater to surface water bodies during events that exceed their design storm.

The project area currently provides treatment or infiltration for 20 acres of PGIS. The completed project will add 21 acres of net new PGIS, and will provide treatment for almost all of the new PGIS and for 188 acres of existing untreated PGIS. This scenario represents additional treatment of more than 9 times the net new PGIS area. This level of treatment is expected to result in a net benefit to water quality and water quantity in action area water bodies during events that do not exceed the design storm. Although treatment facilities on the CRC project will not completely eliminate pollutants during these events, they will discharge pollutants at much lower levels than currently, due to the high level of treatment provided.

During events that exceed the design storm, stormwater will likely overwhelm treatment facilities, resulting in a release of untreated stormwater into action area water bodies. The CRC team performed a precipitation-time series analysis to estimate the number of events and time of year when there could be precipitation events that exceed the water quality design storm for the treatment facilities in the CRC action area. The methodology chosen to determine this was (1) to compare historic daily rainfall data to threshold stormwater design standards for volume control, and (2) to determine the frequency with which exceedance events occurred for each month of the year. Daily precipitation data for PDX was obtained for a period of 83 years, between September 1926 and September 2009 (NOAA 2009) (Table 6-20). Since this project spans multiple jurisdictions, there are variations in the level of treatment required. Therefore, a precipitation-time series analysis was performed for each jurisdiction's treatment requirements. Table 6-21shows the size of the event that exceeds each of the jurisdictions' design storms.

Table 6-20. Average Daily Storm Event Based on Rain Gauge Data from PDX Weather Station (356751)

Month	Average (inches)
Jan	1.22
Feb	1.21
Mar	1.23
Apr	1.21
May	1.45
Jun	1.36
Jul	NA
Aug	1.29
Sep	1.28
Oct	1.21
Nov	1.21
Dec	1.21

Table 6-21. Events Exceeding Jurisdictional Design Storms

Jurisdiction	Design Volume	Event Exceeding Design Volume
City of Portland	90%	1.66 inches in 24 hours
Ecology	91%	1.45 inches in 24 hours
ODOT	85%	1.25 inches in 24 hours

Figure 6-20 shows the frequency distribution of storm events that exceed the design storm for each of the jurisdictions in the action area. The highest frequencies occurred in the late fall to winter months, between November and February.

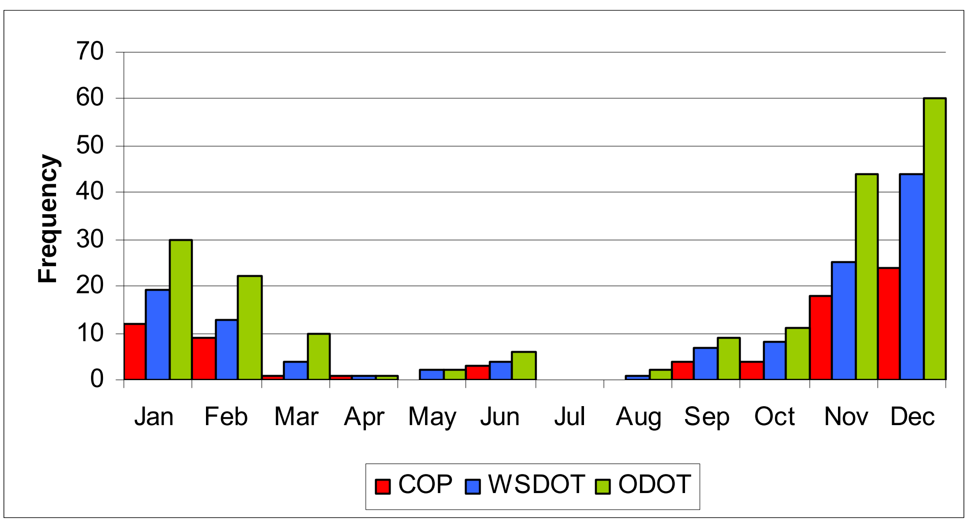

Figure 6-20. Frequency of Design Volume Exceedances by Jurisdiction

This analysis is limited by the assumption that daily precipitation values are representative of 24-hour precipitation events. Realistically, 24-hour storm events can and do occur over the course of two calendar days. If the total daily precipitation is below the threshold exceedance for either of the two days, then the storm event would not qualify as an exceedance event, even though the cumulative 24-hour value may count. Therefore, the frequencies listed in Figure 6-20 are likely lower than the actual number of events that occurred. This assumption, however, is not likely to affect the relative distribution since the timing of storm events during the calendar day is probably not seasonally dependent.

Taking the monthly frequency and dividing it by the number of years of recorded data gives an estimated percent chance that an exceedance event would occur during any given month (Figure 6-21). For example, the table shows that in any given January there is about a 14 percent chance that a storm event will exceed the City of Portland standard, a 23 percent chance of exceeding the Ecology standard, and a 36 percent chance of exceeding the ODOT standard.

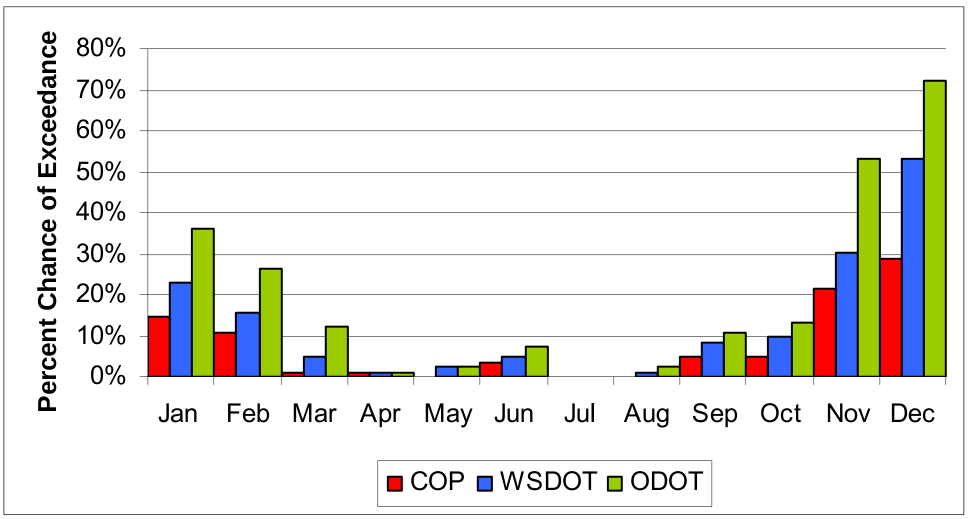

Figure 6-21. Percent Probability of Storm Design Exceedance by Month

During events that exceed the design storm, untreated stormwater may discharge to surface water bodies, potentially degrading water quality in the receiving water bodies. However, the elevated contaminant levels would likely be concentrated around stormwater facility outfalls, and would only occur infrequently following large storm events (Lee et al. 2004). Because these discharges will occur only during larger events, a high level of dilution is expected, reducing the concentration of pollutants. The following sections outline the effects to listed species as they occur in each of the action area receiving water bodies.

6.2.1.3 Stormwater Impacts to the Columbia River and North Portland Harbor

Table 6-22 summarizes the treatment scenario for PGIS that drains to the Columbia River South watershed in Oregon. Overall, there is a net loss of 4.5 acres of PGIS draining to this watershed. Additionally, the project will treat or infiltrate all of the 52.3 acres of new and rebuilt PGIS and significant quantities of the existing retained PGIS, for a net total of 54.6 acres of treated or infiltrated PGIS. Flow control is not required or provided for runoff discharged to the Columbia River or North Portland Harbor. Only one new outfall is proposed.

In order to prevent discharges to the Columbia River and North Portland Harbor, the project will install a sediment debris trap for the LRT guide way. This conservation measure is intended to capture sand used during deicing activities on the guide way.

Table 6-22. Summary of Changes in PGIS – Columbia River South Watershed

	Area (acres)			
	Infiltrated	**Treated**	**Untreated**	**Total**
Existing PGIS	**0.0**	**0.0**	**59.1**	**59.1**
Post-Project PGIS	**0.0**	**54.6**	**0.0**	**54.6**
Existing PGIS retained as-is	0.0	2.3[a]	0.0	2.3
Existing PGIS resurfaced	0.0	0.0	0.0	0.0
Net change in existing PGIS	0.0	2.3	(59.1)	(56.8)
New and rebuilt PGIS	0.0	52.3	0.0	52.3
Net Change in Total PGIS	**0.0**	**54.6**	**(59.1)**	**(4.5)**

a The existing North Portland Harbor Bridge.

Table 6-23 summarizes the treatment scenario for PGIS that drains to the Columbia River North watershed in Washington. Currently, only 2.8 acres of PGIS receives infiltration or treatment. The completed project will add 12.6 acres of net new PGIS to this watershed and will treat or infiltrate 88.4 of the 91.5 acres of new and rebuilt PGIS and significant quantities of the existing resurfaced PGIS, for a net total of 104.3 acres of treated or infiltrated PGIS. This represents additional treatment of more than 800 percent of the net new PGIS. Flow control is not required or provided for runoff discharged to the Columbia River, and no new outfalls are proposed.

Table 6-23. Summary of Changes in PGIS – Columbia River North Watershed

	Area (acres)			
	Infiltrated	**Treated**	**Untreated**	**Total**
Existing PGIS	**2.8**	**0.0**	**97.4**	**100.2**
Post-Project PGIS	**71.6**	**35.5**	**5.7**	**112.8**
Existing PGIS retained as-is	0.0	0.0	0.0	0.0
Existing PGIS resurfaced	13.1	5.6	2.6	21.3
Net change in existing PGIS	10.3	5.6	(94.8)	(78.9)
New and rebuilt PGIS	58.5	29.9	3.1	91.5
Net Change in Total PGIS	**68.8**	**35.5**	**(91.7)**	**12.6**
Existing PGIS not within Footprint[a]	**9.0**	**8.3**	**0.0**	**17.3**

a Areas from which runoff will drain to proposed water quality facilities or "equivalent" areas to compensate for new or rebuilt PGIS from which it may not be feasible to treat runoff.

It is difficult to quantify exactly to what extent the treatment scenario will affect water quality in the Columbia River and North Portland Harbor. But given there will be a net loss of 4.5 acres of PGIS draining to the Columbia River south watershed (Table 6-22), it is likely that the treatment scenario will result in a net benefit to water quality in this area during events that do not exceed the design storm. Additionally, the facilities will treat roughly 800 percent of the net new PGIS in the Columbia River North watershed, potentially resulting in a net benefit to the environmental baseline in the Columbia River during events less than the design storm. During these events, listed fish will continue to be exposed to pollutants, but because the project treats such a large proportion of currently untreated PGIS, the exposure level will likely be lower than currently.

Only during events exceeding the design storm will the project likely discharge untreated runoff into the receiving water bodies, potentially resulting in exposure of fish to waterborne pollutants. The design storms fall under the jurisdiction of the City of Portland, ODOT, and Ecology. For the City of Portland, the design storm is 90 percent of the average annual runoff volume, meaning that, on average, 10 percent of the annual runoff volume will discharge untreated into the receiving water bodies. For ODOT, the design storm is 85 percent of the average annual discharge, meaning that approximately 15 percent of the annual runoff will discharge untreated. In Washington, the design storm is 91 percent of the average annual runoff volume, meaning that 9 percent of the average annual runoff volume will discharge untreated.

Table 6-24 outlines the number of times that a precipitation event typically exceeds the design storms used in areas that drain to the Columbia River and North Portland Harbor. It also illustrates the percent chance that such events will occur in a given month. Events that exceed the design storm are very likely to occur from September through February, but are also possible during other months. Exceedances are unlikely in July and August.

In any case, even during events that exceed the design storm, the project will likely discharge pollutants at a lower rate than currently, due to the high level of treatment relative to the amount of net new PGIS. Additionally, given the large volume of water in the Columbia River and North Portland Harbor, dilution levels are expected to be very high, and pollutant levels will likely dissipate to background levels within a short distance of the outfalls.

Table 6-24. Frequency and Probability of Design Storm Event Exceedance for a Given Month (Columbia River and North Portland Harbor)

	City of Portland		Ecology		ODOT	
Month	No. Events	Probability of Exceedance	No. Events	Probability of Exceedance	No. Events	Probability of Exceedance
Jan	12	14%	19	23%	30	36%
Feb	9	11%	13	16%	22	27%
Mar	1	1%	4	5%	10	12%
Apr	1	1%	1	1%	1	1%
May	0	0%	2	2%	2	2%
Jun	3	4%	4	5%	6	7%
Jul	0	0%	0	0%	0	0%
Aug	0	0%	1	1%	2	2%
Sep	4	5%	7	8%	9	11%
Oct	4	5%	8	10%	11	13%
Nov	18	22%	25	30%	44	53%
Dec	24	29%	44	53%	60	72%

Traffic models projected to 2030 predict that the project will substantially decrease overall traffic congestion on the new bridges and the roadways that contribute runoff to the Columbia River and North Portland Harbor. Idling and brake pad wear, which contribute to the amount of oil, grease, copper, and other pollutants released, are expected to decrease with congestion relief, as will the amount of pollutants transported to the Columbia River and North Portland Harbor. This may further decrease exposure of listed fish to pollutants.

Numerous listed species are present in the Columbia River and North Portland Harbor. The following species may be exposed to water quality effects:

- Adult and juvenile LCR coho; CR chum; SR sockeye; LCR, MCR, UCR, and SR steelhead; and LCR, UCR spring-run, SR fall-run, SR spring/summer-run Chinook.
- Adult and subadult bull trout.
- Adult and subadult green sturgeon.
- All life stages of eulachon.

Figure 4-1 and Figure 4-2 illustrate when these species are present in the Columbia River and North Portland Harbor.

These species could be exposed to untreated stormwater during the overlap of: 1) when the species are present in the action area near stormwater outfalls (see Figure 4-1 and Figure 4-2) and, 2) any event that exceeds the design storm of the treatment facilities (Table 6-24). However, exposure will likely less than it is currently due to the high level of treatment provided.

USFWS and NMFS have both determined that the Columbia River and North Portland Harbor are “flow-control exempt” water bodies. This means that PGIS draining to these water bodies does not require flow control facilities. Increases in PGIS in these watersheds will have no measurable effect on flow.

6.2.1.4 Stormwater Impacts to Columbia Slough

Table 6-25 summarizes the treatment scenario for PGIS that drains to the Columbia Slough watershed. Stormwater outfalls in this watershed discharge directly to Walker Slough and Schmeer Slough. From there, flows are pumped over a levee into the Columbia Slough.

The project will treat or infiltrate 35.1 acres of new and rebuilt PGIS and significant quantities of the existing retained and resurfaced PGIS, for a net total of 40.6 acres of treated or infiltrated PGIS. Flow control is not required for stormwater runoff discharged to Columbia Slough. No new outfalls are proposed in this watershed.

Table 6-25. Summary of Changes in PGIS – Columbia Slough Watershed

	Area (acres)			
	Infiltrated	**Treated**	**Untreated**	**Total**
Existing PGIS	**2.7**	**0.0**	**39.0**	**41.7**
Post-Project PGIS	**1.0**	**42.3**	**8.4**	**51.7**
Existing PGIS retained as-is	0.0	1.9[a]	0.0	1.9
Existing PGIS resurfaced	0.0	6.3	4.7	11.0
Net change in existing PGIS	(2.7)	8.2	(34.3)	(28.8)
New and rebuilt PGIS	1.0	34.1	3.7	38.8
Net Change in Total PGIS	**(1.7)**	**42.3**	**(30.6)**	**10.0**

a The existing North Portland Harbor Bridge. This area is not currently in the watershed.

It is difficult to quantify exactly how the treatment scenario will affect water quality in the Columbia Slough. However, given that the project will treat roughly 350 percent of the net new PGIS in this watershed, it is likely that the treatment will decrease the amount of stormwater pollutants entering the Columbia Slough, resulting in a net benefit to the environmental baseline during the majority of events (i.e., events that do not exceed the design storm). During most events, listed fish will continue to be exposed to pollutants, but due to increased PGIS treatment they are likely exposed to lower pollutant levels than current conditions.

Only during events that exceed the design storm will untreated stormwater be discharged into Walker Slough and Schmeer Slough. Table 6-24 depicts the predicted frequency and probability that untreated runoff will enter these sloughs (note the City of Portland and ODOT frequencies). Such events are very likely to occur from September to March, but are also possible during the other months of the year. These events are very unlikely in July and August.

Upon entering Walker and Schmeer Sloughs, stormwater runoff will become diluted at the outfalls. The water will then travel through several thousand feet of vegetated open conveyance, where it will be further diluted in the water column before discharging to Columbia Slough. The diluted runoff would discharge into the Columbia Slough only during periods when the pump is running. (The pump schedule is unknown. This analysis assumes that the pump is continually running in order to provide a worst-case scenario.) Because discharge to Walker and Schmeer Sloughs is likely to occur only during larger events (that is, events that exceed the design storm), untreated runoff is likely to become highly diluted by the increased volume of water. Given the high levels of dilution and the large distance between the nearest outfall and the Columbia Slough, it is expected that dilution will reduce pollutants to background levels before this runoff enters fish-bearing waters. Therefore, exposure to listed fish in Columbia Slough is unlikely.

Traffic models projected to 2030 predict that the project will substantially decrease overall traffic congestion in the treatment facilities that drain to the Columbia Slough. Idling and brake pad wear, which contribute to the amount of oil, grease, copper, and other pollutants that are released, are expected to decrease with congestion relief, as will the amount of pollutants transported to the Columbia Slough. This may have a net benefit on listed species using this waterway.

With the exception of bull trout, all of the salmonids addressed by this BA could potentially use the Columbia Slough for rearing and migration (as detailed in Section 4). Of these ESUs/DPSs, the following are likely to be present, based on numerous documented detections: LCR Chinook, UWR Chinook, LCR steelhead, UWR steelhead, and LCR coho. Other ESUs/DPSs are not documented but are presumed present, given that recent studies have documented up-river ESUs using the Slough and its adjacent floodplain wetlands (Teel et al. 2009). Because the Columbia Slough portion of the action area is accessible to fish, their presence in this area cannot be discounted.

There are no precise data on the times of year that listed salmonids use Columbia Slough. However, they are likely only present from fall through spring, and may to be exposed to water quality effects at any time during this period when there are events that exceed the design storm (Table 6-24). However, as described earlier, exposure is likely to be minimal due to the high level of stormwater treatment and the high levels of in-stream dilution. Exposure during the summer is possible but not likely, because events that exceed the design storm are relatively rare in summer and because water temperatures often exceed levels in which juvenile salmonids can survive (DEQ 2007).

Addition of PGIS to this stormwater drainage area will have no effect on flows in the Columbia Slough. The Columbia Slough is a flow control-exempt water body, meaning that addition of PGIS in this area is not expected to degrade the flow regime in the Slough, and therefore, the stormwater treatment facilities in this drainage area do not require flow control. Discharges to the Slough are regulated by a Multnomah County Drainage District pump system designed to handle up to the 100-year event. Because the pumps regulate flows between the outfalls and Columbia Slough, additional runoff from these areas will not affect flows in the Slough during the large majority of events, and the inclusion of flow control in treatment facilities would be redundant. Additionally, the tidal influence in Columbia Slough is likely to overwhelm any water quantity impacts occurring during high tides.

Green sturgeon and eulachon are not known to occur in the Columbia Slough. These species are not likely to be exposed to stormwater effects in the Columbia Slough.

6.2.1.5 Stormwater Impacts to Burnt Bridge Creek

Table 6-26 summarizes the treatment scenario for facilities that drain to the Burnt Bridge Creek watershed. At present, nearly all of the PGIS in this watershed is treated. The project will increase the total PGIS in the watershed by 3.1 acres and will treat or infiltrate 16.8 acres of new, rebuilt, and resurfaced PGIS.

According to Ecology standards, discharge to Burnt Bridge Creek between 50 percent of the 2-year event and the 50-year event must be reduced to the pre-development (forested) condition.

Table 6-26. Summary of Changes in PGIS – Burnt Bridge Creek Watershed

	Area (acres)			
	Infiltrated	**Treated**	**Untreated**	**Total**
Existing PGIS	**14.5**	**0.0**	**1.7**	**16.2**
Post-Project PGIS	**16.8**	**0.0**	**2.5**	**19.3**
Existing PGIS retained as-is	0.0	0.0	0.0	0.0
Existing PGIS resurfaced	9.0	0.0	1.2	10.2
Net change in existing PGIS	(5.5)	0.0	(0.5)	(6.0)
New and rebuilt PGIS	7.8	0.0	1.3	9.1
Net Change in Total PGIS	**2.3**	**0.0**	**0.8**	**3.1**
Existing PGIS not within Footprint[a]	**0.9**	**0.0**	**0.0**	**0.9**

a Areas from which runoff will drain to proposed water quality facilities or "equivalent" areas to compensate for new or rebuilt PGIS from which it may not be feasible to treat runoff.

It is difficult to quantify whether the enhanced proportion of infiltration will outweigh the impacts associated with the net new PGIS. (Potential effects are described in earlier subsections of Section 6.2.1) However, given that the project will provide additional treatment or infiltration for roughly 540 percent of the net new PGIS in this watershed, it is possible that the improved treatment scenario will cause a net benefit to the environmental baseline and to listed fish in Burnt Bridge Creek during events that do not exceed the design storm. In any case, the project is not likely to significantly degrade conditions in the creek during events less than the design storm.

During events that exceed the design storm, however, untreated runoff will certainly enter Burnt Bridge Creek. On average, 9 percent of the average annual volume from treatment facilities will discharge untreated into Burnt Bridge Creek. Table 6-27 depicts the estimated frequency and probability of events that will exceed the design storm.

Table 6-27. Frequency and Probability of Design Storm Event Exceedance – Burnt Bridge Creek

	91% Design Volume	
	No. Events	**Probability of Exceedance**
Jan	12	14%
Feb	9	11%
Mar	1	1%
Apr	1	1%
May	0	0%
Jun	3	4%
Jul	0	0%
Aug	0	0%
Sep	4	5%
Oct	4	5%
Nov	18	22%
Dec	24	29%

These types of events are most likely to occur from November through February, but may also occasionally occur during the rest of the year. Discharge during May, July, and August is highly unlikely. However, given the high level of infiltration in this drainage area, actual discharge of untreated stormwater is expected to occur less often than predicted in Table 6-27. Additionally, pollutants will likely be diluted due to the large volume of water that typically is present during these events. Although listed fish may be exposed to untreated stormwater during events that exceed the design storm, exposure will likely be less than it is currently due to the high level of treatment proposed. During events that exceed the design storm, stormwater runoff may also degrade the flow regime in Burnt Bridge Creek. However, due to the high levels of infiltration proposed, impacts are expected to be slight.

All freshwater life stages of coho, Chinook, and steelhead are potentially present in the creek (Weinheimer 2007 personal communication). Therefore, runoff may affect all life stages, as well as spawning, migration, foraging, and rearing habitat. The abundance of these species is thought to be very low in Burnt Bridge Creek (PSMFC 2003). Therefore, it is expected that very few individuals will be exposed to these effects. Steelhead and coho have been detected in Burnt Bridge Creek in proximity to stormwater outfalls, and exposure of these species to stormwater effects is likely. Chinook have been detected in Burnt Bridge Creek within 1 mile of the project-area stormwater outfalls. However, because abundance of Chinook is very low and there is a partial passage barrier between the location of the detection and the nearest project-area outfall, the likelihood of exposure is discountable.

LCR coho, Chinook, and steelhead could be exposed to stormwater runoff during events that exceed the design storm. Exposure is likely from fall through spring, when design storm-exceeding events most frequently occur and when these species have been documented in the stream. Due to the limited data on fish presence, there are no precise dates for when these species occur in Burnt Bridge Creek. There are only two known stream surveys in Burnt Bridge Creek, conducted in November/December 2002 and April 2003 (PSMFC 2003). The results of the surveys indicate that these species are at least present from November through April. They presumably occur there at all times of year except during the warmest summer months.

During summer, exposure is possible, but less likely. Given the lack of data, we cannot discount the possibility that fish occur there during the summer. However, the Washington 303(d) list has documented water temperatures that exceed the range tolerated by salmonids during some summers (Ecology 2009b). Therefore, these species may not be present in Burnt Bridge Creek in the summer, at least not during some years. Additionally, events exceeding the design storm are less likely in the summer, further reducing the likelihood for exposure.

Other salmonid ESUs/DPSs, eulachon, and green sturgeon are not present in Burnt Bridge Creek and will not be affected by stormwater runoff in this stream.

6.2.1.6 Ruby Junction

The CRC project will expand the existing Ruby Junction light rail maintenance facility, resulting in an increase in impervious surface. All of the new, CRC-related PGIS will be routed from the expansion area to a new infiltration facility. Stormwater will be completely infiltrated, with no discharge to any surface water body at any time. During events that exceed the design storm, stormwater will pond in a nearby field adjacent to the treatment facility. Because there is no discharge to any surface water body, this element of the project will have no effect on listed fish.

6.2.1.7 Summary of Stormwater Effects to Listed Fish

The project will provide a high level of treatment for a large proportion of the project-area PGIS, installing treatment not just for new PGIS but also for 188 acres of PGIS that is currently untreated. Project-wide, there will be treatment for over nine times the area of net new PGIS. While the project will not completely eliminate effects to water quality and flow, the high level of treatment is expected to provide an overall benefit to the environmental baseline. Effects to individual listed species are summarized below.

Bull trout adults and subadults could potentially be exposed to degraded water quality in the Columbia River and North Portland Harbor. However, given the very low abundance of bull trout and high levels of dilution in these water bodies, the likelihood of exposure is insignificant and discountable.

Green sturgeon adults and subadults could also be exposed to degraded water quality in the Columbia River and North Portland Harbor. However, given the high levels of dilution, exposure is expected to be insignificant. Due to the rarity of green sturgeon in the areas subjected to diminished water quality, the likelihood of exposure is discountable.

Stormwater effects to listed salmon and steelhead are as follows:

- In the Columbia River and North Portland Harbor, listed salmon and steelhead may potentially be exposed to degraded water quality within a short distance of the outfalls during periods when fish are present (Figure 4-1 and Figure 4-2) and when there is an event that exceeds the design storm (Table 6-27). Exposure will be minimal due to the high dilution capacity of these large water bodies. During events that do not exceed the design storm, the project is expected to discharge runoff that has less pollutant content than the pre-project condition due to the high level of stormwater treatment relative to the net new PGIS. While it is inconclusive whether this constitutes a benefit to these fish, the high level of treatment makes it improbable that the runoff will degrade the baseline or cause higher levels of exposure during these events.

- In the Columbia Slough, there is a minimal chance that listed salmonids will be exposed to degraded water quality. Stormwater outfalls discharge directly into water bodies that do not contain listed fish and travel through several thousand linear feet of a vegetated open conveyance system before entering the Columbia Slough. Given the distance between stormwater outfalls and the nearest locations where listed fish are present, and given the high levels of dilution likely to occur, pollutants will likely dissipate to ambient levels before discharging to fish-bearing waters.

- In Burnt Bridge Creek, LCR coho, steelhead, and Chinook may be exposed to degraded water quality and flow regime during periods when fish are present (fall through spring) and when there is an event that exceeds the design storm (Table 6-27). Due to the low abundance of these species in Burnt Bridge Creek, few individuals will be exposed to these effects. Steelhead and coho are likely to experience exposure to these effects, as they have been detected in proximity to stormwater outfalls associated with this project. For Chinook, exposure is discountable, as they have been detected more than a mile from the nearest outfall and downstream of a partial passage barrier.

6.2.2 Indirect Effects and Land Use Changes Overview

An extensive body of research provides insight into the complex relationship between transportation infrastructure and land use. Different types of transportation system changes can have different types and degrees of indirect effect on land use. For example, some types of roadway projects increase automobile demand which can encourage auto-oriented development, while other roadway projects do not. Conversely, some transit projects lead to increased development density around transit stations, while others do not. Because CRC is a multimodal project, it has the potential to promote auto-oriented and/or transit-oriented development (TOD).

In general, auto-oriented development tends to occur at relatively low densities around the urban periphery; while local and regional land use plans allow some of this type of development, they generally attempt to limit it because it is considered to be an inefficient method of accommodating population and employment growth and results in relatively higher costs, higher environmental impacts, and a greater consumption of land. In contrast, TOD is often higher density, in an already urbanized area, and is typically a more efficient method of accommodating future growth. Concentrating growth can help protect listed species and their habitat from potentially adverse effects of development, such as habitat conversion and contamination from stormwater runoff. However, without proper land use controls and environmental protections, any type of development can degrade habitat and affect listed species.

A review and synthesis of existing research and case studies[2] revealed several factors that influence how a transportation investment such as CRC could influence travel and land use patterns. These factors include proximity to urban boundaries, existing land uses, changes in traffic and transit performance, real estate market characteristics, public perceptions, and land use and growth management regulations.

The following evaluation identifies likely project effects on future travel behavior and land use patterns, and the associated effects on listed species and their habitat. The evaluation applies factors identified in the literature review that influence how transportation projects affect land use. Additionally, it evaluates the results from travel demand modeling and an iterative transportation-land use-real estate model (Metroscope). Current local, state, and federal regulations that manage growth and protect environmental resources within the project vicinity are discussed in terms of potential impact minimization to listed species and their habitat. The review concludes with the anticipated resulting project effects on listed species and their habitat.

6.2.2.1 Will the project create a new facility?

Yes. CRC will extend light rail over Hayden Island and through downtown Vancouver to Clark College. This is the first high capacity transit system in Vancouver and Clark County since the removal of the early streetcar lines in the nearly one hundred years ago. This light rail facility will connect to the existing light rail system that currently ends at the Expo Center in North Portland, allowing riders to travel on light rail between downtown Vancouver to key destinations in the region, such as downtown Portland and Portland International Airport. This light rail extension includes five stations along the alignment and three park and ride facilities SR 14, Mill

[2] See Appendix A of the CRC Land Use Technical Report (CRC 2008c).for a detailed description of this literature review. Available at: http://www.columbiarivercrossing.com/FileLibrary/TechnicalReports/Land_Use_TechnicalReport.pdf.

District, and Clark College. Section 3.10 provides a detailed description of the transit facilities included in this project.

The CRC highway improvements do not represent a new facility. These improvements are to an existing 5-mile segment of an established freeway corridor (I-5). It has been a major auto corridor since the first bridge was constructed in 1917 and has been an Interstate highway for more than 40 years. CRC does not include any new interchanges, but will make improvements to seven interchanges in this 5-mile segment to improve the safety and mobility of motorists. These highway improvements include accommodation of additional auxiliary lanes, full shoulders, separation of conflicting traffic movements (e.g., motorists entering and exiting the freeway) and direct (e.g., non-stop) connections between the intersecting arterials and highways.

Auxiliary lanes are a key component of the CRC highway improvements, but because the highway currently exists they are not considered new facilities. These lanes connect two or more highway interchanges to improve safety and reduce congestion by providing space for motorists to enter and exit the freeway without interacting with through-traffic. Some of the interchanges in the CRC project area are about 0.50 mile apart (the recommended minimum distance is 1 mile), leaving little room for cars entering and exiting the highway to merge with traffic or decelerate and diverge to an off-ramp. Substandard length on- and off-ramps in the project area compound this problem by allowing little time for merging traffic to accelerate to mainline speeds, or for exiting traffic to decelerate on the off-ramps. Auxiliary lanes will increase I-5 capacity within the project area, alleviating congestion occurring at the bottleneck around the river crossing and removing safety problems in this corridor. The existing three through-lanes will be maintained through the project corridor, and the new auxiliary lanes will end north of SR 500 and south of Marine Drive to tie in with the three through-lanes north and south of this project.

CRC provides one change in access between I-5 and intersecting roadways—new direct connections between I-5 and SR 500. Currently, the connections between SR 500 westbound to I-5 northbound and from I-5 southbound to SR 500 eastbound are made indirectly. To make these connections today, traffic exits one highway, travels on 39th Street, then enters the other highway. The project will result in on and off ramps directly connected to SR 500 and I-5 for both of these connections. I-5 southbound traffic will connect to SR 500 via a new ramp underneath I-5. SR 500 westbound traffic will connect to I-5 northbound on a new off-ramp. The 39th Street connections with I-5 to and from the north will be eliminated. Travelers will instead use the connections at Main Street to connect to and from 39th Street. These improvements should make traffic connections between these highways more efficient and reduce congestion on nearby local streets by keeping motorists traveling between SR 500 and I-5 on highways, but do not represent a material change in connections.

6.2.2.2 Will the project improve level of service of an existing facility?

The CRC project will improve transit service and reliability and improve transit travel times. It will also improve the level of service for bicyclists and pedestrians.

The project will also significantly improve the level of service of I-5 as described below. It will decrease the duration of congestion at this bottleneck each day thus reducing the number of cars and highway users caught in congestion. It will also improve safety and remove bridge lifts, thus reducing congestion associated with accidents and eliminating congestion caused by bridge lifts.

Travel demand modeling and traffic simulation estimate that by 2030 CRC will cause the following important transportation performance changes compared to 2030 No-Build conditions (CRC 2008a):

- Increased transit ridership: PM peak period transit ridership is anticipated to increase about 250 percent compared to No-Build, more than doubling the share of travelers during this period that is anticipated to be on transit versus autos.
- More bicyclists and pedestrians: Approximately 5,000 bicyclists and 1,000 pedestrians per day are expected to use the new pathway over the river connecting to paths in North Portland and downtown Vancouver. This compares to only 370 bicyclists and 80 pedestrians currently using the crossing per day.
- Congestion reduction: CRC is anticipated to reduce daily congestion duration from 15 hours under No Build conditions to approximately 5 hours;
- Reduced travel times: Compared to the No Build, CRC is anticipated to provide an average 23 minute travel-time savings for a round trip between 179th in Vancouver and I-84 in Portland during peak periods.[3]
- Greater peak period throughput: CRC will allow 61,800 or more people in 51,800 vehicles to cross the bridge during the 4-hour peak period in the peak direction (southbound in the morning and northbound in the afternoon) versus only 51,300 people in 43,200 vehicles under No-Build conditions. This is largely because the greater congestion with the No-Build alternative does little to curb the number of cars trying to cross the river; it only limits the number of cars that can actually get across in that time frame.
- Minimal traffic diversion to I-205: Though CRC will add a toll on the I-5 crossing, travel demand modeling indicates only a modest 6.5 percent increase in traffic on the I-205 crossing.
- Lower daily traffic: Despite this greater peak-period throughput, CRC is anticipated to lower daily cross-river traffic on the I-5 and I-205 bridges by 3 percent.[4] This is because, even though I-205 traffic volumes go up with a toll on I-5, the combined I-5 and I-205 cross-river traffic go down with LRT and a toll on I-5.

6.2.2.3 Does the project have a causal relationship to land use changes?

CRC's changes to transportation infrastructure and resultant alterations in travel patterns are likely to have an effect on future land use patterns. CRC will facilitate achieving some land use goals in local plans, but perhaps more significantly, this project is expected to concentrate future regional growth within the I-5 corridor. The following evaluation examines how CRC will affect local land use plans and travel patterns. It concludes with a discussion on how CRC can be expected to influence future land use and development patterns.

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[3] AM peak commute period is southbound between 6am–10am; PM peak commute period is northbound between 3pm–7pm.

[4] 184,000 cars will travel over the I-5 bridges under the No Build scenario versus 178,000 with a replacement crossing, a toll on I-5, and light rail.

Effects to Local Land Use Plans

There are no building moratoriums in place that are contingent on CRC, or any plans that include different land use scenarios based on whether this project is constructed (Gillam 2009 personal communication). However, recent planning by the City of Portland for Hayden Island and by the City of Vancouver for its downtown relies on the transportation improvements offered by CRC. The Hayden Island Plan outlines a vision for the future growth and development and redevelopment of the commercial core of Hayden Island. For existing land use and zoning within the geographic extent of this plan, see Figure 6-22 and Figure 6-23. This plan includes the expectation that access to the island will be improved by the new I-5 interchange and light rail extension included by CRC (Figure 6-24). The Hayden Island Plan envisions these access improvements facilitating new, transit-oriented development on the island. For example, the Jantzen Beach shopping center immediately west of the I-5 interchange is expected to redevelop from low-density retail into a medium-density mix of commercial and residential uses with up to 2,000 new housing units centered around the new light rail station (COP 2009b).

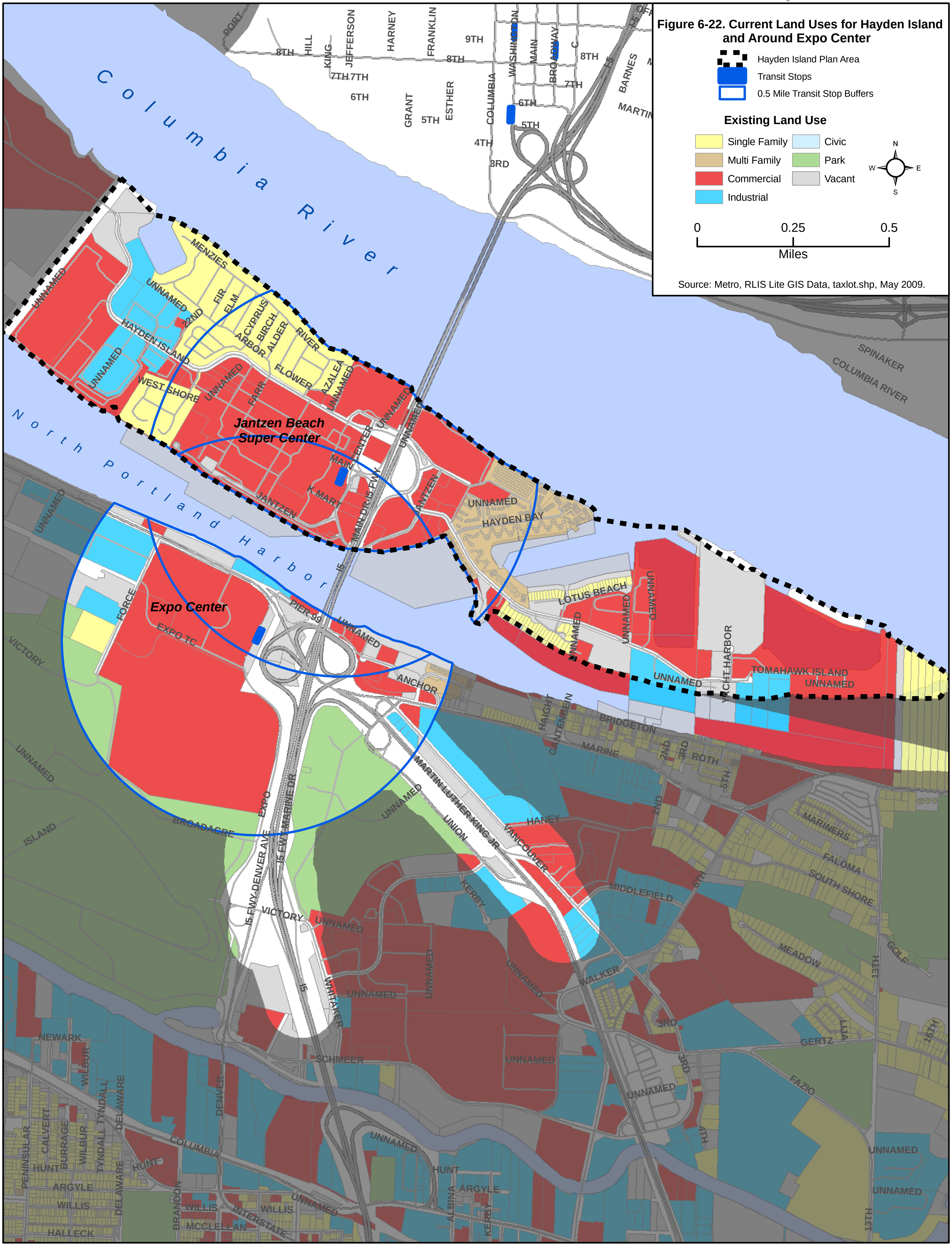

Figure 6-22. Current Land Uses for Hayden Island and Around Expo Center

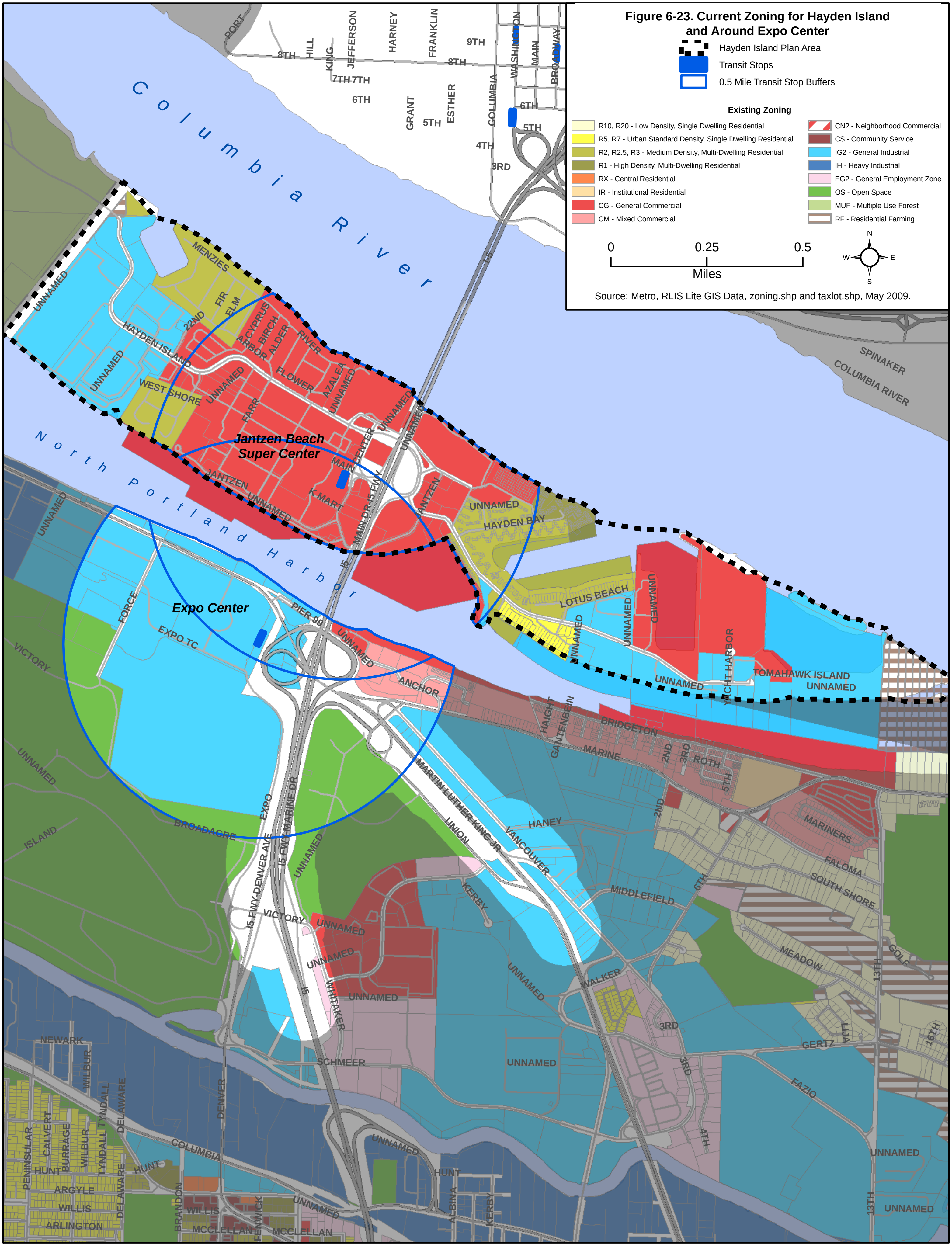

Figure 6-23. Current Zoning for Hayden Island and Around Expo Center

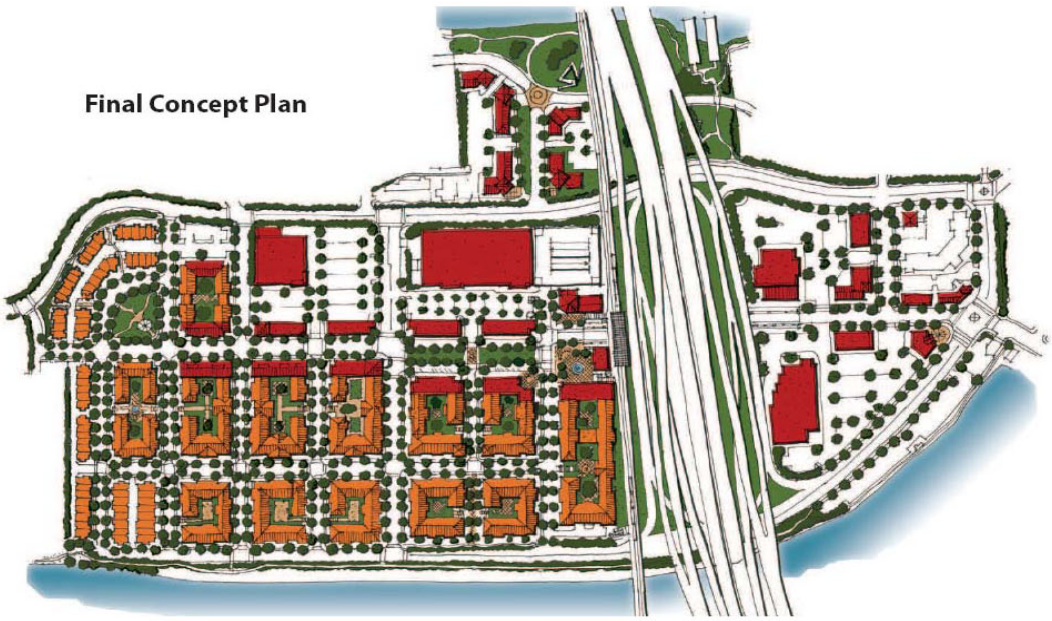

Figure 6-24. Conceptual Plan for Hayden Island

The VCCV[5] identifies high capacity transit through downtown Vancouver (Figure 6-25 and Figure 6-26 for the existing land use and zoning within the geographic extent of this plan) as a key transportation goal and to encourage further development in the downtown. Another goal in the VCCV is extending Main Street to Columbia Way and providing greater public access and connectivity to the waterfront. As part of the CRC project Main Street will be extended to Columbia Way. This is due to the removal of the existing Columbia River bridges and the increased grade of the replacement bridges. The Main Street extension will support the City's vision of providing greater connectivity to the waterfront, an indirect effect.

[5] Vancouver City Center Vision and Subarea Plan, City of Vancouver, adopted June 18, 2007.

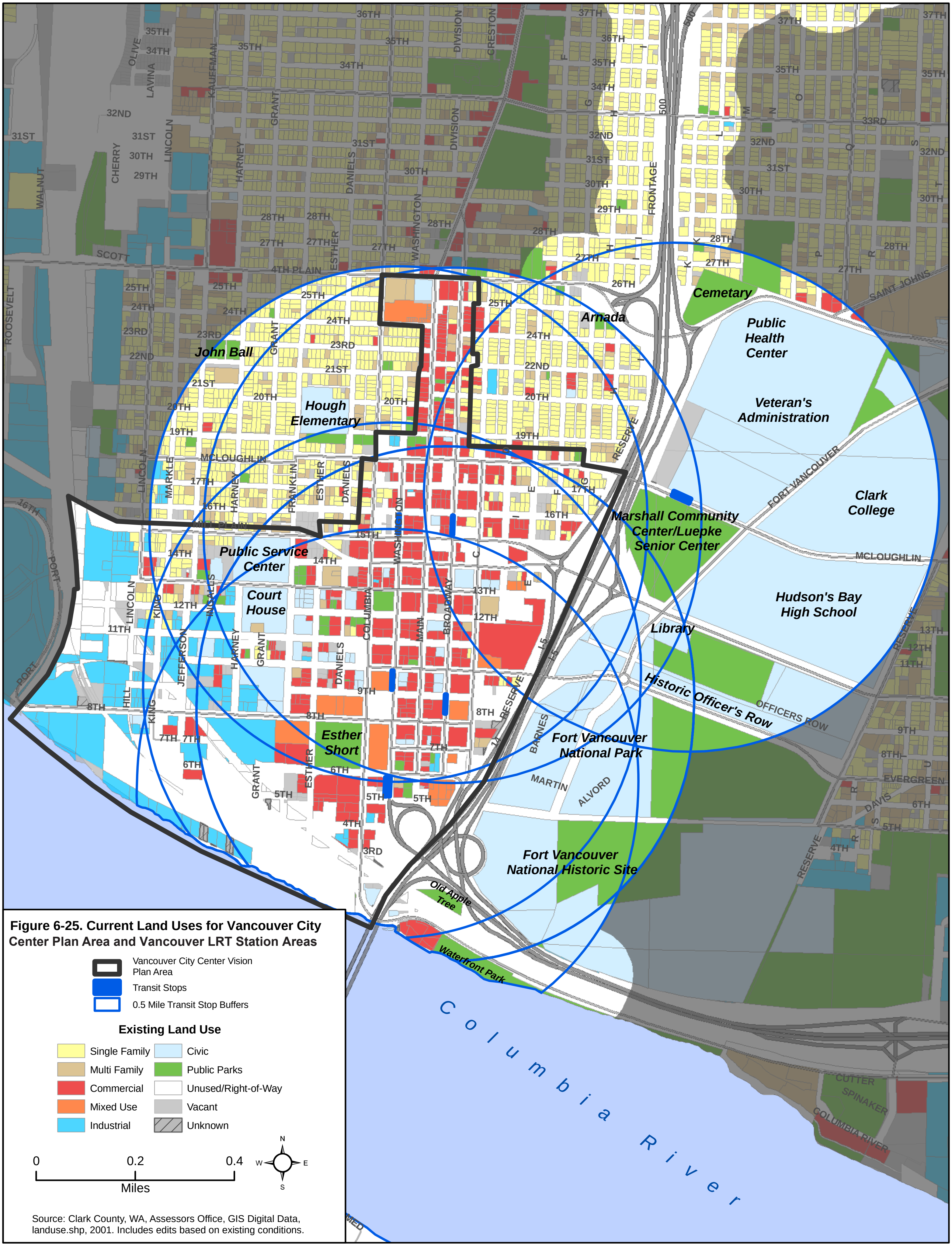

Figure 6-25. Current Land Uses for Vancouver City Center Plan Area and Vancouver LRT Station Areas

Source: Clark County, WA, Assessors Office, GIS Digital Data, landuse.shp, 2001. Includes edits based on existing conditions.

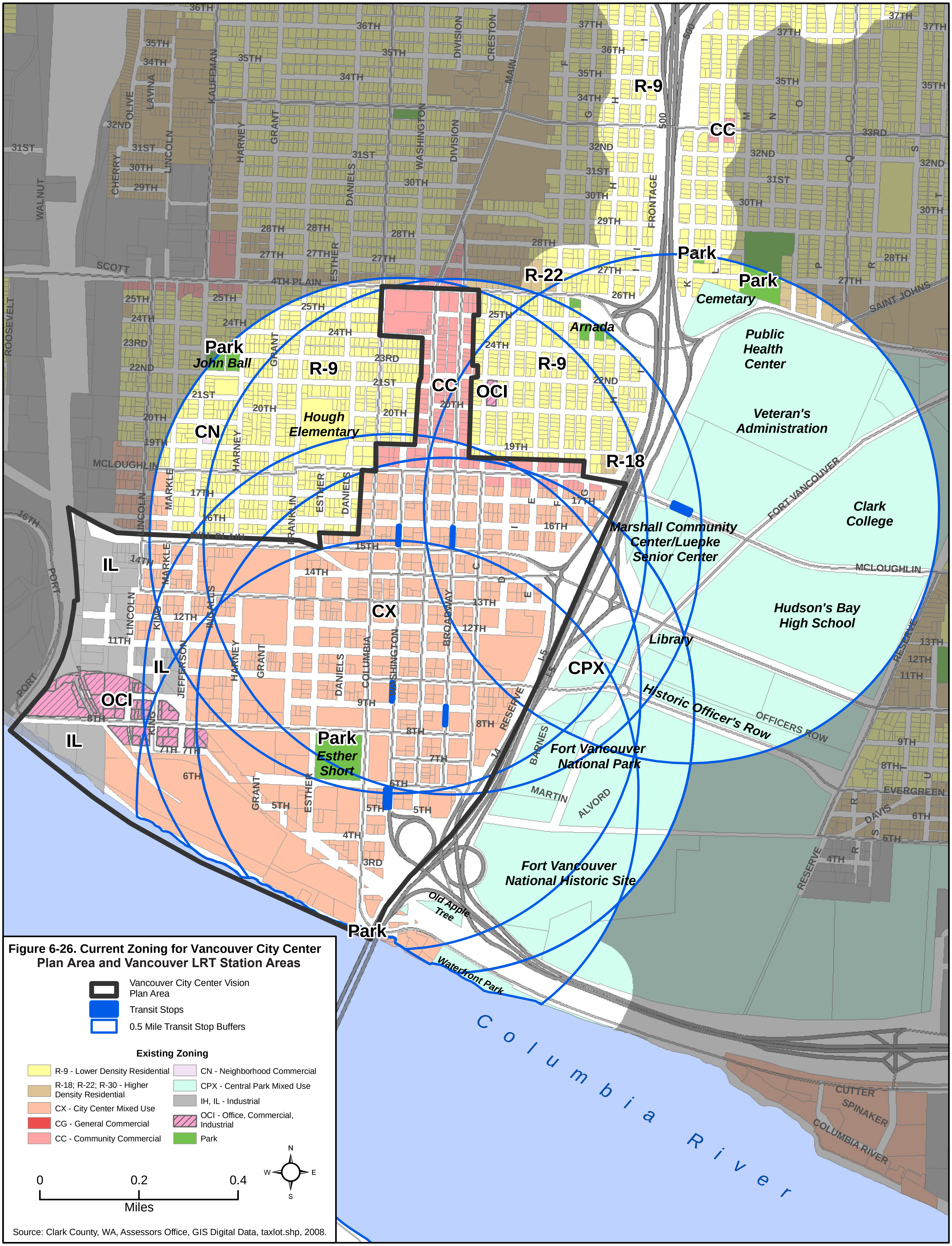

Figure 6-26. Current Zoning for Vancouver City Center Plan Area and Vancouver LRT Station Areas

Source: Clark County, WA, Assessors Office, GIS Digital Data, taxlot.shp, 2008.

The Main Street extension, Columbia Way design, and the completion of the street grid south of the railroad berm will also add additional access to planned redevelopment of 35 acres along the Vancouver waterfront immediately west of I-5. Most of the acreage was formerly occupied by Boise Cascade and used for industrial purposes. Currently, the area is primarily covered in asphalt, has no stormwater treatment, and little riparian vegetation (Figure 6-27). The riverbank currently consists of a combination of riprap, native cottonwoods, and an understory dominated by non-native vegetation. This area has been rezoned and is being redeveloped into a high-density mixed use area with open space and public access along the entire waterfront. The developer's Master Plan for the area was approved by the City of Vancouver Planning Commission on November 10, 2009.[6] The redeveloped area will be accessed first off Columbia Way, near the Red Lion Hotel property's northern entrance, and later by two additional points via tunnels under the BNSF railroad berm at Grant and Esther Streets. The plan does not incorporate redevelopment of the Red Lion Hotel and associated restaurants because it assumes the parcel will be displaced by CRC for staging and construction. Although, the waterfront development is planned and progressing forward separately from CRC, an additional access point from Main Street will potentially increase the rate of the redevelopment.

Figure 6-27. Site of Proposed Redevelopment Project Showing Existing Conditions Along Vancouver Waterfront

[6] Columbia Waterfront, LLC, a group of local investors led by Gramor Development of Tualatin, Oregon., submitted a conceptual pre-application for site development in December 2008. The city commented on the pre-application January 8, 2009. Gramor incorporated city feedback (including feedback on Shorelines and Critical Area Ordinance compliance) into their master plan application.

To achieve the VCCV goal of public use of the shoreline, the area along the shoreline will be dedicated to the City, designed and managed by the City of Vancouver Parks Department, and required by conditions of the Master Plan to be designed in a sustainable manner, as well as be compliant with the Shoreline Management Act (SMA) and Clark County Critical Areas Ordinances (CAO). Preliminary means of complying with the goals for the projects sustainability include: a wide (minimum 200 foot) buffer from the OHW mark, exclusive use of native plants, minimal or no irrigation, limited use of fencing or other appurtenances, and potentially habitat restoration.

Connecting Travel Pattern Changes to Land Use

The CRC project team evaluated the potential for indirect land use changes as a result of altered travel patterns using four analytical methods:

- A survey of national research and case studies on how transportation infrastructure can indirectly impact land use,
- An analysis of growth management in Washington and Oregon,
- Travel demand modeling and traffic operational analysis of CRC, and
- Integrated land use/transportation/real estate modeling that estimates how the CRC project might influence the location of future growth in housing and employment.

Survey of Research and Case Studies

A broad survey of national research and case studies on how transportation infrastructure can indirectly impact land use underpinned the analysis of how this project could induce land use changes. National research and case studies revealed a variety of important factors that influence whether and how transportation investments change travel and land use patterns. In general, some transit projects tended to promote higher density development, particularly around new transit stations, while some projects adding highway capacity increased automobile use and could have the potential to induce low-density, auto-oriented development further from urban centers. At the same time, other transit projects and highway projects did not have these effects. The most relevant findings from the national research were the answers to the following two questions:

- What factors were associated with highway projects that tended to increase auto use and low density development, and
- What factors were associated with high capacity transit projects that tended to increase transit-oriented and higher density development?

Table 6-28 answers the first question regarding factors that increase auto use and auto-oriented development, and identifies the extent to which each factor is or is not included in the CRC project.

Table 6-28. Factors Associated with Highway Projects That Can Lead to Induced Auto Travel and Sprawl

Factors from National Research	Does CRC exhibit these factors?
The project provides new access to areas previously un-served or greatly underserved by highways.	**No.** CRC is entirely within an urbanized area, and I-5 has been an Interstate corridor since 1958. Project adds no new interchanges.
The project provides new highway access to land on the urban edge.	**No.** CRC improvements are located 7 miles inside the Vancouver Urban Growth Area boundary to the north, and over 13 miles inside the Metro Urban Growth Boundary to the south.
The project substantially improves highway travel times.	**Yes.** However, the potential for travel time savings to induce auto use are largely offset by the added toll. Drivers consider both the value of travel time and the cost of the trip, when determining if, when, how, and where to travel. Compared to the No-Build, CRC is anticipated to provide a 23-minute travel time savings for a round trip between 179th and I-84 during peak periods. The cost of the toll is equivalent to a travel time penalty that negates almost 75% of the trip-making effect of this travel time savings. The net effect of these countervailing factors is equivalent to a 6% decrease in travel time; this is not expected to have a material impact on induced demand or access to fringe areas.
The project reduces auto travel costs.	**No**. CRC has the opposite effect by adding a toll on the highway, increasing auto travel costs relative to No Build alternative.
Local and regional land use regulations are ineffective at managing growth.	**No.** Growth management controls backed by state law exist in the I-5 corridor in both Oregon and Washington that require: • the vast majority of future growth to occur within urban growth areas that reduce sprawl and that are sized to meet population and employment forecasts; • comprehensive plans that implement efficient and sustainable urban development within urban growth areas; • minimum densities in urban areas; and, • protections for rural, agricultural, and environmentally sensitive areas.
There are real estate markets supporting low density development.	**Yes, but these areas are small and distant from the project area** The minimum average densities required to be achieved in Vancouver growth management areas is notably higher than that required in Metro's "Inner Neighborhood" designation. In certain locations densities as high as those targeted for Town Centers, Station Areas, and Main Streets are anticipated. The minimum densities required in the urban growth areas of Washougal, Battle Ground, Camas, and Ridgefield are similar to the densities required in Metro's "Outer Neighborhoods." The two urban growth areas that allow low densities are Yacolt (20 miles from Vancouver) and La Center (15 miles from Vancouver). These growth areas are distant and quite small, representing only 0.9% of the County's population in 2004, and 1.7% of the County's projected population in 2024; no material urban sprawl is anticipated in these areas from the CRC Project.

Table 6-29 answers the second question regarding factors that increase transit ridership and encourage higher density development around transit stations, and identifies the extent to which each of these factors is or is not included in the CRC project.

Table 6-29. Factors Associated with High-Capacity Transit Projects That Can Promote Transit-Oriented Development

Factors from National Research	Does CRC exhibit these factors?
The project increase transit ridership.	**Yes**. The portion of travelers over the I-5 crossing on transit is projected to be more than twice as high with the project, compared to the No Build alternative.a
The project provides new access to developable/redevelopable land previously unserved or underserved by transit.	**Yes**. The project area is not currently served by high capacity transit and there is substantial latent demand for cross-river transit service
There are real estate markets supporting such development.	**Yes**. The majority of the recent and planned developments in downtown Vancouver are high density and/or mixed use.
There is positive public perception of transit.	**Yes**. Over 70% of residents polled support extending light rail across the river to Vancouver.[b]
Local and regional land use regulations support transit-oriented development.	**Yes**. Comprehensive plans and implementing regulations, including zoning, exist in Oregon and Washington that (a) require minimum densities in urban areas, (b) encourage compact and mixed-use development, and (c) encourage transit-oriented development.

a PM peak period transit mode split for the I-5 crossing.

b A scientific telephone poll of 504 randomly selected households in Multnomah, Washington, and Clackamas Counties in Oregon, and Clark County in Washington (Riley Research Associates 2008).

Analysis of Washington and Oregon Growth Management

The national research and case studies emphasized the importance of land use regulations for influencing the type and magnitude of effect from transportation improvements. The jurisdictions in Washington and Oregon have strong growth management measures in place that have many similarities.

Both states mandate growth management. Oregon's Senate Bill 100, adopted in 1973, specifies 19 Statewide Planning Goals that are applicable to all 36 counties and 212 cities. When Washington adopted its Growth Management Act (GMA) in 1990, the Act applied to most counties and the cities therein, including Clark County and the City of Vancouver. Both growth management systems require the development and adoption of 20-year comprehensive plans with urban growth boundaries/areas that provide clear distinctions between rural and urban land. Both laws also encourage compact urban forms and multimodal transportation systems, established land use courts, require capital facility planning, allow for the collection of system development charges, and are tied to numerous implementing mechanisms.

The GMA includes 14 goals to guide the development and adoption of comprehensive plans and development regulations. These goals are very similar to the 19 Statewide Planning Goals in Oregon. They discourage sprawling development, encourage focusing growth and development in existing urban areas with adequate public facilities, encourage economic development throughout the state consistent with comprehensive plans, encourage efficient multimodal transportation systems, and require that adequate public facilities and services necessary to support development be available when new development is ready for occupancy.

Metro is a regional government tasked with land use planning in the Portland metropolitan area in Oregon with a long history of effective growth management. The City of Portland has a sophisticated zoning code with provisions for focusing growth where desired and encouraging compact mixed-use development around transit facilities. After 19 years of planning and regulation under the state GMA, the City of Vancouver and Clark County have also developed robust growth management policies and regulations. The Vancouver Comprehensive Plan targets growth in designated urban centers and corridors connecting these centers in an approach comparable to Metro's 2040 Growth Concept that outlined a plan for accommodating regional growth expected in 50 years. Vancouver has a Transit Overlay District allowing for "higher densities and more transit-friendly urban design" than afforded by base zoning. Portland has a similar Light Rail Transit Station Zone that is an overlay zone allowing for "increased densities for the mutual re-enforcement of public investments and private development". Also, in preparation for the construction of the CRC project, the City of Vancouver has recently made changes to the downtown plan (the VCCV) and is implementing regulations that encourage complementary development along the light rail alignment.

Clark County and the City of Vancouver have planned residential densities of approximately 16 and 20 persons per acre. This compares favorably to Metro's "inner neighborhood" and "outer neighborhood" areas that target 14 and 13 persons per acre, respectively. Metro has other significant goals applied throughout its jurisdiction, tied to designations such as Regional, Town Centers and Main Streets with much higher density targets. The City of Vancouver has policy and regulations encouraging higher densities in planned sub-areas, downtown, and along transit corridors that are comparable to the densities targeted in Metro's Town Centers and Main Streets.

Travel Demand Modeling

Travel time and resulting accessibility can influence the demand for land at both the urban fringe and in established urban areas. Significant improvements in travel time from areas along the urban periphery to key destinations such as downtown Portland could increase pressure for suburban residential development in northern Clark County. At the same time, increases in transit ridership could promote higher density development around transit stations in the central Vancouver area. Travel demand modeling and traffic simulation can provide valuable information about how the CRC project might change travel behavior and, in turn influence land use patterns.

Travel demand modeling and traffic simulation indicate that the CRC project has a far greater effect on transit ridership than I-5 travel times. Though CRC is anticipated to substantially reduce congestion within the project area compared to the No Build scenario, travel times are not as dramatically changed because this project improves a relatively small portion of the region's highway system, and because the toll on the I-5 crossing will add a perceived penalty to auto travel. Modeling the toll entailed incurring a 6-minute time penalty (one-way) to simulate drivers' responses to paying this fee as assumed in Metro's demand modeling. This penalty is based on the average value travelers place on their time[7]. Accounting for this 6-minute time-penalty incurred by the toll, the round-trip travel time savings on I-5 between 179th Street north of Vancouver to I-84 near downtown Portland diminishes from a 28-minute savings to just a 16-minute savings.

[7] In October, 2008, the project convened a panel of national experts to review the travel demand model methodology, including this method of simulating the toll's effect. The panel unanimously concluded CRC's methods and conclusions were valid and reasonable.

Because of the toll and the introduction of a reliable and efficient transit alternative, modeling shows that the project is anticipated to actually lower the number of vehicles using the I-5 crossing each day by about 1 percent.[8] In contrast, transit ridership is anticipated to increase over 250 percent during the p.m. peak period.[9] These travel pattern changes suggest the project will not induced automobile demand, and thus should not increase development pressure along the urban periphery. The significant increase in transit ridership also suggests CRC could spur development around the new light rail stations.

Transportation/Land Use/Real-Estate Modeling (Metroscope)

Another method for evaluating this project's potential for inducing land use changes entailed review of a Metroscope model analysis of transportation improvements in the I-5 corridor similar to CRC. Metroscope is an integrated land use and transportation model designed by Metro to predict how changes in transportation infrastructure could influence the future distribution of employment and housing throughout the region.

In 2001, as part of the I-5 Partnership Study, Metro used its Metroscope model to estimate land use changes if I-5 were to increase to four through-lanes between Going Street in Portland and 134th Street in Vancouver, and light rail were extended to Clark College. This scenario had the same transit improvements as CRC, but added capacity to a significantly longer portion of I-5, adding 22 new lane-miles versus 11 lane-miles that will be added with CRC. This 2001 scenario also did not include a toll on the bridge. This scenario had important similarities to CRC, but added more highway capacity and didn't include an important demand management tool (tolling). These differences resulted in greater travel time savings and increased vehicle use compared to CRC. As such, this scenario represents more potential to induce auto demand and auto-oriented development along the urban periphery, and possibly less potential for transit-oriented development.

Under this scenario, Metroscope showed only minimal changes in employment location and housing demand compared to the No-Build scenario. Metroscope estimated a one percent regional redistribution of jobs to the I-5 corridor with 4,000 more in North and Northeast Portland and 1,000 more in Clark County. The model estimated very modest changes in residential values (a proxy for residential demand), with the highest increase in some Clark County and North Portland areas experiencing up to three percent greater values by 2020, equating to about 0.12 percent growth per year. This analysis also concluded the land-use policies in the Metro boundary and in Clark County were far more likely to influence growth patterns than a single project like CRC.

[8] 184,000 cars will travel over the I-5 bridges under the No Build scenario versus 178,000 with a replacement crossing, a toll on I-5, and light rail.

[9] With a replacement crossing, a toll on the I-5 bridges, and light rail, 7,250 people will ride transit during the PM peak period compared to 2,050 people for the No Build alternative.

Conclusion: Expected Land Use Changes

Though a large project like CRC has the possibility of having far-reaching effects on travel and land use patterns, local plans and an analysis of how this will affect travel patterns suggest it will have the most pronounced effects immediately surrounding the new infrastructure. CRC will not induce automobile demand or development pressure on the urban periphery, but the project is likely to redistribute some future growth in jobs and housing to the I-5 corridor and to promote planned development on Hayden Island and in downtown Vancouver, particularly around new light rail stations.

It is impossible to predict specific land use changes from this project, but the preceding analysis does provide a good indication of the general location and type of development that will be induced by CRC. The most pronounced land use changes as a result of this project will be on Hayden Island and in downtown Vancouver, where the transportation improvements from this project are anticipated in local plans and likely necessary for these areas to fully develop as these plans envision.

Improved multimodal access to Hayden Island should allow for a more cohesive community, with more residences and new locally-focused commercial services replacing the dispersed, auto-oriented regional retail outlets. The anticipated redevelopment of the Jantzen Beach shopping center into a mixed-use community focused on the new light rail station is perhaps the most significant change expected on the island. Figure 6-22 shows existing land uses on Hayden Island and around the Expo Center light rail station, while Figure 6-23 shows the existing zoning in this area that is anticipated to change in the near future. The proposed zoning will allow for higher residential and commercial densities on the island, notably west of the I-5 interchange where the Jantzen Beach Supercenter is currently located.

In downtown Vancouver, planned development and redevelopment may be accelerated and facilitated because of improved connectivity to the existing downtown street grid. Transit oriented development is expected around the LRT stations in downtown Vancouver as well (Figure 6-28). Studies of high-capacity transit projects indicate that areas within walking distance, or approximately a half-mile, of new LRT transit stations can attract new development.[10] Figure 6-25and Figure 6-26 show the existing land uses and zoning in Vancouver around these LRT stations and in the area of the VCCV.

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[10] Reconnecting America. 2007., TOD 101: Why Transit-Oriented Development And Why Now? Available at: www.reconnectingamerica.org/public/download/tod101full.

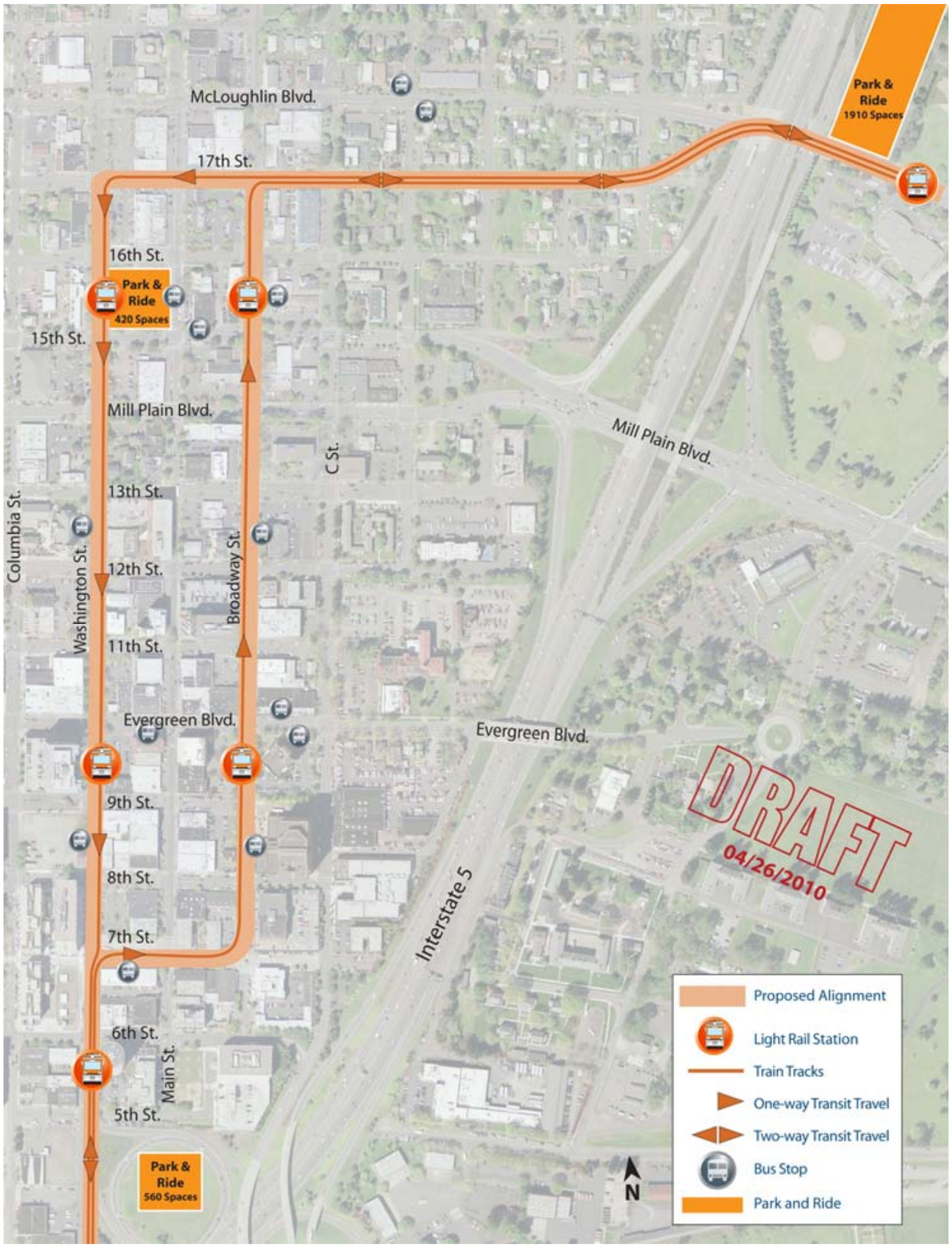


Figure 6-28. LRT Alignment through Downtown Vancouver

The areas around the downtown LRT stations are zoned "City Center Mixed Use," which allows high-density residential and commercial uses. Recent development in downtown Vancouver means that many areas around the new light rail station are already built up, but there are still some vacant and underutilized parcels that offer potential for these stations to spur added density of jobs and housing. The stations between 15th and 16th Streets are probably most likely to spur development as this area has several vacant parcels and generally lower densities, though zoning and height restrictions reflect the intent for this area to serve as a transition from the downtown to northern neighborhoods. Additional new development can be expected in some of the other remaining vacant or underutilized parcels in the project area. Table 6-30 shows the vacant land within 0.50 mile of the light rail stations to be constructed with the CRC project.

Table 6-30. Area of Vacant Land within 0.50 mile of Proposed LRT Stations

Current Zoning	Acres of Vacant Land
0.50 mile from Hayden Island LRT station	
CG – General Commercial	8.74
IG2 – General Industrial	1.05
R2 – Medium Density, Multi-Dwelling Residential	2.06
R3 – Medium Density, Multi-Dwelling Residential	0.00
0.50 mile from Vancouver LRT stations	
CC – Community Commercial	0.01
CPX – Central Park Mixed Use	0.06
CX – City Center Mixed Use	3.72
OCI – Office, Commercial, Industrial	0.43
IH – Industrial	0.02
IL- Industrial	0.46
R-9 – Lower Density Residential	0.03
Total	**16.58**

In addition, the Main Street extension, Columbia Way design, and the completion of the street grid south of the railroad berm will provide an additional access point to the 35 acre waterfront area immediately west of I-5 that is currently in planning for redevelopment. This access, although only one of two other non-project access points, potentially could increase the rate of redevelopment at the site. The details of how the areas along the shoreline would be redeveloped are not yet available. However, the new designs will be required by conditions of the Master Plan to be designed in a sustainable manner and be SMA and CAO compliant.

The Action Area related to land use reflects these potential land use changes by including areas within a half mile of each of the transit stations, including the existing Expo Station, as the project will affect this area by reconfiguring the Marine Drive interchange and by extending light rail north from this station. The areas of the Hayden Island Plan and the VCCV are also included in the action area.

6.2.2.4 What measures are in place to minimize effects from land use changes?

The form of development in the Action Area will be largely dictated by adopted land use plans and policies. In addition to land use plans, listed species and their habitats are also protected at the federal level and any land use change caused by the Project would be required to comply with federal standards as well. This section identifies and outlines the federal, state, regional and local regulations that would minimize effects from land use changes.

Federal

The two primary federal laws protecting listed fish and wildlife and their habitats would apply to development or land use change indirectly caused by the CRC project include the CWA and the ESA, both of which are briefly outlined here.

Clean Water Act

The CWA requires a Section 404 permit from USACE for impacts to jurisdictional wetlands or other waters. For activities that may result in discharge to waters of the U.S., Section 401 of the CWA requires certification that the project will comply with water quality requirements and standards. Dredging, filling, and other activities that alter a waterway require a Section 404 permit and Section 401 certification. The appropriate state agency must also certify that development meets state water quality standards and does not endanger waters of the state or U.S. or wetlands. Water quality certifications are issued by DEQ and Ecology.

Endangered Species Act

The ESA (16 USC 1531-1544, as amended) regulates the take of any federally listed species. Take is defined in the law to include harass and harm; harm is further defined to include any act which actually kills or injures federally listed species, including acts that may modify or degrade habitat in a way that significantly impairs essential behavioral patterns of the species. Under Section 7 of the ESA, any federal agency that permits, funds, carries out, or otherwise authorizes an action is required to ensure that the action will not jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat. An incidental take permit, obtained through a formal Section 7 consultation with NMFS and/or USFWS, will be required if there is potential for development to adversely impact federally listed species or their critical habitat. Informal consultations occur for projects that result in a "not likely to adversely affect" determination; formal consultations occur for projects that are "likely to adversely affect" listed species.

State Regulations

Effective growth management controls backed by state law exist in the I-5 corridor on both sides of the Columbia River. Overall, these land use controls require:

- The vast majority of future growth to occur within urban growth areas, reducing sprawl and meeting population and employment forecasts;
- Comprehensive plans that implement efficient and sustainable urban development within urban growth areas;
- Minimum densities in urban areas; and,
- Protections for rural, agricultural, and environmentally sensitive areas.

Oregon

Statewide Land Use Planning

In 1973, the Oregon Legislature enacted Senate Bill 100[11] (SB 100), which established the statewide land use planning program. The primary goals of SB 100 are to protect the state's farm and forest economies and prevent the spread of unplanned urban sprawl. SB 100 requires cities and counties to adopt and implement comprehensive land use plans that comply with 19 statewide goals and guidelines.

[11] ORS 197.175(2)

One of the primary features of Oregon's land use planning system is the requirement that cities, counties, and regional governments draw urban growth boundaries (UGBs) that separate urban land from rural land (Goal 14). These boundaries establish where cities and urbanized areas can and cannot grow. The UGBs work together with planned growth laid out in local adopted Comprehensive Plans.

Another strong land use protection built into the Oregon system is designed to prevent the conversion of farm and forest lands to urban uses (Goals 3 and 4). A zoning designation called “exclusive farm use” limits farm and forest lands to agriculture production or timber harvesting. Farm and forest lands allow only a small range of compatible uses, limiting the amount of housing or infrastructure that can be built.

Statewide Land Use Goal 5, Natural Resources, Scenic and Historic Areas, and Open Spaces is also instrumental to minimizing the effects of land use change. Goal 5 requires cities and counties to inventory these resources and adopt programs to protect them.

Oregon Department of Fish and Wildlife Habitat Mitigation Policy

The Oregon Wildlife Habitat Mitigation Policy is intended to support the Wildlife Policy (ORS 496.012) and the Food Fish Management Policy (ORS 506.109) of the State of Oregon. The policy provides consistent goals and standards to mitigate impacts to fish and wildlife habitat caused by development. Under the policy, ODFW requires or recommends mitigation for losses of fish and wildlife habitat resulting from development actions, depending upon the habitat protection and mitigation opportunities provided by specific statutes. Priority for mitigation actions is given to habitat for native fish and wildlife species. Mitigation actions for non-native fish and wildlife species may not adversely affect habitat for native fish and wildlife.

Washington

Growth Management Act

The GMA was adopted because the Washington State Legislature found that uncoordinated and unplanned growth posed a threat to the environment, sustainable economic development, and the quality of life in Washington. The GMA (Chapter 36.70A RCW) was adopted by the Legislature in 1990. The GMA requires state and local governments to manage Washington’s growth by identifying and protecting critical areas and natural resource lands, designating urban growth areas, and preparing comprehensive plans and implementing them through capital investments and development regulations. The GMA goals that will influence land use changes include those that discourage sprawling development, encourage development in urban areas with adequate public facilities, and encourage efficient multimodal transportation systems. The GMA goals are not ranked in any order with one goal having more importance over others. When local governments develop their plans and regulations, they determine how the goals will be carried out. Cities and counties develop their comprehensive plans to be in compliance with the GMA goals and to provide for 20 years of growth and development needs.

Shoreline Management Act

The SMA was enacted in 1972 with the following purpose: *“to prevent the inherent harm in an uncoordinated and piecemeal development of the state’s shorelines.”* The SMA has three broad policies:

- Encourage water-dependent uses: "uses shall be preferred which are consistent with control of pollution and prevention of damage to the natural environment, or are unique to or dependent upon use of the states' shorelines..."
- Protect shoreline natural resources, including "...the land and its vegetation and wildlife, and the water of the state and their aquatic life..."
- Promote public access: "the public's opportunity to enjoy the physical and aesthetic qualities of natural shorelines of the state shall be preserved to the greatest extent feasible consistent with the overall best interest of the state and the people generally." (Ecology 2009).

Local jurisdictions implement the SMA through individual Shoreline Master Programs that identify shorelines of the state and designate which shoreline protection category each reach of the shoreline falls under. Each designation defines appropriate uses and development standards, and development with shorelines is subject to administrate review with Ecology providing review of permit decisions.

State Environmental Policy Act

The State Environmental Policy Act (SEPA) of Washington (Chapter 43.21C RCW) was enacted in 1971. SEPA applies to decisions by every state and local agency within Washington State, including state agencies, counties, cities, ports, and special districts. These decisions may be related to issuing permits for private projects, constructing public facilities, or adopting regulations, policies, or plans.

It provides the framework for agencies to consider the environmental consequences of a proposal before taking action and also gives agencies the authority to condition or deny a proposal due to identified likely significant adverse impacts. For example, if an Environmental Impact Statement indicates the proposal will damage a wetland, the agency decision-maker may require the applicant to change his proposal so that no construction will be done within one hundred feet of the wetland. SEPA is implemented through the SEPA Rules, Chapter 197-11 WAC (Ecology 2009).

Hydraulic Project Approval

In 1949, the Washington State Legislature passed a state law now known as the "Hydraulic Code" (Chapter 77.55 RCW). The Hydraulic Code has been amended occasionally since it was originally enacted, but the basic authority has been retained. It is intended to ensure that required construction activities are performed in a manner to prevent damage to the state's fish, shellfish, and their habitat. An HPA from WDFW would be required for work occurring within waters of the state (defined as all salt and fresh waters waterward of the OHW line and within the territorial boundary of the state). The major types of activities in freshwater requiring an HPA include, but are not limited to: stream bank protection; construction or repair of bridges, piers, and docks; pile driving; channel change or realignment; conduit (pipeline) crossing; culvert installation; dredging; gravel removal; pond construction; placement of outfall structures; log, log jam, or debris removal; installation or maintenance of water diversions; and mineral prospecting (WDFW 2009).

By complying with the Hydraulic Code, most construction activities can be allowed with little or no adverse impact on fish or shellfish (WDFW 2009). Permits are processed by WDFW and are submitted with a Joint Aquatic Resources Permit Application.

Regional and Local

The Action Area is influenced by several local and regional governments including Metro, City of Portland, City of Vancouver, and Clark County. The regional and local controls most pertinent to protecting fish and wildlife habitat from indirect land use effects are found in density and growth policies, natural resource protection ordinances, and stormwater controls.

Density and Growth

Metro, the regional government in the Portland Metropolitan region, has a long history of effective growth management through the development and implementation of the regional urban growth boundary (UGB), the Metro 2040 Growth Concept and the Urban Growth Management Functional Plan. In 1978, to comply with Statewide Goal 14, Urbanization, Metro adopted the regional UGB for the Portland metropolitan area. The UGB defines the area within the three Oregon metro counties where urban-level zoning, infrastructure, and development may occur. Local jurisdiction comprehensive plans and implementing ordinances must provide urban services necessary to achieve the urban level of development envisioned in the UGB assumptions.

During the first 20 years of the plan, the UGB has expanded by about 1.5 percent. By comparison, population within the three-county Portland metropolitan region has increased by approximately 60 percent (1978-1996), and employment has increased by approximately 73 percent (1978-1996). In 2002, Metro expanded the UGB by approximately 18,000 acres. The UGB has profoundly affected the land use and development patterns in the Oregon by promoting infill and redevelopment rather than expansion (CRC 2008). This deliberate pattern of development provides protection for resources outside of the UGB.

Metro’s 2040 Growth Concept and Urban Growth Management Functional Plan were both adopted in 1997. The 2040 Growth Concept defines development in the metropolitan region through the year 2040 and guides how the UGB is managed. It encourages efficient land use, directing most development to existing urban centers and along existing major transportation corridors and promotes a balanced transportation system within the region that accommodates a variety of transportation options such as bicycling, walking, driving and public transit (Metro 1997). The plan designates regional and town centers and calls for growth to be concentrated in these centers—as well as main streets, station communities and corridors—in order to use urban land most efficiently (Metro 1997). The Urban Growth Management Functional Plan establishes requirements and tools to implement the goals of the 2040 Growth Concept including Title 6, defining density and development standards for areas designated as Central City, Regional Center, Town Center or Station Community (Metro Code 3.07.610–3.07.650: Title 6, Functional Plan). Title 6 requires cities to plan for increased densities in these areas, effectively focusing future growth within the core of developed areas, and away from the fringes.

Local comprehensive plans must be in alignment with Metro’s 2040 Growth Concept and Functional Plan, and are based on the regional transportation policy set in 1976. At that time, the policy shifted from emphasizing automobile accommodation to a broader approach aimed at the efficient use of land and integration with the transportation system. A 1973 Governor’s task force on transportation concluded that fiscal and environmental realities made it impractical to rely on new radial highways to meet future travel demand, and that most of the new commuter growth into the central city needed to be accommodated with mass transit. As a result, for over 20 years land use and transportation plans have been based on the policy that no new radial highway capacity would be built in the region. Instead, future capacity and level-of-service to and from the central city would depend primarily on high-capacity transit.

Within the City of Portland, zoning controls the allowed maximum densities for new developments and zones allowing higher densities are all focused around the Metro-designated Regional Centers, Town Centers, and Station areas.

In 1990, the Washington GMA established requirements for counties to plan for and manage growth (RCW 36.70A.070(6)). The GMA requires local governments to identify and protect critical and natural resource lands, designate urban growth areas, and prepare comprehensive plans to be implemented through capital investments and development regulations. The land use regulations in the City of Vancouver (Chapter 20, Vancouver Municipal Code [VMC]) and Clark County (Title 40, Clark County Unified Development Code) have robust growth management policies and regulations that comply with the GMA requirements. The Vancouver Comprehensive Plan targets growth in designated urban centers and corridors connecting these centers in a growth management approach comparable to Metro's 2040 Growth Concept. Vancouver also has a Transit Overlay District (VMC 20.550) allowing for "higher densities and more transit-friendly urban design" than afforded by base zoning. This overlay zone is similar to Portland's Light Rail Transit Station Zone that is an overlay zone allowing for "increased densities for the mutual re-enforcement of public investments and private development" (CPC 33.450).

Clark County and the City of Vancouver have planned residential densities of approximately 16 and 20 persons per acre. This compares favorably to Metro's "inner neighborhood" and "outer neighborhood" areas that target 14 and 13 persons per acre, respectively. The City of Vancouver has policies and regulations encouraging higher densities in planned sub-areas, downtown, and along transit corridors that are comparable to the densities anticipated in Metro's Town Centers and Main Streets (VMC, Chapter 20).

Natural Resource Protection

The City of Portland, Metro, the City of Vancouver, and Clark County all have extensive environmental protections in place that minimize impacts to wetlands, riparian areas, and sensitive habitat areas.

City of Portland

Any indirect impacts to fish and wildlife that could result from land use changes within the City of Portland would be required to meet the standards for protecting fish, wildlife, and their habitat found in the Environmental Overlay Zones and the Tree Cutting regulations in the City of Portland Code.

The environmental zones provide for fish habitat protection through the designation of environmental protection or conservation zones. These zones were developed to comply with Metro's Title 3 and Goal 5 of the Statewide Planning goals and are based on an inventory and Economic Social, Environmental, and Energy analysis of important natural resources within the city. Development or disturbances within these zones must be at least 50 feet from the boundary of any wetland and include a 25-foot transition area buffer from the edge of all identified conservation or protection resource areas. The protected resource areas are identified within Natural Resource Management Plans and the official City of Portland Zoning Maps and are not based on a system wide buffer measurement. Applicants must conduct an alternatives analysis and determine that their proposal has the least detrimental effects to the protected resources. Proposals are required to demonstrate how they have avoided and minimized impacts before being allowed to create an adverse impact. Unavoidable impacts must be mitigated. Mitigation must meet strict vegetation replacement standards and include ongoing maintenance and monitoring to ensure success (1994. CPC 33.430, as amended).

The City of Portland also protects trees that are not within an Environmental Overlay zone. Permits administered by City of Portland Urban Forestry department are required to cut trees on private or public property. The City also regulates the cutting and planting of trees on public property, including street trees located on the public right-of-way. Permits are required to plant, prune, remove, or cut the roots of any tree located on public property (2002. CPC 20.42).

City of Vancouver and Clark County

In Washington, Vancouver and Clark County environmentally sensitive areas are protected under the GMA through the local jurisdiction Critical Areas Ordinances, the SMA through Shoreline Master Programs, SEPA implementing regulations, and tree protections.

Critical Areas Protection Ordinances

The Fish and Wildlife Habitat Conservation Area and Wetlands ordinances under the Vancouver and CAO applies to habitat for any life stage of state or federally designated endangered, threatened, or sensitive fish or wildlife species, priority habitats and habitats of local importance, riparian management areas and riparian buffers, and water bodies. CAOs also regulate development in the floodplain, erosion hazard areas, and critical aquifer recharge areas. Any development within fish and wildlife habitat areas, wetlands or buffers would be required to obtain a Critical Areas Permit. A Critical Areas Report would be required as part of the submittal for a Critical Areas Permit. Similar to the City of Portland Environmental Review process, the Critical Areas permit requires applicants to demonstrate they have first avoided impacts, then minimized those that are unavoidable, and finally provides appropriate mitigation. A Critical Areas Report for a riparian management area or riparian buffer must include an evaluation of habitat functions using the Clark County Habitat Conservation Ordinance Riparian Habitat Field Rating Form or another habitat evaluation tool approved by the WDFW.

The Fish and Wildlife Habitat Conservation Area chapter (VMC 20.740.110) uses Riparian Management Areas and Riparian Buffers to protect habitat. The regulated areas extend from the ordinary high water mark of protected waters to a specified distance as measured horizontally in each direction. The Riparian Management Area is adjacent to the lake, stream, or river, and the Riparian Buffer is adjacent to the Riparian Management Area. The specified distances vary considerably as determined by the resource type and quality and the proposed land use change. The Riparian Management Area distance is either 25 feet for a non-fish bearing, perennial/seasonal, small stream that is not connected to any other surface water, or 100 feet from the ordinary high water mark of all other applicable water resources. Outside of the Riparian Management Area, the Riparian Buffer extends from the edge of the Riparian

Management Area and ranges from 25 feet to 75 feet. Functions and resources within the buffer and management areas are protected by standards requiring findings of no net loss. Permitted development uses within the Riparian Management Area are limited to three general types: water oriented, infrastructure oriented, or approved mitigation oriented. Applicants proposing these types of uses must demonstrate findings of no net loss through impact avoidance, minimization techniques and mitigation.

The Wetlands chapter (VMC 20.740.140) establishes protections for wetlands and buffers based on a wetland rating system and the proposed land use intensity. Buffers range from 25 feet for a Category IV wetland with a low land use intensity activity proposed to 300 feet for a Category I wetland with a high land use intensity activity proposed. Permitted activity types are limited by category of wetland. For instance, only necessary infrastructure that cannot be located elsewhere or low impact trails and wildlife viewing structures are allowed within Category I wetlands, and applicants must demonstrate no net loss of wetland functions. (Critical Areas Protection Ordinance. 2005. City of Vancouver – Vancouver Municipal Code (VMC) 20.740; Fish and Wildlife Habitat Conservation Areas. 2005. VMC 20.740.110. Vancouver, WA. Critical Areas and Shorelines. 2005. Clark County Code. Title 40.4. Vancouver, WA.)

Shoreline Master Programs

The local Shoreline Management Master Programs at the City of Vancouver and Clark County implement the Washington Shoreline Management Act and provide protection to fish and wildlife habitat. A Substantial Development Permit would be required for development activities occurring within areas regulated by the Shoreline Management Master Program. Within the City of Vancouver, Shorelines of the state include the Columbia River, Vancouver Lake, Lake River, Salmon Creek, Mill Creek, Burnt Bridge Creek (From I-205 to its mouth), and Glenwood (a.k.a. Curtain Creek). The Columbia River and Vancouver Lake are also classified as shorelines of statewide significance due to their size, flow rates and general significance. The regulations of the City of Vancouver Shoreline Management Master Program apply to shorelands extending landward for two hundred feet in all directions measured on a horizontal plane from the ordinary high water mark or the landward extend of the 100-year floodplain; floodways and areas landward two hundred feet from such floodways; whichever is farther landward, and all associated wetlands. Reaches of the shoreline are designated with one of several Environment Designations and various standards apply within each designation. Generally, development on lands within Shoreline jurisdiction must balance the multiple uses and needs along shorelines, including protecting natural resources and habitats, or mitigating impacts (Shoreline Management Area. 2005. VMC 20.760. Vancouver, WA and Critical Areas and Shorelines. 2005. Clark County Code. Title 40.4. Vancouver, WA).

The cities of Battle Ground, Camas, Clark County, La Center, Ridgefield, Vancouver, Washougal, and Yacolt are collaborating in a two- to three- year effort to update their respective SMPs. These SMP updates are funded by a Department of Ecology grant administered through the City of Vancouver on behalf of the eight jurisdictions. In early 2010, they will be working to develop a shoreline inventory and characterization report with the help of a Technical Advisory Committee. The report will document existing conditions for areas including those discussed herein. In the spring of 2010 they will begin to review and update goals and policies with the help of the community and a Shoreline Stakeholder Advisory Committee.

SEPA

Vancouver and Clark County implement SEPA through local ordinances that review individual projects and submit threshold determinations to the Department of Ecology (SEPA Regulations. 2004. VMC 20.790 and SEPA. 2009. Clark County Code 40.570).

Street Trees

Street Trees and Tree Conservation municipal codes require permits if development would result in the cutting of trees on public or private property. There are two kinds of permits required for trees in the City of Vancouver: one for street trees and one for private trees. If the tree is in the public right-of-way, a street tree permit is required (Street Trees. VMC 12.04; and Tree Conservation. VMC 20.770)

Stormwater Controls

Indirect land use changes that could potentially be a result of the project may create additional impervious surfaces. Increased impervious surface increases stormwater runoff which can adversely affect fish habitat. The City of Portland implements stormwater management under a permit issued by the DEQ under the CWA. The Phase I NPDES Municipal Separate Storm Sewer System (MS4) Permit requires municipalities with populations of 100,000 or more to support CWA goals by reducing pollutants in stormwater discharges from their MS4s to the maximum extent practicable. The CWA goals include restoring and maintaining the chemical, physical, and biological integrity of our waters (rivers, streams, lakes, wetlands, and marine waters) (Portland Stormwater Management Manual, 2008).

Within Portland, the Bureau of Environmental Services requires stormwater treatment for any increase in impervious surface greater than 500 sq. ft. There are many treatment options available for on site quality and quantity treatment (City of Portland Stormwater Management Manual 2008). Treatment options include vegetated swales, grassy swales, vegetated filters, and vegetated infiltration basins.

Vancouver's Surface Water Management Program administers activities required by the CWA and the city's Phase II NPDES Permit issued by the Washington Department of Ecology. The City is currently reviewing the stormwater program to bring it into compliance with Phase II standards. The City relies on the 2005 Stormwater Management Manual for Western Washington for technical requirements that must be met by development with stormwater impacts (VMC 14.24-26). Treatment options include vegetated swales, grassy swales, vegetated filters, and vegetated infiltration basins, in addition to other Department of Ecology-approved methods.

6.2.2.5 What are the potential impacts to species and habitat from land use changes?

As noted above population and employment growth is anticipated to occur with or without the CRC project, and land uses will change to accommodate more people and jobs. More people and jobs will also mean greater demands for transportation. Potential impacts to species and habitats could occur from changes in traffic patterns, development, and redevelopment resulting in impacts to water quality and water quantity, and a decrease in natural habitats. In addition, development may result in changes to riparian and nearshore areas, including changes in vegetation and overwater structures. Listed species may be affected through the addition of impervious surface (particularly pollutant generating surfaces), unsuccessful treatment of stormwater from pollutant generating surfaces, and a decrease in riparian and aquatic habitat.

With respect to traffic changes, without the CRC project, the number of vehicles crossing the bridge is anticipated to be slightly higher than with the CRC project, and would move more slowly and less efficiently (i.e., congestion for up to 15 hours per day). Current stormwater treatment within the action area is limited (see Section 3.12 of the BA). With the construction of the CRC project, including the addition of light rail to Clark College and a toll on the I-5 crossing, growth in automobile traffic is anticipated to be slightly reduced and would move more efficiently through the corridor. This reduction in average daily traffic (ADT) and congestion, coupled with the integration of stormwater treatment meeting current regulatory standards for new and redeveloped impervious surfaces, will likely result in improved water quality within the action area.

New development or redevelopment near the project area is anticipated to occur in response to local plans that encourage medium- and high-density development on Hayden Island and through downtown Vancouver. The CRC project is expected to facilitate the land use visions in these plans by providing or accommodating the anticipated transportation facilities that would support the new development. Furthermore, the introduction of light rail through these areas is anticipated to spur higher density development as local zoning code and plans encourage transit-oriented development around high-capacity transit.

New development or redevelopment of existing infrastructure would comply with applicable land use codes, in particular the need to upgrade to existing stormwater treatment regulations. Redevelopment associated with the project is anticipated to occur in downtown Vancouver and northeastward to Clark College as shown on Figure 6-28 Redevelopment will also occur on Hayden Island as shown on Figure 6-24, and potentially in north and northeast Portland along Marine Drive and MLK. No listed terrestrial species are located at these sites, but runoff from stormwater could indirectly impact habitat associated with the fish species addressed in this BA. Development and redevelopment, including removal or renovation of existing in-water structures such as docks, piers, and floating homes and near-shore development, would comply with the relevant laws, regulations, policies, and code in force at the time of the action. As noted above, these regulatory approvals range from street tree removal, to stormwater treatment, to environmental zone and critical areas protections, to more complicated processes for larger developments.

With the integration of local and state land use requirements discussed in Section 4 of this document, negative impacts to listed species and their habitats from development and redevelopment would be limited. Local regulations require the avoidance or minimization of impacts to protected resources. These resources include shorelines, wetlands, streambanks, and their buffers, that are often most important to juvenile salmonids and their habitat. For upland development activities, state laws and local implementation of those laws, such as Washington’s SMA and CAO, dictate what type of development is allowed within 200 feet of the shoreline and the type and quantity of vegetation that must be retained or planted in the area. For upland development activities in Oregon, the City of Portland’s environmental zone provides for similar requirements, but only within 35 to 50 feet of the top of bank.

For fill within the Columbia River and North Portland Harbor, federal laws such as Section 404 of the Clean Water Act and consultation under Section 7 of the ESA will require analysis and approval by federal agencies to ensure that impacts are avoided, minimized, or offset if necessary. Likewise, for work within waters, WDFW's hydraulic project approval and ODFW's habitat mitigation policy require avoidance, minimization, and offsets of negative impacts. Each agency's process mandates that resources be protected or mitigated for.

With implementation of laws and regulations described above negative impacts to existing aquatic and terrestrial resources would likely result in a net benefit in the long term.

Further away from the immediate project alignment, development and redevelopment are not projected to occur as a result of this project. If land use changes did occur, the regulations, policies, and restrictions discussed above would minimize adverse effects to listed species and their habitats.

In summary, the CRC project is expected to encourage more compact development within existing urban areas that should accommodate future growth more efficiently, reducing potential loss of habitat and impervious surface throughout the region. By concentrating future regional population and employment growth in North Portland and downtown Vancouver, the CRC project should reduce development pressure in outlying areas that is more likely to result in loss of previously undisturbed habitat and incur a greater development footprint to accommodate this growth. Redevelopment and development within the project area will need to comply with stringent natural resource laws, regulations, and codes. Proper enforcement of these requirements should result in better treatment of stormwater runoff and incorporation of upland, riparian, and in-water habitat elements that are conducive to salmon recovery.

6.3 EFFECTS TO FISH HABITAT

6.3.1 Shallow-Water Habitat

The project will have both temporary and permanent impacts on shallow-water habitat (water less than 20 feet deep) in the Columbia River and North Portland Harbor. Temporary impacts to shallow water include: in-water and overwater structures (work platforms, work barges, tower cranes, oscillator support piles, cofferdams, and barges), turbidity, and elevated underwater noise. Permanent impacts include the addition of in-water and overwater bridge elements and the removal of existing in-water and overwater structures.

This section outlines the role of shallow-water habitat in the life history of fish and provides an analysis of the project's likely effects on fish in shallow-water habitat in the CRC action area.

6.3.1.1 Fish Distribution in Shallow-Water Habitat

Shallow water is of particular importance in the life history of fish for migration, feeding, holding, rearing, and predator avoidance (Everhart et al. 1953; Simenstad et al. 1982; Spence et al. 1996 as cited in Bottom et al. 2005). LCR Chinook and CR chum migrate as subyearlings and are particularly dependent on nearshore, shallow-water areas during outmigration (Levy and Northcote 1982, Myers and Horton 1982, Simenstad et al. 1982, and Levings et al. 1986 as cited in Bottom et al. 2005). Typically, these fish are less than less than 50 to 60 mm fork length and primarily use water that is less than 1 m deep (Bottom et al. 2005). Numerous studies have documented smaller fish (subyearling Chinook) utilizing nearshore habitats (Johnsen and Sims

1973; Dawley et al. 1986; McCabe et al. 1986; Ledgerwood et al. 1991, as cited in Carter et al. 2009), frequently at depths of 3 m or less (Carlson et al. 2001, as cited in Carter et al. 2009). However, LCR Chinook and CR chum can and do occupy other parts of the channel (Bottom et al. 2005; NMFS 2005c). While these fish are highly dependent on shallow water and are most likely to occur there, they do not occur exclusively in the nearshore and may potentially be present across the entire cross-section of the channel (Bottom et al. 2005).

Other juvenile salmonids outmigrate after they reach the yearling stage or older. These species include all of the salmonid runs addressed by this BA except for chum. (Note that LCR Chinook may emigrate as either subyearlings or as yearlings.) In general, cross-sectional distribution of these larger juveniles in the stream channel appears to be correlated with size. Fish measuring 60 to 100 mm fork length use deeper water, such as shoals and distributary channels. Fish greater than 100 mm in length are found in both deep and shallow water habitats, indicating that these individuals do not show preferential use of a particular water depth (Bottom et al. 2005), although they may seek out these areas for resting or as flow refugia during high-velocity events. Fish that migrate as yearlings or older tend to move quickly and occupy deeper-water habitats, but it is well documented that all use the nearshore to some extent during their outmigration (Bottom et al. 2005; NMFS 2005c; Celedonia et al. 2008; Friesen 2005; Southard et al. 2006; Carter et al. 2009). These juveniles may alternate active migration in deeper water interspersed with periods of holding and resting in shallow water and/or low-velocity areas (Bottom et al. 2005; Celedonia et al. 2008). Thus, while these older juveniles are less dependent on the nearshore than their subyearling migrant counterparts, they are likely to be present across the entire cross-section of the channel (Bottom et al. 2005; Southard et al. 2006).

Rearing juveniles are largely dependent on shallow water habitats (Bottom et al. 2005; Southard et al. 2006; NMFS 2006). ESUs that rear in the action area include LCR Chinook, UCR spring-run Chinook, UWR Chinook, CR chum, LCR coho, and LCR steelhead.

Adult salmonids generally migrate at mid-channel, but may occupy depths of 1 to 50 feet (NMFS 2006). While they may occur in shallow-water habitat, they are not particularly dependent on it, although they may seek out these areas for resting or as flow refugia during upstream migration (Bottom et al. 2005).

None of the life stages of eulachon or green sturgeon occurring in the action area are particularly dependent on shallow water, as described in Section 4.

6.3.1.2 Effects to Shallow-Water Habitat in the CRC Action Area

In the case of the CRC project, shallow-water impacts include physical loss of habitat, increase in the area of overwater structures, temporary turbidity, and underwater noise.

The following habitats, species, and life stages of fish could be exposed to these effects:

- Holding, feeding, and migration habitat for juveniles and holding and migration habitat for adults in several ESUs/DPSs: LCR coho; CR chum; SR sockeye; LCR, MCR, UCR, and SR steelhead; and LCR, UCR spring-run, SR fall-run, and SR spring/summer-run Chinook.
- Rearing habitat for juvenile Chinook (LCR, UCR spring-run, and UWR), LCR coho, CR chum, and LCR steelhead.

- Adult bull trout migration and holding habitat. Because of the extremely low numbers of bull trout in this portion of the action area, risk of exposure to this effect is discountable.
- Adult and subadult green sturgeon feeding and migration habitat. Because of the extremely low numbers of green sturgeon in this portion of the action area, risk of exposure to this effect is discountable.
- Adult and larval eulachon spawning and migration habitat.

Figures 4-1 and 4-2 show when these species are likely to be present in the action area and could be exposed to activities occurring in shallow water. Since shallow-water impacts will occur continually throughout the 4-year in-water construction period, as many as four migration cycles of salmon, steelhead, and eulachon could be exposed to these effects.

All of these species and life stages may use shallow-water habitat at some point during their presence in the action area. Of these life stages, rearing juvenile salmonids and subyearling migrant salmonids (CR chum and LCR Chinook) are the most closely dependent on shallow-water habitat, and therefore are the most vulnerable to these effects.

Physical Loss of Shallow-Water Habitat

The project will lead to temporary physical loss of approximately 20,700 sq. ft. of shallow-water habitat. Project elements responsible for temporary physical loss include the footprint of the numerous temporary piles associated with in-water work platforms, work bridges, tower cranes, oscillator support piles, cofferdams, and barge moorings in the Columbia River and North Portland Harbor. Table 6-31 and Table 6-32 quantify the temporary physical loss of shallow-water habitat.

The in-water portions of the new structures will result in the permanent physical loss of approximately 250 sq. ft. of shallow-water habitat at pier complex 7 in the Columbia River. Demolition of the existing Columbia River structures will permanently restore about 6,000 sq. ft. of shallow-water habitat, and removal of a large overwater structure at the Quay will permanently restore about 600 sq. ft. of shallow-water habitat. Overall, there will be a net permanent gain of about 5,345 sq. ft. of shallow-water habitat in the Columbia River (Table 6-31). At North Portland Harbor, there will be a permanent net loss of about 2,435 sq. ft. of shallow-water habitat at all of the new in-water bridge bents (Table 6-32). Note that all North Portland Harbor impacts are in shallow water.

Table 6-31. Physical Impacts to Shallow-Water Habitat in the Columbia River

Structure	Columbia River	
	Area	**Time in Water**
Temporary		
Work Platforms – Construction (P2 & 7) (portions are in shallow water)	728 sq. ft.	150–300 days each
Barge Moorings – Construction (P7)	25 sq. ft.	120 days each
Cofferdams –Construction (P7) (about a quarter is in shallow water)	2,000 sq. ft.	240 days each
Barge Moorings – Demolition (existing Pier 10, 11)	200 sq. ft.	30 days each
Cofferdams – Demolition (existing Pier 10, 11)	15,000 sq. ft.	40 days each
Total Temporary Impact	**17,753 sq. ft.**	**---**

	Columbia River	
Permanent		
New Bridge Shafts (2 Drilled Shafts at P7)	236 sq. ft.	Permanent
Existing Bridge Piers to be Removed (Existing Pier 10, 11)	- 6,181 sq. ft.	Permanent
Existing Piers to be Removed – Red Lion at the Quay	- ~600 sq. ft.	Permanent
Total Permanent Impact	**- 5,345 sq. ft.**	**---**

Table 6-32 Physical Impacts to Shallow-Water Habitat in North Portland Harbor

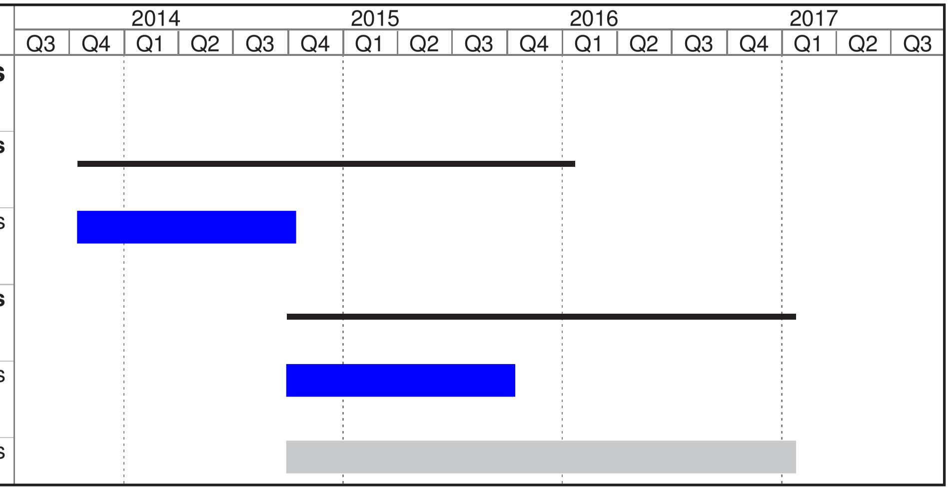
Structure	North Portland Harbor	
	Area	**Time in Water**
Temporary		
Work Bridges – Construction (9 locations)	400–710 sq. ft.	Up to 42 days each
Oscillator Platforms (31 locations)	1,200–1,560 sq. ft.	Up to 34 days each
Barge Moorings – Construction (31 locations)	318–678 sq. ft.	Up to 34 days each
Total Temporary Impact	**1,970–2,940 sq. ft.**	**---**
Permanent		
New Bridge Shafts (31 columns)	2,435 sq. ft.	Permanent
Total Permanent Impact	**2,435 sq. ft.**	**---**

The structures listed in Table 6-31 and Table 6-32 will not all occur in the action area at the same time. Figure 6-29 shows the sequencing of in-water structures in shallow-water habitat.

Physical loss of shallow-water habitat is of particular concern for rearing or subyearling migrant salmonids. In general, in-water structures that completely block the nearshore may force these juveniles swim into deeper-water habitats to circumvent them. Deep-water areas generally represent lower quality habitat because predation rates may be higher there. Numerous studies show that predators such as walleye and northern pikeminnow occur in deepwater habitat for at least part of the year (Johnson 1969; Ager 1976; Paragamian 1989; Wahl 1995; Pribyl et al. 2004). In the case of the CRC project, in-water portions of the structures will not pose a complete blockage to nearshore movement anywhere in the action area. Although these structures will cover potential rearing and nearshore migration areas, the habitat is not rare and is not of particularly high quality. These juveniles will still be able to use the abundant shallow-water habitat available for miles in either direction.

Neither the permanent nor the temporary structures will force these juveniles into deeper water, and therefore pose no added risk of predation. Additionally, northern pikeminnow and walleye tend to avoid high-velocity areas during the spring juvenile salmonid outmigration (NMFS 2000b; Gray and Rondorf 1986; Pribyl et al. 2004). The high velocities present in deep-water portions of the CRC project area may limit the potential for actual predation in deep-water areas.

Task Name	Start	Finish	Duration
Bridge Construction Scenario 2/5/13	**9/16/13**	**4/5/17**	**928 days**
Pier 2	**10/16/13**	**1/22/16**	**593 days**
Work Bridge (Approx. 350 s.f.)	10/16/13	10/13/14	259 days
Pier 7	**9/29/14**	**1/23/17**	**606 days**
Work Bridge (Approx. 350 s.f.)	9/29/14	10/13/15	272 days
Barge Moorings (Approx. 200 s.f.)	9/29/14	1/23/17	606 days



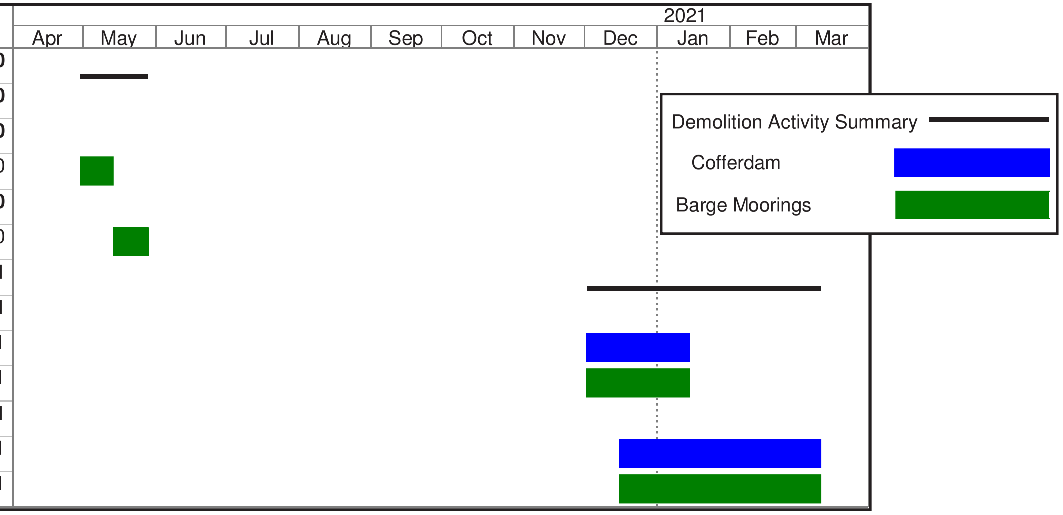
Conceptual Schedule Only, March 2010
Note: This is a proposed schedule, so activity start and finish dates are likely to change.

Pier Activity Summary
Work Bridge
Barge Moorings

Figure 6-29. Sequencing of Temporary In-Water Structures for Construction in Shallow Water in the Columbia River

Columbia River CROSSING

Task Name	Duration	Start	Finish
Superstructure Demolition	**21 days**	**4/30/20**	**5/28/20**
Remove Spans	**21 days**	**4/30/20**	**5/28/20**
Span 9	**10 days**	**4/30/20**	**5/13/20**
Barge Moorings (~56 s.f.)	10 days	4/30/20	5/13/20
Span 10	**11 days**	**5/14/20**	**5/28/20**
Barge Moorings (~56 s.f.)	11 days	5/14/20	5/28/20
Substructure Demolition	**72 days**	**12/2/20**	**3/11/21**
Pier 10	**32 days**	**12/2/20**	**1/14/21**
Cofferdam (7,500 s.f.)	32 days	12/2/20	1/14/21
Barge Moorings (50 s.f.)	32 days	12/2/20	1/14/21
Pier 11	**62 days**	**12/16/20**	**3/11/21**
Cofferdam (7,500 s.f.)	62 days	12/16/20	3/11/21
Barge Moorings (50 s.f.)	62 days	12/16/20	3/11/21

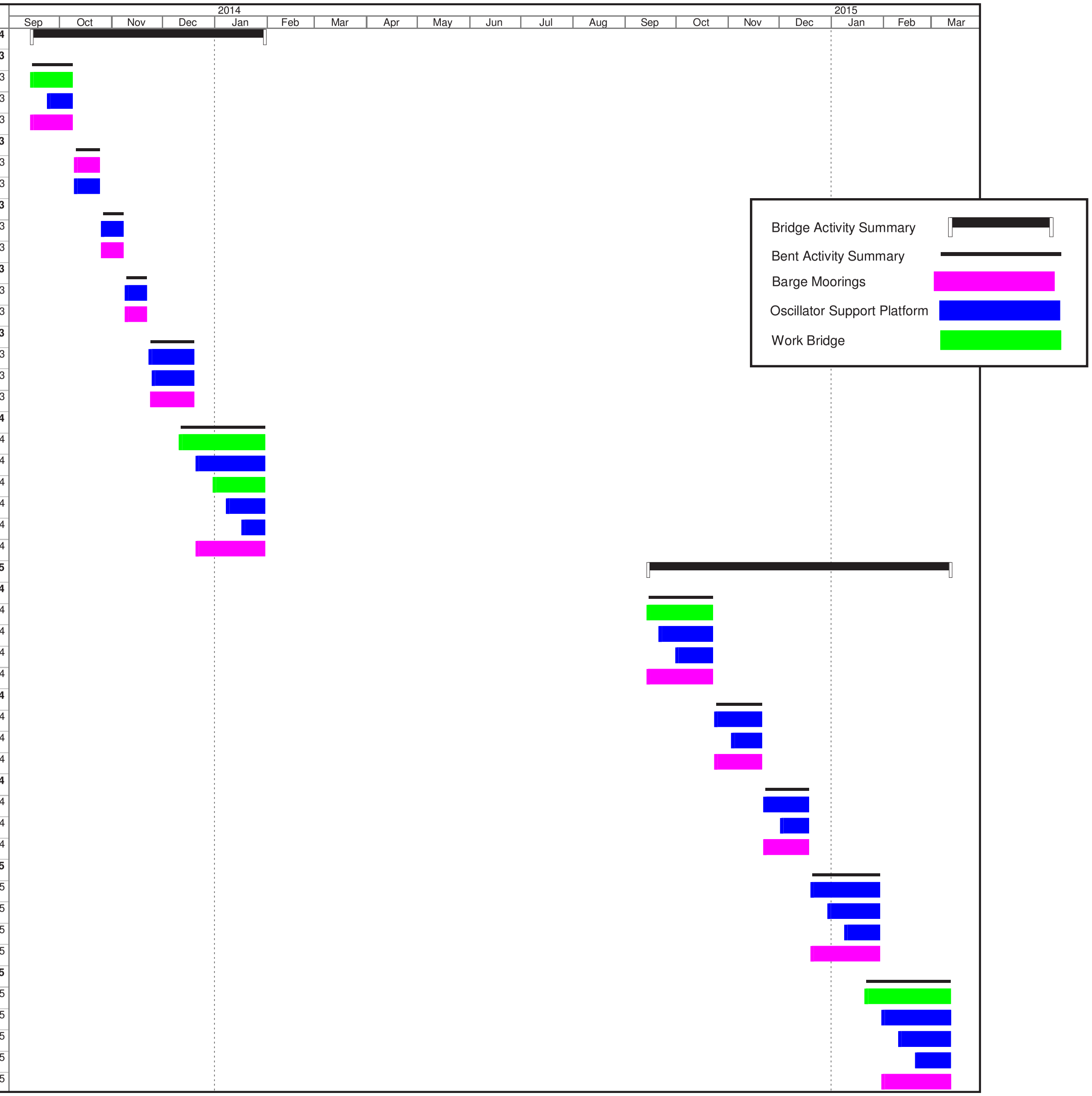


Conceptual Schedule Only, April 2010
Note: This is a proposed schedule, so activity dates are likely to change.

Figure 6-30. Sequencing of Temporary In-Water Structures for Demolition in Shallow Water in the Columbia River

Columbia River CROSSING

Task Name	Duration	Start	Finish
Widening of Existing Bridge	**111 days**	**9/15/13**	**1/30/14**
Bent 4	**20 days**	**9/15/13**	**10/8/13**
Work Bridge (45 - 80 s.f.)	20 days	9/15/13	10/8/13
Oscillator Support Platform (30 - 50 s.f.)	10 days	9/25/13	10/8/13
Barge Moorings (21 - 38 s.f.)	20 days	9/15/13	10/8/13
Bent 5	**10 days**	**10/11/13**	**10/24/13**
Oscillator Support Platform (30 - 50 s.f.)	10 days	10/11/13	10/24/13
Barge Moorings (21 - 38 s.f.)	10 days	10/11/13	10/24/13
Bent 6	**10 days**	**10/27/13**	**11/7/13**
Oscillator Support Platform (30 - 50 s.f.)	10 days	10/27/13	11/7/13
Barge Moorings (21 - 38 s.f.)	10 days	10/27/13	11/7/13
Bent 7	**10 days**	**11/10/13**	**11/21/13**
Oscillator Support Platform (30 - 50 s.f.)	10 days	11/10/13	11/21/13
Barge Moorings (21 - 38 s.f.)	10 days	11/10/13	11/21/13
Bent 8	**22 days**	**11/24/13**	**12/19/13**
Oscillator Support Platform 1 (30 - 50 s.f.)	22 days	11/24/13	12/19/13
Oscillator Support Platform 2 (30 - 50 s.f.)	20 days	11/26/13	12/19/13
Barge Moorings (21 - 38 s.f.)	22 days	11/24/13	12/19/13
Bent 9	**42 days**	**12/12/13**	**1/30/14**
Work Bridge 1 (45 - 80 s.f.)	42 days	12/12/13	1/30/14
Oscillator Support Platform 1 (30 - 50 s.f.)	33 days	12/22/13	1/30/14
Work Bridge 2 (45 - 80 s.f.)	25 days	1/1/14	1/30/14
Oscillator Support Platform 2 (30 - 50 s.f.)	17 days	1/9/14	1/30/14
Oscillator Support Platform 3 (30 - 50 s.f.)	10 days	1/18/14	1/30/14
Barge Moorings (21 - 38 s.f.)	33 days	12/22/13	1/30/14
Light Rail Transit/Multi-Use Plan Bridge	**142 days**	**9/15/14**	**3/12/15**
Bent 2	**30 days**	**9/15/14**	**10/22/14**
Work Bridge (45 - 80 s.f.)	30 days	9/15/14	10/22/14
Oscillator Support Platform 1 (30 - 50 s.f.)	23 days	9/22/14	10/22/14
Oscillator Support Platform 2 (30 - 50 s.f.)	15 days	10/2/14	10/22/14
Barge Moorings (21 - 38 s.f.)	30 days	9/15/14	10/22/14
Bent 3	**21 days**	**10/25/14**	**11/20/14**
Oscillator Support Platform 1 (30 - 50 s.f.)	21 days	10/25/14	11/20/14
Oscillator Support Platform 2 (30 - 50 s.f.)	13 days	11/4/14	11/20/14
Barge Moorings (21 - 38 s.f.)	21 days	10/25/14	11/20/14
Bent 4	**20 days**	**11/23/14**	**12/18/14**
Oscillator Support Platform 1 (30 - 50 s.f.)	20 days	11/23/14	12/18/14
Oscillator Support Platform 2 (30 - 50 s.f.)	12 days	12/3/14	12/18/14
Barge Moorings (21 - 38 s.f.)	20 days	11/23/14	12/18/14
Bent 5	**34 days**	**12/21/14**	**1/29/15**
Oscillator Support Platform 1 (30 - 50 s.f.)	34 days	12/21/14	1/29/15
Oscillator Support Platform 2 (30 - 50 s.f.)	26 days	12/31/14	1/29/15
Oscillator Support Platform 3 (30 - 50 s.f.)	18 days	1/10/15	1/29/15
Barge Moorings (21 - 38 s.f.)	34 days	12/21/14	1/29/15
Bent 6	**41 days**	**1/22/15**	**3/12/15**
Work Bridge (45 - 80 s.f.)	41 days	1/22/15	3/12/15
Oscillator Support Platform 1 (30 - 50 s.f.)	32 days	2/1/15	3/12/15
Oscillator Support Platform 2 (30 - 50 s.f.)	24 days	2/11/15	3/12/15
Oscillator Support Platform 3 (30 - 50 s.f.)	16 days	2/21/15	3/12/15
Barge Moorings (21 - 38 s.f.)	32 days	2/1/15	3/12/15

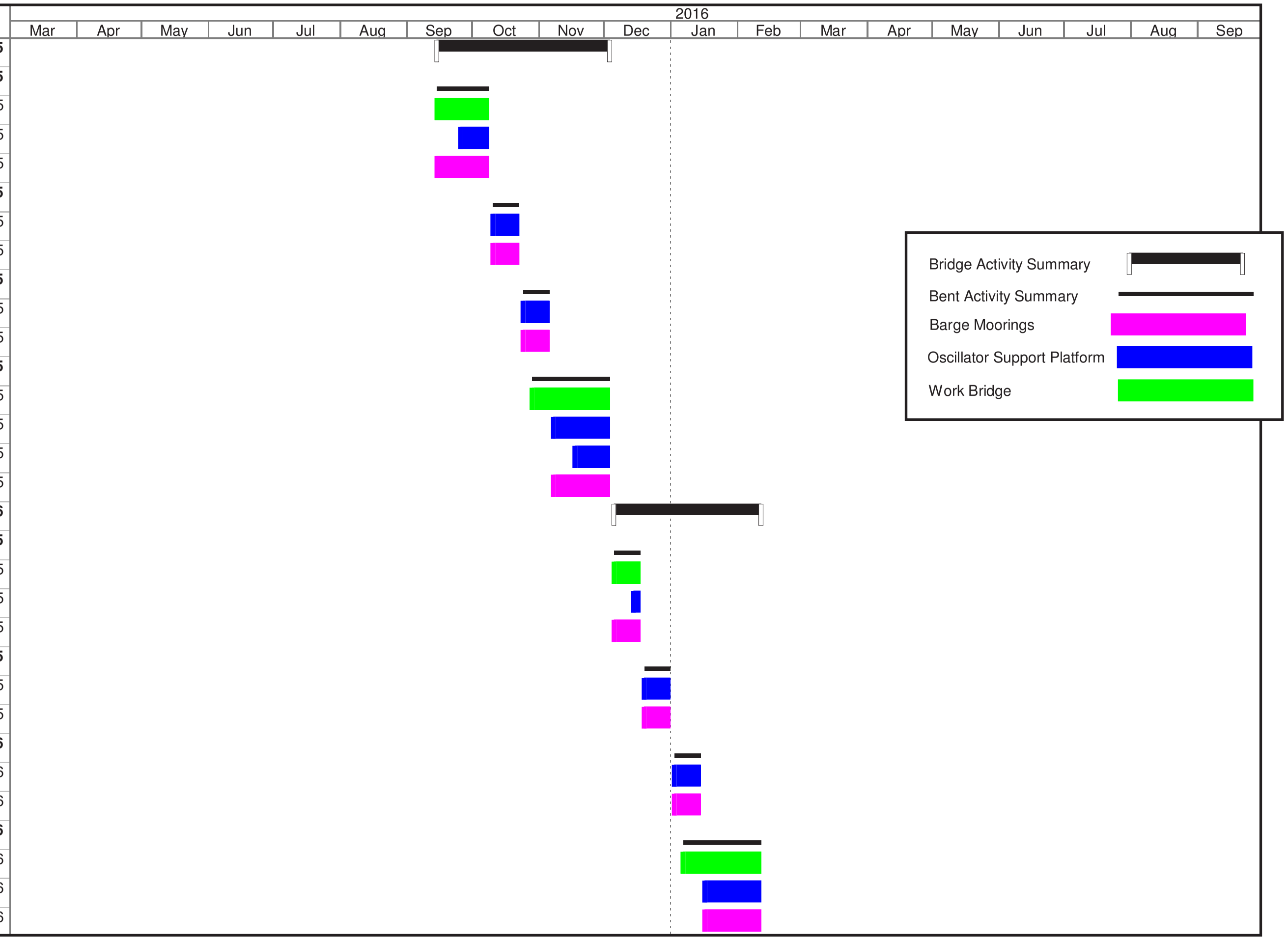


Conceptual Schedule Only, April 2010
Note: This is a proposed schedule, so activity dates are likely to change.

Figure 6-31. Sequencing of Temporary In-Water Structures for Construction in Shallow Water in North Portland Harbor

Columbia River CROSSING

Task Name	Duration	Start	Finish
Northbound Collector Distributor Ramp	**66 days**	**9/15/15**	**12/3/15**
Bent 6	**21 days**	**9/15/15**	**10/8/15**
Work Bridge (45 - 80 s.f.)	21 days	9/15/15	10/8/15
Oscillator Support Platform (30 - 50 s.f.)	10 days	9/26/15	10/8/15
Barge Moorings (21 - 38 s.f.)	21 days	9/15/15	10/8/15
Bent 7	**10 days**	**10/11/15**	**10/22/15**
Oscillator Support Platform (30 - 50 s.f.)	10 days	10/11/15	10/22/15
Barge Moorings (21 - 38 s.f.)	10 days	10/11/15	10/22/15
Bent 8	**12 days**	**10/25/15**	**11/5/15**
Oscillator Support Platform (30 - 50 s.f.)	12 days	10/25/15	11/5/15
Barge Moorings (21 - 38 s.f.)	12 days	10/25/15	11/5/15
Bent 9	**29 days**	**10/29/15**	**12/3/15**
Work Bridge (45 - 80 s.f.)	29 days	10/29/15	12/3/15
Oscillator Support Platform 1 (30 - 50 s.f.)	20 days	11/8/15	12/3/15
Oscillator Support Platform 2 (30 - 50 s.f.)	12 days	11/18/15	12/3/15
Barge Moorings (21 - 38 s.f.)	20 days	11/8/15	12/3/15
Southbound Collector Distributor Ramp	**57 days**	**12/6/15**	**2/11/16**
Bent 2	**12 days**	**12/6/15**	**12/17/15**
Work Bridge (45 - 80 s.f.)	12 days	12/6/15	12/17/15
Oscillator Support Platform (30 - 50 s.f.)	3 days	12/15/15	12/17/15
Barge Moorings (21 - 38 s.f.)	12 days	12/6/15	12/17/15
Bent 3	**10 days**	**12/20/15**	**12/31/15**
Oscillator Support Platform (30 - 50 s.f.)	10 days	12/20/15	12/31/15
Barge Moorings (21 - 38 s.f.)	10 days	12/20/15	12/31/15
Bent 4	**12 days**	**1/3/16**	**1/14/16**
Oscillator Support Platform (30 - 50 s.f.)	12 days	1/3/16	1/14/16
Barge Moorings (21 - 38 s.f.)	12 days	1/3/16	1/14/16
Bent 5	**29 days**	**1/7/16**	**2/11/16**
Work Bridge (45 - 80 s.f.)	29 days	1/7/16	2/11/16
Oscillator Support Platform (30 - 50 s.f.)	20 days	1/17/16	2/11/16
Barge Moorings (21 - 38 s.f.)	20 days	1/17/16	2/11/16



Conceptual Schedule Only, April 2010
Note: This is a proposed schedule, so activity dates are likely to change.

Figure 6-31 (Continued). Sequencing of Temporary In-Water Structures for Construction in Shallow Water in North Portland Harbor

Columbia River CROSSING

Physical loss of shallow-water habitat will have only negligible effects on foraging, migration, and holding of salmonids that are of the yearling age class or older. These life functions are not dependent on shallow-water habitat for these age classes. Furthermore, the lost habitat is not of particularly high quality. There is abundant similar habitat immediately adjacent along the shorelines of the Columbia River and throughout North Portland Harbor. The lost habitat represents only a small fraction of the remaining habitat available for miles in either direction. There will still be many acres of habitat for foraging, migrating, and holding.

Physical loss of shallow-water habitat will have only negligible effects on eulachon and green sturgeon for the same reason as above.

It is impossible to quantify the number of fish that will be exposed to this effect, but it is possible to estimate the extent and duration of the effect. This effect will occur when structures will be present in the water (Table 6-31, Table 6-32, and Figure 6-29) during the timing of fish presence in this portion of the action area (see Figures 4-1 and 4-2).

Increase in Overwater Coverage

The project will place several overwater structures in shallow water in the Columbia River and North Portland Harbor. Temporary overwater structures include temporary work platforms, work bridges, oscillator support platforms, and stationary barges. Permanent overwater structures likely to have effects on fish include only the shaft caps on the Columbia River bridges. Table 6-33 and Table 6-34 quantify the area and duration of project-related overwater structures in the action area.

Table 6-33. Overwater Coverage in Shallow Water Habitat in the Columbia River

Structure Type	Columbia River	
	Area	**Duration in Water**
Temporary		
Work bridges (P2, P7)	36,000 sq. ft.	150–300 days/pier complex
Barges for Demolition (Existing Piers 10 & 11)	14,350 sq. ft.	Varies up to 30 days/barge
Total Temporary Impact	**50,350 sq. ft.**	---
Permanent		
Shaft Caps (P7 – Half of SB)	1,688 sq. ft.	Permanent
Pier at Red Lion at the Quay to be Removed	-18,965 sq. ft.	Permanent
Total Permanent Impact	**-17,277 sq. ft.**	---

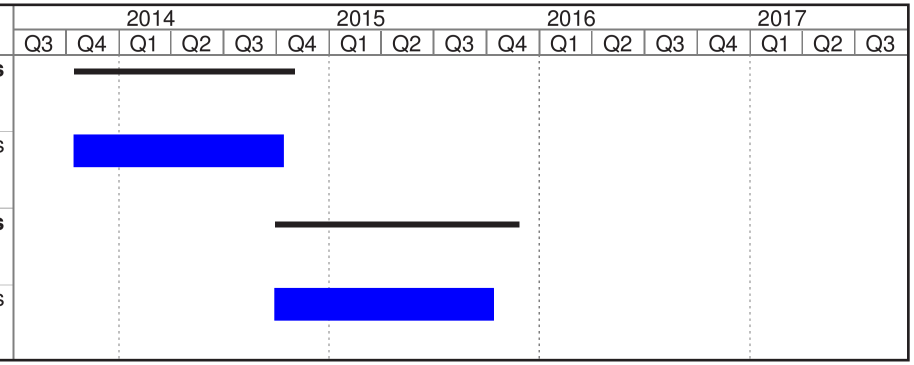
Table 6-34. Overwater Coverage in Shallow Water Habitat in North Portland Harbor

	North Portland Harbor	
Structure Type	**Area**	**Duration in Water**
Temporary		
Work Bridges (8 locations)	29,640 sq. ft.	Up to 42 days each
Oscillator Support Platforms (31 locations)	27,900 sq. ft.	Up to 34 days each
Barges for Construction (31 locations)	64,164 sq. ft.	Up to 34 days each
Total Temporary Impact	**108,164 sq. ft.**	---
Permanent		
None	N/A	Permanent
Total Permanent Impact	**N/A**	---

Temporary structures will not all be present in the action area at the same time. Figure 6-32, Figure 6-33, and Figure 6-34 provide the sequencing of overwater structures in the shallow-water portions of the action area. The maximum amount of shade from overwater structures in shallow water in the Columbia River will be no more than about 18,500 sq. ft. at one time. In North Portland Harbor, the maximum amount of shade in shallow water at one time will be about 112,180 sq. ft.

Effects of overwater coverage on fish and fish habitat are discussed in Section 6.1.3.3.

Task Name	Start	Finish	Duration
Pier 2	**10/16/13**	**1/22/16**	**593 days**
Work Bridge (17,500 s.f.)	10/16/13	10/13/14	259 days
Pier 7	**9/29/14**	**1/23/17**	**606 days**
Work Bridge (18,500 s.f.)	9/29/14	10/13/15	272 days



Conceptual Schedule Only, March 2010
Note: This is a proposed schedule, so activity start and finish dates are likely to change.

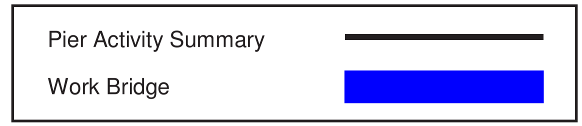
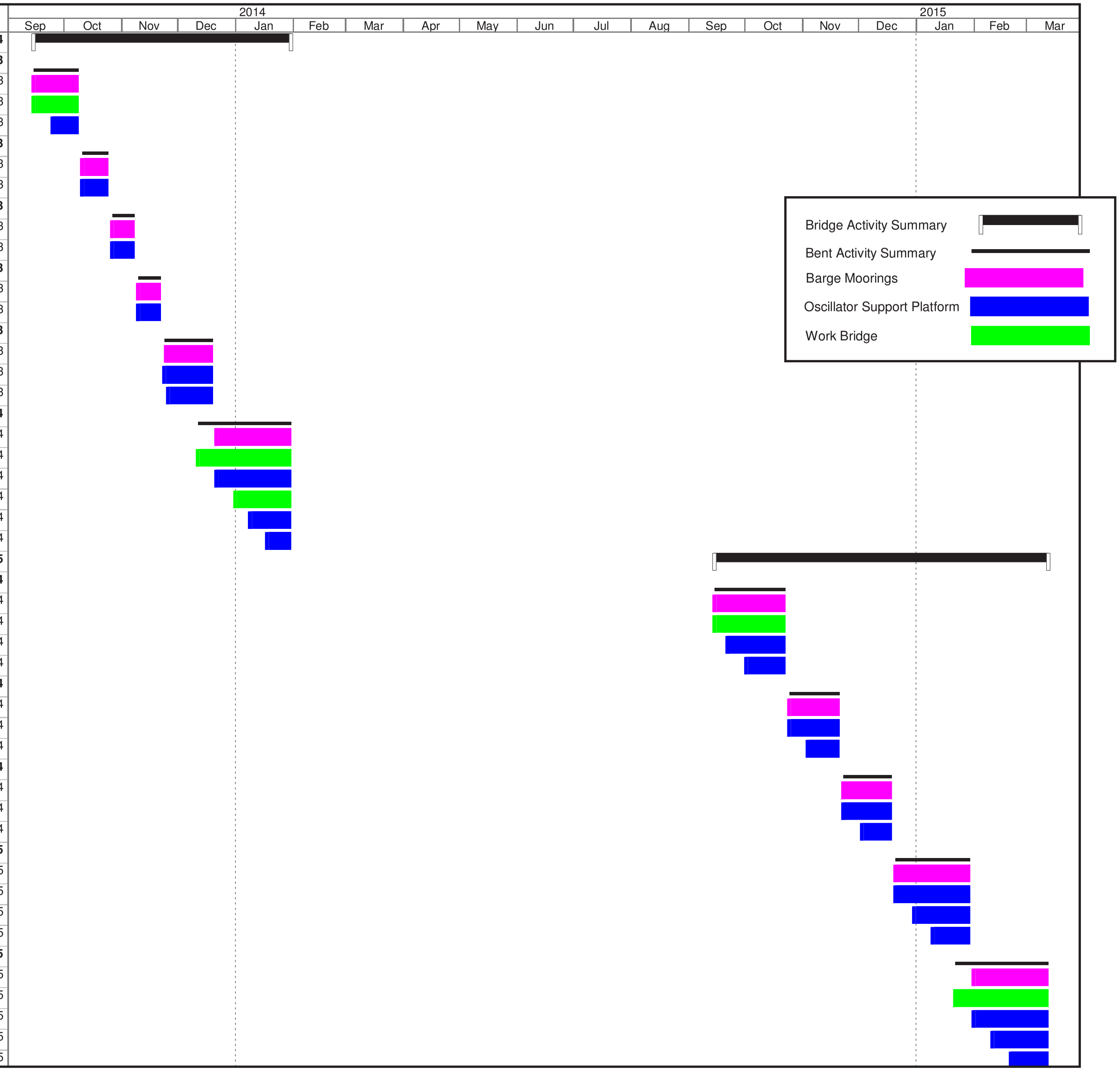


Figure 6-32. Sequencing of Temporary Over-Water Structures for Construction in Shallow Water in the Columbia River

Columbia River CROSSING

Task Name	Duration	Start	Finish
Widening of Existing Bridge	**111 days**	**9/15/13**	**1/30/14**
Bent 4	**20 days**	**9/15/13**	**10/8/13**
Two Medium Crane Barges (35,000 s.f.)	20 days	9/15/13	10/8/13
Work Bridge (3,360 s.f.)	20 days	9/15/13	10/8/13
Oscillator Support Platform (900 s.f.)	10 days	9/25/13	10/8/13
Bent 5	**10 days**	**10/11/13**	**10/24/13**
Two Medium Crane Barges (35,000 s.f.)	10 days	10/11/13	10/24/13
Oscillator Support Platform (900 s.f.)	10 days	10/11/13	10/24/13
Bent 6	**10 days**	**10/27/13**	**11/7/13**
Two Medium Crane Barges (35,000 s.f.)	10 days	10/27/13	11/7/13
Oscillator Support Platform (900 s.f.)	10 days	10/27/13	11/7/13
Bent 7	**10 days**	**11/10/13**	**11/21/13**
Two Medium Crane Barges (35,000 s.f.)	10 days	11/10/13	11/21/13
Oscillator Support Platform (900 s.f.)	10 days	11/10/13	11/21/13
Bent 8	**22 days**	**11/24/13**	**12/19/13**
Four Medium Crane Barges (70,000 s.f.)	22 days	11/24/13	12/19/13
Oscillator Support Platform 1 (900 s.f.)	22 days	11/24/13	12/19/13
Oscillator Support Platform 2 (900 s.f.)	20 days	11/26/13	12/19/13
Bent 9	**42 days**	**12/12/13**	**1/30/14**
Six Medium Crane Barges (105,000 s.f.)	33 days	12/22/13	1/30/14
Work Bridge 1 (2,240 s.f.)	42 days	12/12/13	1/30/14
Oscillator Support Platform 1 (900 s.f.)	33 days	12/22/13	1/30/14
Work Bridge 2 (2,240 s.f.)	25 days	1/1/14	1/30/14
Oscillator Support Platform 2 (900 s.f.)	17 days	1/9/14	1/30/14
Oscillator Support Platform 3 (900 s.f.)	10 days	1/18/14	1/30/14
Light Rail Transit/Multi-Use Plan Bridge	**142 days**	**9/15/14**	**3/12/15**
Bent 2	**30 days**	**9/15/14**	**10/22/14**
Four Medium Crane Barges (70,000 s.f.)	30 days	9/15/14	10/22/14
Work Bridge (2,960 s.f.)	30 days	9/15/14	10/22/14
Oscillator Support Platform 1 (900 s.f.)	23 days	9/22/14	10/22/14
Oscillator Support Platform 2 (900 s.f.)	15 days	10/2/14	10/22/14
Bent 3	**21 days**	**10/25/14**	**11/20/14**
Four Medium Crane Barges (70,000 s.f.)	21 days	10/25/14	11/20/14
Oscillator Support Platform 1 (900 s.f.)	21 days	10/25/14	11/20/14
Oscillator Support Platform 2 (900 s.f.)	13 days	11/4/14	11/20/14
Bent 4	**20 days**	**11/23/14**	**12/18/14**
Four Medium Crane Barges (70,000 s.f.)	20 days	11/23/14	12/18/14
Oscillator Support Platform 1 (900 s.f.)	20 days	11/23/14	12/18/14
Oscillator Support Platform 2 (900 s.f.)	12 days	12/3/14	12/18/14
Bent 5	**34 days**	**12/21/14**	**1/29/15**
Six Medium Crane Barges (105,000 s.f.)	34 days	12/21/14	1/29/15
Oscillator Support Platform 1 (900 s.f.)	34 days	12/21/14	1/29/15
Oscillator Support Platform 2 (900 s.f.)	26 days	12/31/14	1/29/15
Oscillator Support Platform 3 (900 s.f.)	18 days	1/10/15	1/29/15
Bent 6	**41 days**	**1/22/15**	**3/12/15**
Six Medium Crane Barges (105,000 s.f.)	32 days	2/1/15	3/12/15
Work Bridge (1,520 s.f.)	41 days	1/22/15	3/12/15
Oscillator Support Platform 1 (900 s.f.)	32 days	2/1/15	3/12/15
Oscillator Support Platform 2 (900 s.f.)	24 days	2/11/15	3/12/15
Oscillator Support Platform 3 (900 s.f.)	16 days	2/21/15	3/12/15

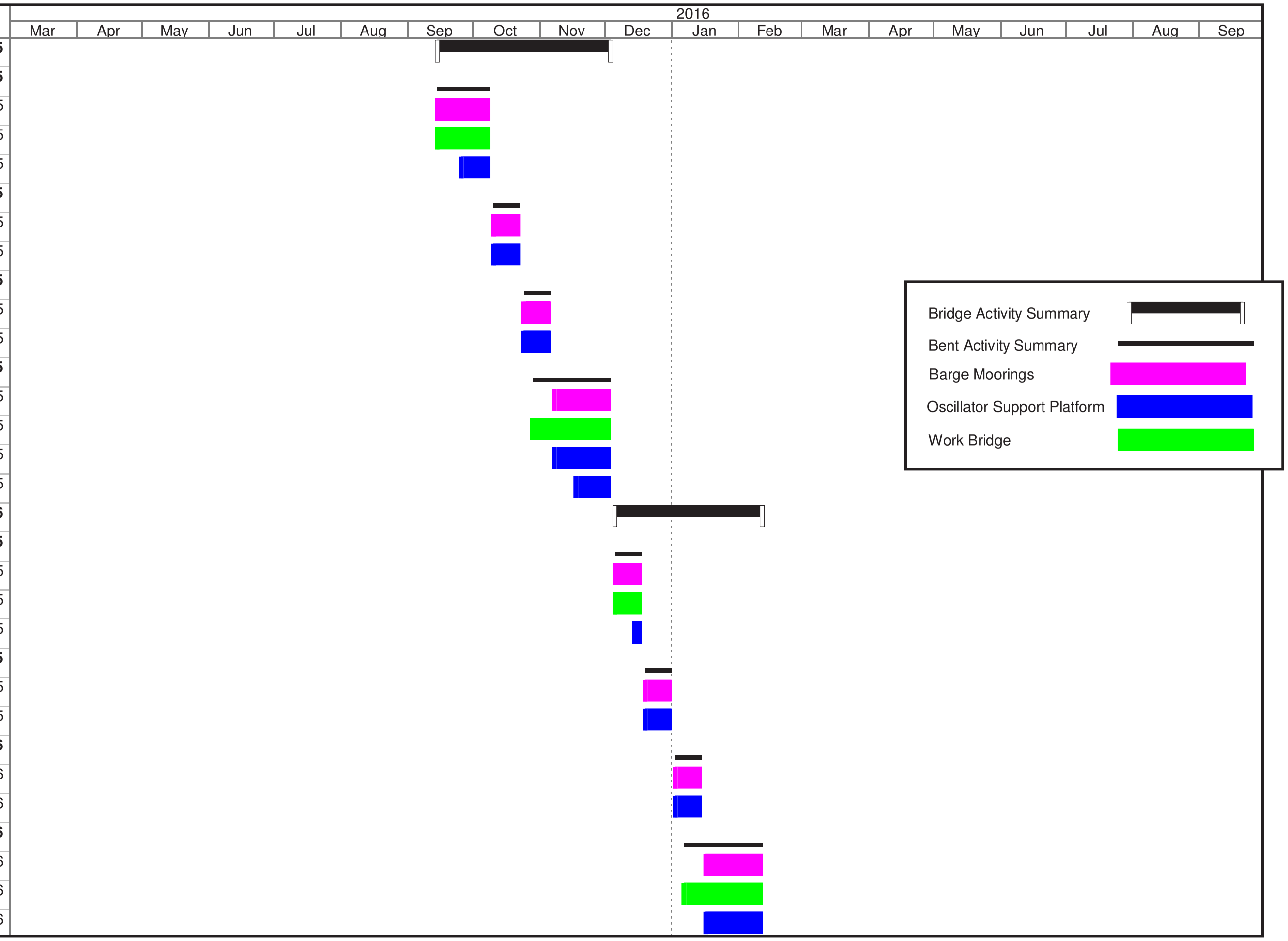


Conceptual Schedule Only, April 2010
Note: This is a proposed schedule, so activity dates are likely to change.

Figure 6-33. Sequencing of Temporary Overwater Structures for Construction in Shallow Water in North Portland Harbor

Columbia River CROSSING

Task Name	Duration	Start	Finish
Northbound Collector Distributor Ramp	**66 days**	**9/15/15**	**12/3/15**
Bent 6	**21 days**	**9/15/15**	**10/8/15**
Two Medium Crane Barges (35,000 s.f.)	21 days	9/15/15	10/8/15
Work Bridge (4,080 s.f.)	21 days	9/15/15	10/8/15
Oscillator Support Platform (900 s.f.)	10 days	9/26/15	10/8/15
Bent 7	**10 days**	**10/11/15**	**10/22/15**
Two Medium Crane Barges (35,000 s.f.)	10 days	10/11/15	10/22/15
Oscillator Support Platform (900 s.f.)	10 days	10/11/15	10/22/15
Bent 8	**12 days**	**10/25/15**	**11/5/15**
Two Medium Crane Barges (35,000 s.f.)	12 days	10/25/15	11/5/15
Oscillator Support Platform (900 s.f.)	12 days	10/25/15	11/5/15
Bent 9	**29 days**	**10/29/15**	**12/3/15**
Four Medium Crane Barges (70,000 s.f.)	20 days	11/8/15	12/3/15
Work Bridge 1 (2,240 s.f.)	29 days	10/29/15	12/3/15
Oscillator Support Platform 1 (900 s.f.)	20 days	11/8/15	12/3/15
Oscillator Support Platform 2 (900 s.f.)	12 days	11/18/15	12/3/15
Southbound Collector Distributor Ramp	**57 days**	**12/6/15**	**2/11/16**
Bent 2	**12 days**	**12/6/15**	**12/17/15**
Two Medium Crane Barges (35,000 s.f.)	12 days	12/6/15	12/17/15
Work Bridge (4,880 s.f.)	12 days	12/6/15	12/17/15
Oscillator Support Platform (900 s.f.)	3 days	12/15/15	12/17/15
Bent 3	**10 days**	**12/20/15**	**12/31/15**
Two Medium Crane Barges (35,000 s.f.)	10 days	12/20/15	12/31/15
Oscillator Support Platform (900 s.f.)	10 days	12/20/15	12/31/15
Bent 4	**12 days**	**1/3/16**	**1/14/16**
Two Medium Crane Barges (35,000 s.f.)	12 days	1/3/16	1/14/16
Oscillator Support Platform (900 s.f.)	12 days	1/3/16	1/14/16
Bent 5	**29 days**	**1/7/16**	**2/11/16**
Four Medium Crane Barges (70,000 s.f.)	20 days	1/17/16	2/11/16
Work Bridge (2,280 s.f.)	29 days	1/7/16	2/11/16
Oscillator Support Platform (900 s.f.)	20 days	1/17/16	2/11/16

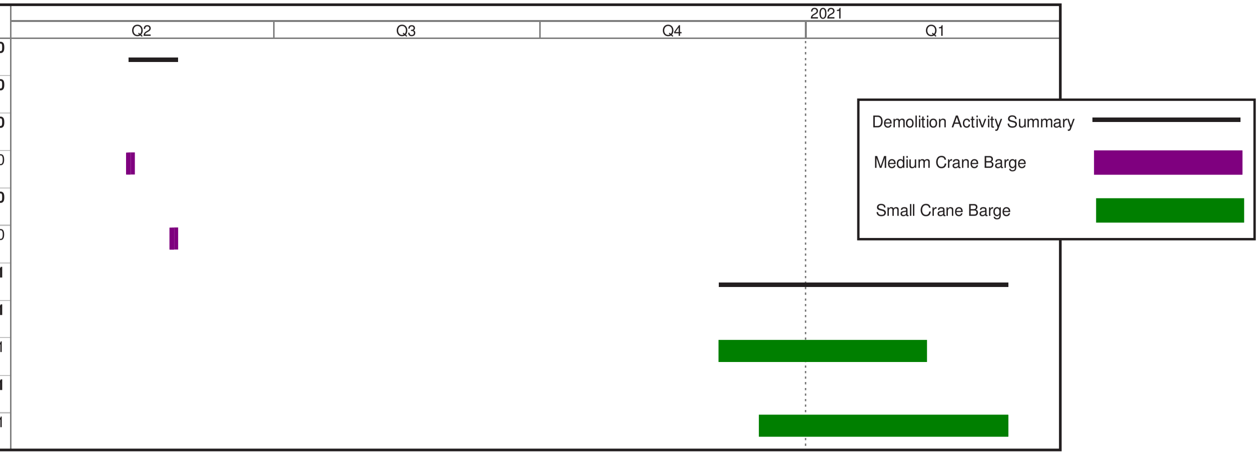


Conceptual Schedule Only, April 2010
Note: This is a proposed schedule, so activity dates are likely to change.

Figure 6-33 (Continued).
Sequencing of Temporary Overwater Structures for Construction in Shallow Water in North Portland Harbor

Columbia River CROSSING

Task Name	Duration	Start	Finish
Superstructure Demolition	**13 days**	**5/12/20**	**5/28/20**
Remove Spans	**13 days**	**5/12/20**	**5/28/20**
Span 9	**2 days**	**5/12/20**	**5/13/20**
Medium Crane Barge (10,500 s.f.)	2 days	5/12/20	5/13/20
Span 10	**2 days**	**5/27/20**	**5/28/20**
Medium Crane Barge (10,500 s.f.)	2 days	5/27/20	5/28/20
Substructure Demolition	**72 days**	**12/2/20**	**3/11/21**
Pier 10	**52 days**	**12/2/20**	**2/11/21**
Small Crane Barge (6,000 s.f.)	52 days	12/2/20	2/11/21
Pier 11	**62 days**	**12/16/20**	**3/11/21**
Small Crane Barge (6,000 s.f.)	62 days	12/16/20	3/11/21



Conceptual Schedule Only, April 2010
Note: This is a proposed schedule, so activity dates are likely to change.

Figure 6-34. Sequencing of Temporary Barges Used for Demolition in Shallow Water in the Columbia River

Temporary Turbidity

The project will temporarily degrade shallow-water habitat by creating turbidity. Table 6-35 summarizes the activities likely to generate turbidity in shallow water.

Table 6-35. Activities Likely to Generate Turbidity in Shallow Water

Activity	Timing[a]	Location[b]	Likely Extent of Turbidity	Duration of Effect (hr/day)	Number of Work Days
Install temporary piles, impact methods	Mid Sept – Mid April	Adjacent to P2, P7 in CR Adjacent to 31 NPH shafts	~25 feet	< 0.66	~74 in CR 134 in NPH
Install temporary piles, vibratory methods	Year-round	Adjacent to P2, P7 in CR Adjacent to 31 NPH shafts	~25 feet	up to 24	~590 at P2 ~600 at P7 334 in NPH
Remove temporary piles, direct pull or vibratory	Year-round	Adjacent to P2, P7 in CR Adjacent to 31 NPH shafts	Minimal	up to 24	~590 at P2 ~600 at P7 334 in NPH
Installing steel casings to drill permanent shafts – vibratory hammer, oscillator, or rotator	Year-round	P7 in CR Adjacent to 31 NPH shafts	~25 feet	8 – 10	80 at P7 < 1 / NPH shaft
Drill and excavate permanent shafts	Year-round	P7 in CR Adjacent to 31 NPH shafts	None (contained)	n/a	80 at P7 ≤ 8 / NPH shaft
Operate stationary and moving barges in shallow water	Year-round	P7 in CR Adjacent to 31 NPH shafts Demo existing piers 10 and 11 in CR	<300 feet	numerous times per day	~600 at P7 ~640 in NPH
Debris removal (clamshell)	11/1 – 02/28	Potentially at 31 locations in NPH.	~300 feet (or as prescribed by permits)	4-6 hr/day, Up to 4x/day	Less than 7
Demolish existing Columbia River bridge piers (includes installation and demolition of cofferdams)	Year-round	Existing Piers 10 and 11 in CR	Minimal	8 – 10	~266

a All activities likely to take place throughout the four-year in-water construction period.
b CR = Columbia River; NPH = North Portland Harbor; P = Pier Complex.

General effects of turbidity are described in detail in Section 6.1.5.2. Turbidity will pose fairly limited impacts to shallow-water habitat, as the project will restrict the extent of turbidity to distances specified by regulatory permits (anticipated to be no more than 300 feet). In actuality, many of the activities will restrict the turbidity plume to far shorter distances than the anticipated 300-foot mixing zone (Table 6-35). Permits will also restrict the duration of each turbidity plume to approximately 4 to 6 hours.

Figure 4-1 and Figure 4-2 show when listed fish are present in the action area and could be exposed to this effect. The turbidity plumes may make discrete areas temporarily unavailable for foraging, rearing, holding, and migration, but only for short periods of time (as specified by the regulatory permits). Due to the high dilution capacity of the Columbia River and North Portland Harbor, the turbidity plumes are expected to disperse relatively quickly and within a short distance of the source. Both adult and juvenile fish will be able to use the abundant, similar-quality shallow-water habitat outside of the areas subject to high turbidity.

Underwater Noise

Impact pile driving will create elevated noise levels in North Portland Harbor and the Columbia River. Impact pile driving will occur in shallow water at Pier 2 and Pier 7 in the Columbia River, and at all new bents in North Portland Harbor. Impact pile driving at some of the other Columbia River piers and North Portland Harbor bents will extend into shallow-water habitat (Figure 6-1 through Figure 6-13).

The effect of high underwater noise levels on fish is described in greater detail in Section 6.1.1.1 and Appendix K. Table 6-9 and Table 6-10 outline the extent, duration, and timing of hydroacoustic effects, and Figure 4-1 and Figure 4-2 show when listed fish occur in this portion of the action area and could be exposed to elevated noise levels. Rearing and subyearling-migrant salmonids are more vulnerable to this effect due to their high level of dependence on nearshore habitat. However, all of the fish species addressed by this BA could potentially be exposed to this effect.

In summary, underwater noise will temporarily degrade shallow-water habitat, creating noise above the disturbance threshold in the Columbia River for a minimum of 858 m from the pile being driven and extending from RM 101 to 118 (RKm 163 to 190). In North Portland Harbor, noise will exceed the disturbance threshold for a minimum of 858 m from the pile being driven and extending from 3.5 miles (5,632 m) downstream of the project area to 1.9 miles (3,058 m) upstream of the project area (Figure 6-12 and Figure 6-13).

Additionally, in areas located within 5 to 446 m of pile driving at various piers in the Columbia River and North Portland Harbor, underwater noise is expected to temporarily exceed the injury threshold for fish (Figure 6-1 through Figure 6-11). These areas will be unsuitable for foraging, rearing, migrating, and holding because fish entering this area may potentially be killed or injured. Underwater noise may also create a temporary barrier to migration for both adults and juveniles when above the disturbance threshold in these areas during this time period (Caltrans 2009).

Vibratory pile driving is expected to create noise above ambient levels in shallow-water habitat at pier complex 2 and pier complex 7 in the Columbia River, at existing piers 10 and 11 in the Columbia River, and at 31 shafts in North Portland Harbor. Elevated noise levels are not expected to cause injury to fish in these areas; however, they could prompt avoidance of areas.

6.3.2 Deep-Water Habitat

Deep-water habitat (water greater than 20 feet deep) occurs only in the Columbia River. This section outlines the role of deep water as habitat for fish and provides an analysis of likely effects to fish in deep-water portions of the CRC action area.

6.3.2.1 Fish Distribution in Deep-Water Habitat

Listed fish will have mixed use of deep-water habitat in the action area. Typically, rearing and subyearling-migrant salmonids are highly dependent on shallow-water habitat in the upper estuary (Carter et al. 2009), including the action area, as described in Section 6.3.1.1; however, they do not occur exclusively in shallow water and are known to stray occasionally into the surface layer of deeper waters (Bottom et al. 2005).

Larger juvenile salmonid migrants of the yearling age class or older commonly use deep-water portions of the navigation channel in high numbers while actively outmigrating, taking advantage of higher velocities there (Carter et al. 2009), as described in Section 6.3.1.1.

Adult salmonids do not show any specific preference for deep-water habitat over shallow-water habitat (Bottom et al. 2005). While they generally migrate at mid-channel, they may be found at depths of 1 to 50 feet (NMFS 2006). They commonly use deep-water portions of the action area for foraging and hold in low-velocity areas of deep-water habitat (such as behind bridge piers).

Eulachon adults and juveniles are known to range at depths of greater than 50 feet and are likely to be present in deep-water portions of the action area (Hay and McCarter 2000).

Adult and subadult green sturgeon use waters at depths of 30 feet or less and also could be present in deep-water portions of the action area (73 FR 52084).

6.3.2.2 Effects to Fish in the CRC Action Area

The project will have both temporary and permanent impacts to deep-water habitat in the Columbia River. Impacts include physical loss of habitat, increase in overwater coverage, turbidity, and underwater noise.

Impacts to deep-water habitat will affect the following habitats, species and life stages of listed fish:

- Feeding, holding and migration habitat for juveniles and holding and migration habitat for adults of the following ESUs/DPSs: LCR coho; CR chum; SR sockeye; LCR, MCR, UCR, and SR steelhead; and LCR, UCR spring-run, SR fall-run, and SR spring/summer-run Chinook.
- Rearing habitat for juvenile Chinook (LCR, UCR spring-run, and UWR), LCR coho, LCR steelhead, and CR chum.
- Adult and subadult bull trout migration and holding habitat. (Because of the extremely low numbers of bull trout in this portion of the action area, risk of exposure to this effect is discountable.)
- Adult and subadult green sturgeon feeding and migration habitat. (Because of the extremely low numbers of green sturgeon in this portion of the action area, risk of exposure to this effect is discountable.)
- Adult and larval eulachon spawning and migration habitat.

Figures 4-1 and 4-2 show when these species are likely to be present in this portion of the action area and could be exposed to activities occurring in deep water. Since deep-water impacts will occur continually throughout the 4-year in-water construction period, as many as four migration cycles of salmon, steelhead, and eulachon could be exposed to these effects.

Physical Loss of Deep-Water Habitat

Table 6-36 summarizes the physical impacts to deep-water habitat in the Columbia River.

Table 6-36. Physical Impacts to Deep-Water Habitat in the Columbia River

Impact	Area	Time in Water
Temporary		
Work Platforms – Construction (P 3–6) [a]	3,870 sq. ft.	150–300 days each
Tower Cranes – Construction (P 2–7)	603 sq. ft.	350 days/crane
Barge Moorings – Construction (P 2–6)	226 sq. ft.	120 days/pier complex
Barge Moorings – Demolition (Existing Piers 2–9)	754 sq. ft.	40 days/pier complex
Coffer Dams – Demolition (Existing Piers 2–9)	52,500 sq. ft.	~317
Total Temporary Impact	**57,953 sq. ft.**	**---**
Permanent		
New Bridge Drilled Shafts (P 2–7)	6,361 sq. ft.	Permanent
Existing Bridges Piers to be Removed (Existing Piers 2–9)	-21,633 sq. ft.	Permanent
Total Permanent Impact	**-15,272 sq. ft.**	**---**

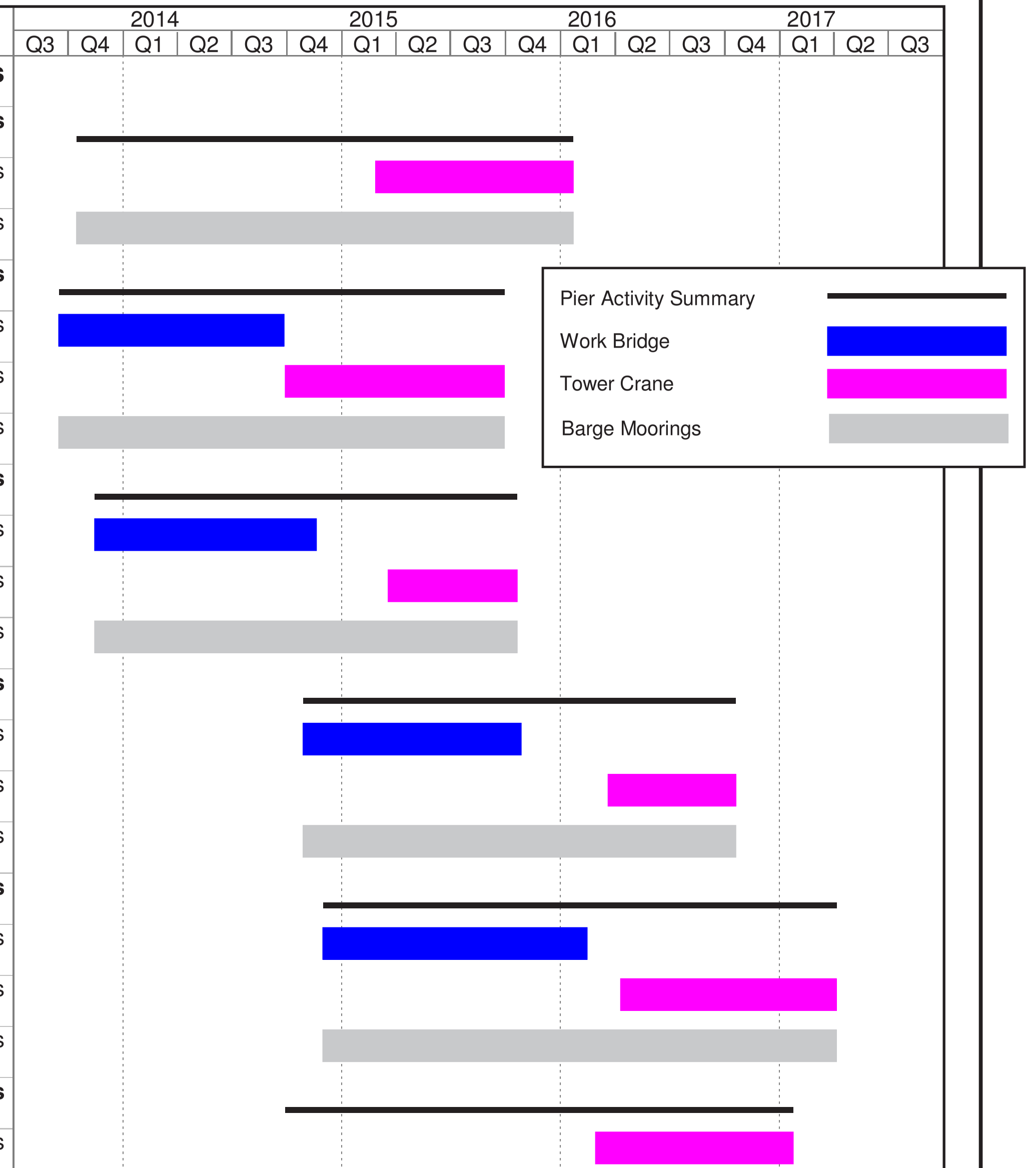
a P = Pier Complex

The structures shown in Table 6-36 will not all be in place at the same time. Figure 6-35 and Figure 6-36 provide the sequencing of in-water structures in deep-water habitat.

The project will lead to temporary physical loss of approximately 16,635 sq. ft. of deep-water habitat, consisting chiefly of coarse sand with a small proportion of gravel. Project elements responsible for temporary physical loss include the cofferdams and numerous temporary piles associated with in-water work platforms and moorings. The in-water portions of the new structures will result in the permanent physical loss of approximately 6,300 sq. ft. of deep-water habitat at pier complex 2 through 7 in the Columbia River. Demolition of the existing Columbia River piers will permanently restore about 21,000 sq. ft. of deep-water habitat. Overall, there will be a net permanent gain of about 15,000 sq. ft. of deep-water habitat in the Columbia River.

Although there will be a temporary net physical loss of deep-water habitat, this is not expected to have a significant impact on listed fish. None of the fish addressed by this BA are particularly dependent on deep-water habitat. The lost habitat is not rare or of particularly high quality, and there is abundant similar habitat in immediately adjacent areas of the Columbia River and for many miles both upstream and downstream. The lost habitat will represent a very small fraction (far less than 1 percent) of the remaining habitat available. Additionally, the in-water portions of the permanent and temporary in-water structures will occupy no more than about 1 percent of the width of the Columbia River. Therefore, the structures will not pose a physical barrier to migration. Due to the small size of the impact relative to the remaining habitat available, this effect will be insignificant.

Task Name	Start	Finish	Duration
Bridge Construction Scenario 2/5/13	**9/16/13**	**4/5/17**	**928 days**
Pier 2	**10/16/13**	**1/22/16**	**593 days**
Tower Crane (Aprox. 100 s.f.)	2/27/15	1/22/16	236 days
Barge Moorings (Approx. 45 s.f.)	10/16/13	1/22/16	593 days
Pier 3	**9/16/13**	**9/29/15**	**532 days**
Work Bridge (Approx. 600 s.f.)	9/16/13	9/26/14	270 days
Tower Crane (Approx. 100 s.f.)	9/29/14	9/29/15	262 days
Barge Moorings (Approx. 45 s.f.)	9/16/13	9/29/15	532 days
Pier 4	**11/15/13**	**10/20/15**	**503 days**
Work Bridge (Approx. 600 s.f.)	11/15/13	11/19/14	264 days
Tower Crane (Approx. 100 s.f.)	3/20/15	10/20/15	153 days
Barge Moorings (Approx. 45 s.f.)	11/15/13	10/20/15	503 days
Pier 5	**10/29/14**	**10/19/16**	**516 days**
Work Bridge (Approx. 600 s.f.)	10/29/14	10/27/15	260 days
Tower Crane (Approx. 100 s.f.)	3/21/16	10/19/16	153 days
Barge Moorings (Approx. 45 s.f.)	10/29/14	10/19/16	516 days
Pier 6	**12/1/14**	**4/5/17**	**613 days**
Work Bridge (Approx. 600 s.f.)	12/1/14	2/15/16	315 days
Tower Crane (Approx. 100 s.f.)	4/11/16	4/5/17	258 days
Barge Moorings (Approx. 45 s.f.)	12/1/14	4/5/17	613 days
Pier 7	**9/29/14**	**1/23/17**	**606 days**
Tower Crane (Aprox. 100 s.f.)	2/29/16	1/23/17	236 days

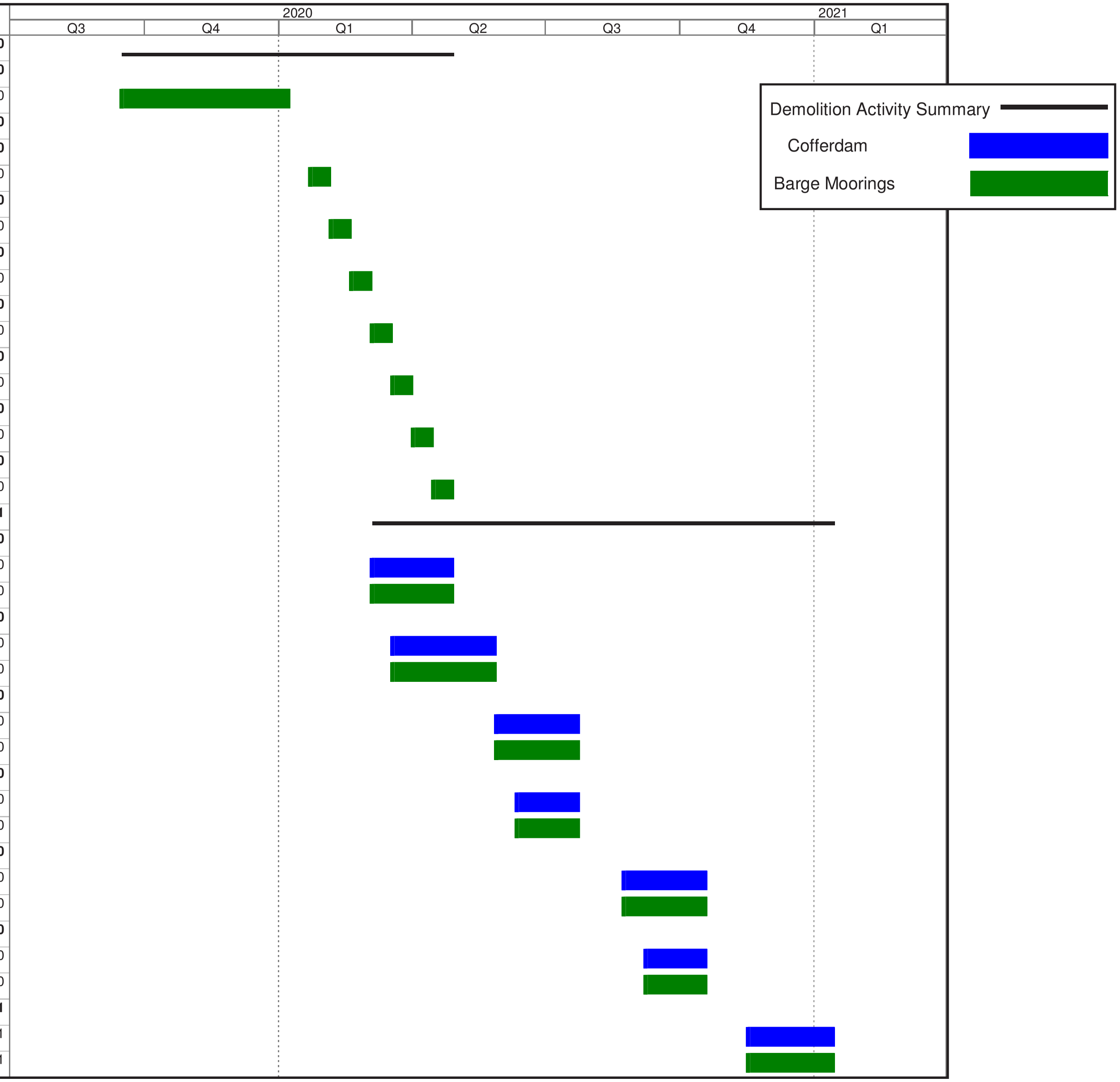


Conceptual Schedule Only, March 2010
Note: This is a proposed schedule, so activity start and finish dates are likely to change.

Figure 6-35. Sequencing of Temporary In-Water Structures for Construction in Deep Water in the Columbia River

Columbia River CROSSING

Task Name	Duration	Start	Finish
Superstructure Demolition	**163 days**	**9/16/19**	**4/29/20**
Demolish Lift Span Towers	**83 days**	**9/16/19**	**1/8/20**
Barge Moorings (~75 s.f.)	83 days	9/16/19	1/8/20
Remove Spans	**70 days**	**1/23/20**	**4/29/20**
Span 2	**10 days**	**1/23/20**	**2/5/20**
Barge Moorings (~56 s.f.)	10 days	1/23/20	2/5/20
Span 3	**10 days**	**2/6/20**	**2/19/20**
Barge Moorings (~56 s.f.)	10 days	2/6/20	2/19/20
Span 4	**10 days**	**2/20/20**	**3/4/20**
Barge Moorings (~56 s.f.)	10 days	2/20/20	3/4/20
Span 5	**10 days**	**3/5/20**	**3/18/20**
Barge Moorings (~56 s.f.)	10 days	3/5/20	3/18/20
Span 6	**10 days**	**3/19/20**	**4/1/20**
Barge Moorings (~56 s.f.)	10 days	3/19/20	4/1/20
Span 7	**10 days**	**4/2/20**	**4/15/20**
Barge Moorings (~56 s.f.)	10 days	4/2/20	4/15/20
Span 8	**10 days**	**4/16/20**	**4/29/20**
Barge Moorings (~56 s.f.)	10 days	4/16/20	4/29/20
Substructure Demolition	**226 days**	**3/5/20**	**1/14/21**
Pier 2	**40 days**	**3/5/20**	**4/29/20**
Cofferdam (7,500 s.f.)	40 days	3/5/20	4/29/20
Barge Moorings (50 s.f.)	40 days	3/5/20	4/29/20
Pier 3	**51 days**	**3/19/20**	**5/28/20**
Cofferdam (7,500 s.f.)	51 days	3/19/20	5/28/20
Barge Moorings (50 s.f.)	51 days	3/19/20	5/28/20
Pier 4	**41 days**	**5/29/20**	**7/24/20**
Cofferdam (7,500 s.f.)	41 days	5/29/20	7/24/20
Barge Moorings (50 s.f.)	41 days	5/29/20	7/24/20
Pier 6	**31 days**	**6/12/20**	**7/24/20**
Cofferdam (7,500 s.f.)	31 days	6/12/20	7/24/20
Barge Moorings (50 s.f.)	31 days	6/12/20	7/24/20
Pier 7	**41 days**	**8/24/20**	**10/19/20**
Cofferdam (7,500 s.f.)	41 days	8/24/20	10/19/20
Barge Mooring (50 s.f.)	41 days	8/24/20	10/19/20
Pier 8	**30 days**	**9/8/20**	**10/19/20**
Cofferdam (7,500 s.f.)	30 days	9/8/20	10/19/20
Barge Moorings (50 s.f.)	30 days	9/8/20	10/19/20
Pier 9	**43 days**	**11/17/20**	**1/14/21**
Cofferdam (7,500 s.f.)	43 days	11/17/20	1/14/21
Barge Moorings (50 s.f.)	43 days	11/17/20	1/14/21



Conceptual Schedule Only, April 2010
Note: This is a proposed schedule, so activity dates are likely to change.

Figure 6-36. Sequencing of Temporary In-Water Structures for Demolition in Deep Water in the Columbia River

Columbia River CROSSING

Increase in Overwater Coverage

The project will place several overwater structures in deep-water portions of the Columbia River. Temporary overwater structures include work platforms, tower cranes, and stationary barges. Permanent new overwater structures likely to have effects on fish include only the shaft caps on the Columbia River bridges. Table 6-37 quantifies the area and duration of project-related overwater structures in deep-water portions of the action area.

Table 6-37. Overwater Coverage in Deep-water Habitat in the Columbia River

Type	Area	Duration in Water (days)
Temporary		
Work Platforms for Drilling Shafts (P 3 – 6) [a]	112,000 sq. ft.	260 – 315 / platform
Tower Cranes (P 2 – 7)	2,400 sq. ft.	150 – 200 /crane
Barges for Construction (P 3 – 6)	106,432 sq. ft.	300 – 480 / complex
Barges for Demolition (Existing Piers 2 – 9)	14,350 sq. ft.	~320
Total Temporary Impact	**235,182 sq. ft.**	
Permanent		
Shaft Caps (P3 – P6)	56,813 sq. ft.	Permanent
Total Permanent Impact	**56,813 sq. ft.**	

a P = Pier Complex

The structures shown in Table 6-37 will not all be in place at the same time. Figure 6-37 and Figure 6-38 provide the sequencing of overwater structures in deep-water habitat.

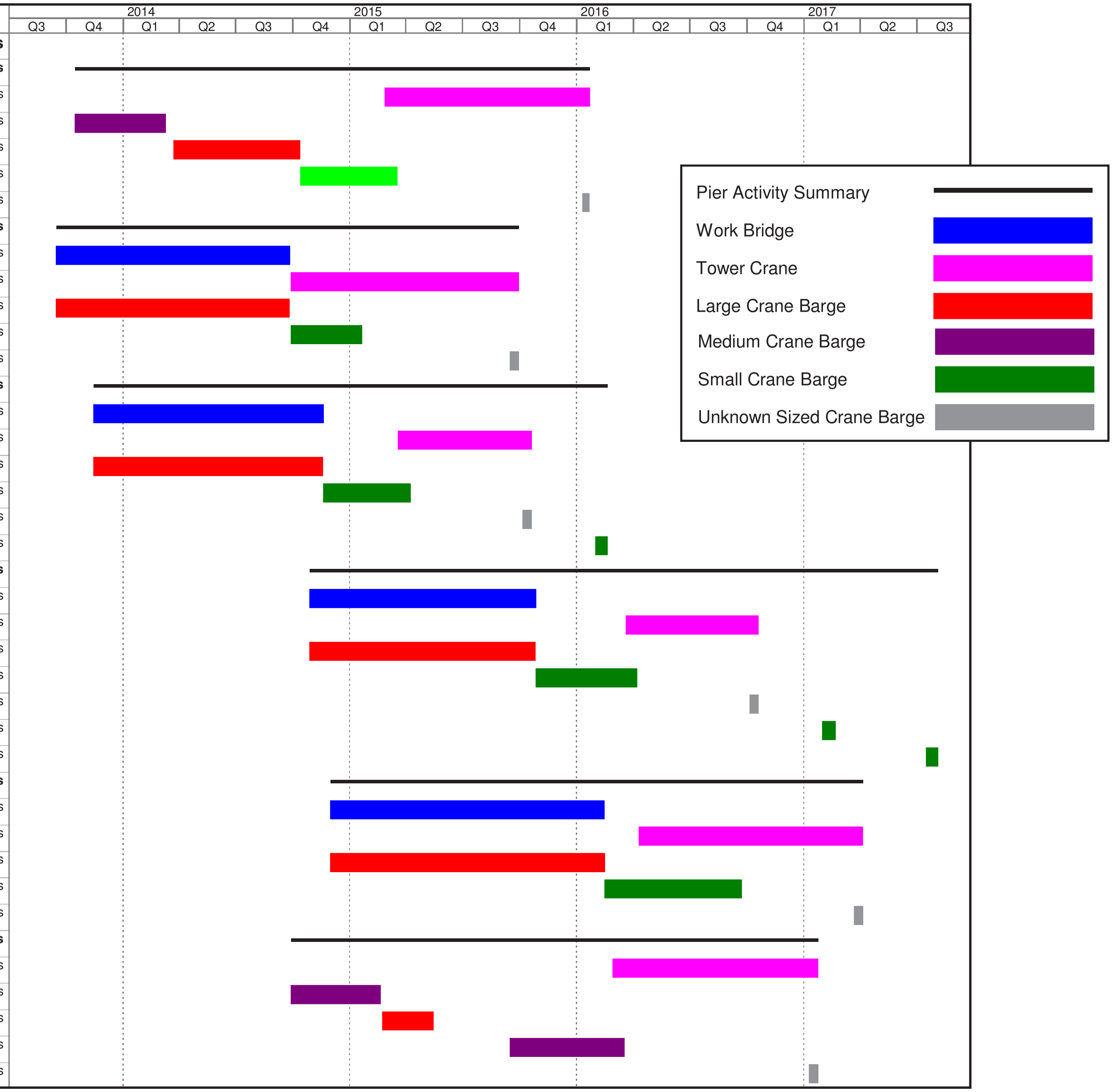
General effects of overwater coverage on fish are described in detail in Section 6.1.3. In summary, overwater coverage creates dense shade that may attract predators and may cause visual disorientation to juvenile fish, which may in turn result in delayed migration and increased vulnerability to predators. Of the juvenile fish that use the action area, rearing juveniles and subyearling-migrant salmonids are highly dependent on shallow-water habitat and therefore are less vulnerable to these effects in deep water. However, as these individuals are not restricted to the nearshore (Bottom et al. 2005), they may stray into deeper water, and there is a small chance of exposure to these effects. Larger juveniles of the yearling age class or older commonly use deep-water habitat during migration, and therefore are likely to be exposed to these effects.

Of the shade sources in the action area, the barges, work platforms, and tower cranes (Table 6-37) are temporary sources of shade that could create a sharp light-dark interface likely to prompt these effects.

The existing and proposed bridge spans in the Columbia River are more than 30 feet above the water surface and are therefore not likely to create dense shade on the water surface. For this reason, shade cast by these structures is unlikely to affect fish.

The shaft caps of the proposed Columbia River structures are at the water line and could create a net gain of permanent new dense shade (approximately 57,000 sq. ft.) in deep water.

Task Name	Start	Finish	Duration
Bridge Construction Scenario 2/5/13	**9/16/13**	**8/4/17**	**1015 days**
Pier 2	**10/16/13**	**1/22/16**	**593 days**
Tower Crane (400 s.f.)	2/27/15	1/22/16	236 days
Medium Crane Barge (10,500 s.f.)	10/16/13	3/11/14	104 days
Large Crane Barge (30,000 s.f.)	3/24/14	10/13/14	145 days
Medium and Small Crane Barges (16,500 s.f.)	10/14/14	3/19/15	112 days
Unknown Sized Crane Barge	1/11/16	1/22/16	9 days
Pier 3	**9/16/13**	**9/29/15**	**532 days**
Work Bridge (29,000 s.f.)	9/16/13	9/26/14	270 days
Tower Crane (400 s.f.)	9/29/14	9/29/15	262 days
Large Crane Barge (30,000 s.f.)	9/16/13	9/26/14	269 days
Small Crane Barge (6,000 s.f.)	9/29/14	1/21/15	82 days
Unknown Sized Crane Barge	9/16/15	9/29/15	10 days
Pier 4	**11/15/13**	**2/19/16**	**591 days**
Work Bridge (29,000 s.f.)	11/15/13	11/19/14	264 days
Tower Crane (400 s.f.)	3/20/15	10/20/15	153 days
Large Crane Barge (30,000 s.f.)	11/15/13	11/19/14	263 days
Small Crane Barge (6,000 s.f.)	11/20/14	4/9/15	100 days
Unknown Sized Crane Barge	10/7/15	10/20/15	10 days
Small Crane Barge (6,000 s.f.)	2/1/16	2/19/16	15 days
Pier 5	**10/29/14**	**8/4/17**	**723 days**
Work Bridge (29,000 s.f.)	10/29/14	10/27/15	260 days
Tower Crane (400 s.f.)	3/21/16	10/19/16	153 days
Large Crane Barge (30,000 s.f.)	10/29/14	10/27/15	259 days
Small Crane Barge (6,000 s.f.)	10/28/15	4/8/16	117 days
Unknown Sized Crane Barge	10/6/16	10/19/16	10 days
Small Crane Barge (6,000 s.f.)	1/31/17	2/20/17	15 days
Small Crane Barge (6,000 s.f.)	7/17/17	8/4/17	15 days
Pier 6	**12/1/14**	**4/5/17**	**613 days**
Work Bridge (29,000 s.f.)	12/1/14	2/15/16	315 days
Tower Crane (400 s.f.)	4/11/16	4/5/17	258 days
Large Crane Barge (30,000 s.f.)	12/1/14	2/15/16	316 days
Small Crane Barge (6,000 s.f.)	2/16/16	9/23/16	158 days
Unknown Sized Crane Barge	3/23/17	4/5/17	10 days
Pier 7	**9/29/14**	**1/23/17**	**606 days**
Tower Crane (400 s.f.)	2/29/16	1/23/17	236 days
Medium Crane Barge (10,500 s.f.)	9/29/14	2/20/15	104 days
Large Crane Barge (30,000 s.f.)	2/23/15	5/15/15	60 days
Medium Crane Barge (10,500 s.f.)	9/16/15	3/18/16	132 days
Unknown Sized Crane Barge	1/10/17	1/23/17	10 days



Conceptual Schedule Only, March 2010
Note: This is a proposed schedule, so activity start and finish dates are likely to change.

Figure 6-37. Sequencing of Temporary Over-Water Structures for Construction in Deep Water in the Columbia River

Task Name	Duration	Start	Finish
Superstructure Demolition	**100 days**	**12/12/19**	**4/29/20**
Demolish Lift Span Towers	**20 days**	**12/12/19**	**1/8/20**
Two Medium Crane Barges (21,000 s.f.)	20 days	12/12/19	1/8/20
Remove Spans	**62 days**	**2/4/20**	**4/29/20**
Span 2	**2 days**	**2/4/20**	**2/5/20**
Medium Crane Barge (10,500 s.f.)	2 days	2/4/20	2/5/20
Span 3	**2 days**	**2/18/20**	**2/19/20**
Medium Crane Barge (10,500 s.f.)	2 days	2/18/20	2/19/20
Span 4	**2 days**	**3/3/20**	**3/4/20**
Medium Crane Barge (10,500 s.f.)	2 days	3/3/20	3/4/20
Span 5	**2 days**	**3/17/20**	**3/18/20**
Medium Crane Barge (10,500 s.f.)	2 days	3/17/20	3/18/20
Span 6	**2 days**	**3/31/20**	**4/1/20**
Medium Crane Barge (10,500 s.f.)	2 days	3/31/20	4/1/20
Span 7	**2 days**	**4/14/20**	**4/15/20**
Medium Crane Barge (10,500 s.f.)	2 days	4/14/20	4/15/20
Span 8	**2 days**	**4/28/20**	**4/29/20**
Medium Crane Barge (10,500 s.f.)	2 days	4/28/20	4/29/20
Substructure Demolition	**226 days**	**3/5/20**	**1/14/21**
Pier 2	**40 days**	**3/5/20**	**4/29/20**
Small Crane Barge (6,000 s.f.)	40 days	3/5/20	4/29/20
Pier 3	**51 days**	**3/19/20**	**5/28/20**
Small Crane Barge (6,000 s.f.)	51 days	3/19/20	5/28/20
Pier 4	**41 days**	**5/29/20**	**7/24/20**
Small Crane Barge (6,000 s.f.)	41 days	5/29/20	7/24/20
Pier 6	**51 days**	**6/12/20**	**8/21/20**
Small Crane Barge (6,000 s.f.)	51 days	6/12/20	8/21/20
Pier 7	**41 days**	**8/24/20**	**10/19/20**
Small Crane Barge (6,000 s.f.)	41 days	8/24/20	10/19/20
Pier 8	**50 days**	**9/8/20**	**11/16/20**
Small Crane Barge (6,000 s.f.)	50 days	9/8/20	11/16/20
Pier 9	**43 days**	**11/17/20**	**1/14/21**
Small Crane Barge (6,000 s.f.)	43 days	11/17/20	1/14/21

Conceptual Schedule Only, April 2010
Note: This is a proposed schedule, so activity dates are likely to change.

Figure 6-38. Sequencing of Temporary Barges Used for Demolition in Deep Water in the Columbia River

Columbia River CROSSING

Neither the temporary nor the permanent structures will create a swath of dense shade completely spanning deep-water habitat. Therefore, even if these structures were to create a shadow line that juvenile salmonids avoid crossing during daylight hours, juveniles could simply circumvent the shadow, resulting in no measurable delay to migration. Nighttime migration would be unaffected. Larval eulachon do not have volitional movement and are therefore not subject to visual disorientation or migration delays.

The increase in the shade footprint increases the amount of suitable habitat for predators and therefore could presumably increase the number of predators in this portion of the action area. This could potentially cause a temporary and/or permanent increase in predation rates on juveniles, although it is not possible to quantify the extent of this effect. All of the juveniles (see Figure 4-2) that use this portion of the action area could potentially be exposed to this effect.

Although it is impossible to quantify the extent to which increased shade may affect predation rates or cause visual disorientation in juveniles, it is possible to estimate the physical extent and duration of the effect. This effect will occur both when the structures are present in the water (Figure 6-37 and Figure 6-38) and during the timing of juvenile fish presence in this portion of the action area (see Figure 4-2).

Turbidity

The project will temporarily degrade deep-water habitat by creating turbidity. Table 6-38 summarizes the activities likely to generate turbidity in deep water.

Table 6-38. Activities Likely to Generate Turbidity in Deep Water in the Columbia River

Activity	Timing[a]	Location[b]	Likely Extent of Turbidity	Duration of Effect (hr/day)	Number of Work Days
Install temporary piles, impact methods	9/15 – 4/15	Adjacent to P 2 – 7	~25 feet	0.66	~138
Install temporary piles, vibratory methods	Year-round	Adjacent to P 2 – 7	~25 feet	up to 24	continually over ~928
Remove temporary piles, direct pull or vibratory	Year-round	Adjacent to P 2 – 7	Minimal	up to 24	continually over ~928
Install steel casings to drill permanent shafts – vibratory hammer, oscillator, or rotator	Year-round	Adjacent to P 2 – 7	~25 feet	8 – 10	60 – 80 days / pier complex
Drill and excavate permanent shafts	Year-round	Adjacent to P 2 – 7	None (contained)	N/A	60 – 80 days / pier complex
Demolish existing Columbia River bridge piers (includes installation and demolition of cofferdams)	Year-round	Existing Piers 2 – 9	Minimal	8 – 10	~320

a All activities likely to take place throughout the 4-year in-water construction period.

b CR = Columbia River; P = Pier Complex

General effects of turbidity are described in detail in Section 6.1.5.2. In summary, turbidity will pose fairly limited impacts to deep-water habitat, as the project will restrict the extent of turbidity to distances specified by regulatory permits. It is anticipated that the regulatory permits will specify a mixing zone of no more than 300 feet. In actuality, many of the activities will restrict the turbidity plume to far shorter distances (Table 6-38). Permits will also restrict the duration of each turbidity plume to approximately 4 to 6 hours at a time.

The turbidity plumes may make discrete areas temporarily unavailable for foraging, holding and migration, but only for short periods of time (as specified by the regulatory permits). Due to the high dilution capacity of the Columbia River, turbidity plumes are expected to disperse relatively quickly and within a short distance of the source. Due to the large size of the water body relative to the small size of the turbidity plume, fish are not likely to become trapped in turbid water. Fish will be able to use the abundant turbidity refugia in deep-water habitat outside of the areas subjected to high turbidity.

Both adult and juvenile fish could be exposed to this effect. Exposure could occur during the overlap of turbidity-generating activities (Table 6-38, Figure 6-35, and Figure 6-36) with the timing of fish presence in this portion of the action area (see Figure 4-1 and 4-2).

Underwater Noise

Both vibratory and impact pile driving will create elevated noise levels in deep-water habitats in the Columbia River. The effect of high underwater noise levels is outlined in greater detail in Section 6.1.1.1 and Appendix K.

Impact pile driving will occur in deep-water portions of the Columbia River at Piers 2 through 7. (Note that pier complexes 2 and 7 occur partially in shallow water and partially in deep water.) Essentially all of the deep-water habitat in the project area will be exposed to elevated noise levels due to impact pile driving at various times, depending on the size and type of pile used and whether or not a noise attenuation device is in place.

In summary, underwater noise from impact pile driving will temporarily degrade deep-water habitat, creating noise above the disturbance threshold in deep-water areas of the Columbia River for a minimum of 858 m from the pile and extending from RM 101 to 118 (RKm 163 to 190). Figure 6-12 and Figure 6-13 show the extent of noise that exceeds the disturbance threshold. Figure 6-14, Table 6-9, and Table 6-10 show the timing and duration of this effect.

Additionally, in areas located within 5 to 446 m of pile driving at various piers in the Columbia River, underwater noise is expected to exceed the injury threshold for fish. Figure 6-1 through Figure 6-11 show the extent of noise that exceeds the injury threshold. Figure 6-14, Table 6-9, and Table 6-10 show the timing and duration of this effect. These areas will be unsuitable for foraging, migrating, and holding because fish entering this area may potentially be killed or injured. Underwater noise may also create a temporary barrier to migration for both adults and juveniles in these areas during this time period.

Vibratory pile driving is expected to create noise above ambient levels in deep-water habitat at pier complex 2 through 7 in the Columbia River and at existing Piers 2 through 9 in the Columbia River. Elevated noise levels are not expected to cause injury to fish in these areas; however, they could prompt avoidance of the areas.

6.3.3 Riparian Habitat

In North Portland Harbor and the Columbia River, effects to riparian habitat will be negligible, as there is very little functioning riparian vegetation in the action area. The project will revegetate disturbed shoreline areas, resulting in a net benefit to riparian habitat in the long term. It has not yet been determined exactly where replanting will take place. However, it is anticipated that replanting will occur on or adjacent to the current sites of the trees where practicable. In any case, the number, type, and size of the replanted trees will be selected to comply with standards outlined in the City of Portland and City of Vancouver tree ordinances.

In Oregon, the project will remove three deciduous trees, all with trunks less than 1 foot in diameter, from the riparian zone on the south bank of the Columbia River. The project will also remove two deciduous ornamental trees from the riparian zone adjacent to North Portland Harbor. These trees are located in a landscaped setting and have trunks of approximately 1 foot in diameter. In Washington, 10 trees with trunks less than 1 foot in diameter will be removed from the riparian zone on the north shore of the Columbia River.

In general, removal of trees from riparian areas results in a reduction of shade in the water column and a concurrent increase in water temperature. However, in the case of the CRC project, only approximately 15 trees will be removed from the Columbia River/North Portland Harbor riparian area. This represents an extremely small amount of shaded water (less than 10,000 sq. ft., patchily distributed among at least three locations) relative to the thousands of acres of unshaded water located immediately adjacent to the area from which trees will be removed. Because of the small size of the shaded area relative to the large volume of water and because of the high current velocity in these water bodies, it is unlikely that these fifteen riparian trees create enough shade to measurably decrease water temperatures in the water column. Thus, the loss of these trees is expected to cause only negligible effects to water temperature, if any.

Additionally, removal of trees from riparian areas may reduce the potential for large woody debris recruitment in a watershed over the long term. However, given the large size of the lower Columbia system and the thousands of remaining riparian trees in this area, removal of 15 trees will not measurably decrease the potential for long-term large woody debris recruitment in the action area or in the lower Columbia system overall.

There will be no excavation, vegetation clearing, or removal of trees from the Columbia Slough riparian area. Therefore, the project will have no effect on Columbia Slough riparian habitat.

The project will not remove any trees from the Burnt Bridge Creek riparian area.

6.3.4 Hydraulic Shadowing

The project will cause both permanent and temporary increases in hydraulic shadowing in the Columbia River and North Portland Harbor. In-water work structures (work platforms, work platforms, tower cranes, oscillator support platforms, and cofferdams) are project elements that will cause temporary increases in hydraulic shadowing. The in-water elements of the new structures (bridge piers and shafts) will permanently increase hydraulic shadowing in North Portland Harbor and the Columbia River.

Figure 6-39 shows the current hydraulic footprint of the existing structures at Columbia River for the 100-year event. In the Columbia River, the hydraulic shadow extends 200 to 1,100 feet downstream of the piers, with velocities in the shadow ranging from 0 to 3 feet per second (fps). The hydraulic footprint was not modeled for the existing North Portland Harbor structures.

Figure 6-40 and Figure 6-41 show the predicted post-project hydraulic footprint for the 100-year event in the Columbia River and North Portland Harbor. In the Columbia River, the hydraulic shadow of the completed structures is expected to increase significantly compared to that of the existing structures, extending up to 1,600 feet downstream of each pier, with velocities in the shadow ranging from 0 to 3 fps. Although the hydraulic shadow was not modeled at the existing North Portland Harbor structures, it is expected to increase in length because of the increase in the number of shafts and the width of the structures. The hydraulic shadow of the completed North Portland Harbor structures is also expected to extend up to approximately 400 feet downstream of each pier, with velocities in the shadow ranging from 0 to 2 fps.

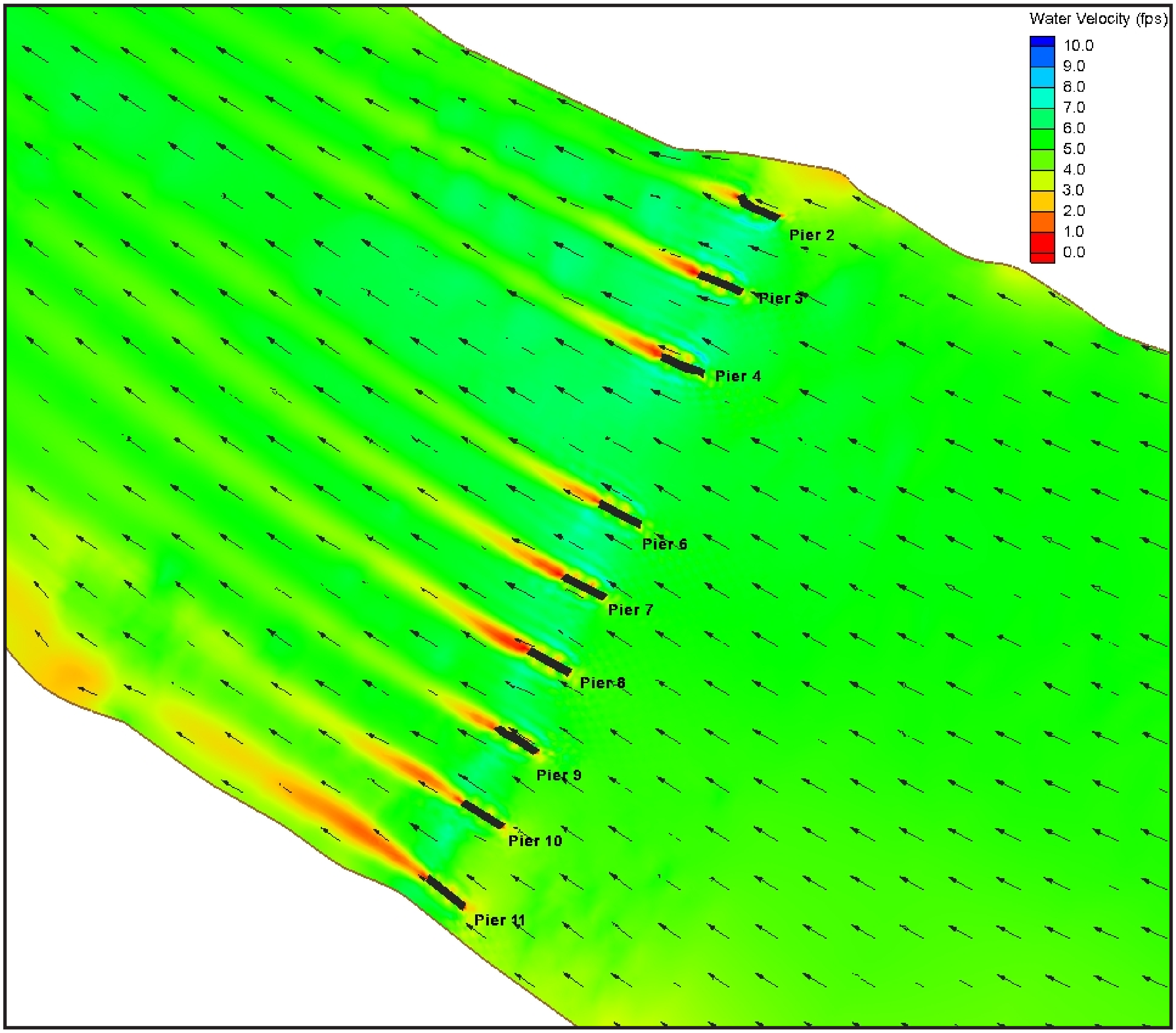
The modeling for the Columbia River bridges in Figure 6-40 uses an earlier design with three sets of bridge piers with up to twelve drilled shafts each. The proposed design now consists of only two sets of piers, with only nine drilled shafts per pier. At present, the design team has not yet revised the hydraulics analysis for the two-pier structure. In lieu of this information, we will continue to use data from the three-pier hydraulics analysis. Because the three-pier scenario will result in a larger hydraulic shadow, it is assumed that this is an overestimate of the effect of hydraulic shadowing.

In-water work structures will also temporarily increase hydraulic shadowing in the project area. No hydraulic analysis of temporary in-water work structures (cofferdams, work platforms, work bridges, tower cranes, and oscillator support platforms) was performed, but it will be completed prior to construction. At this time, it is assumed only that these structures will cause a temporary increase in hydraulic shadowing in the Columbia River and North Portland Harbor during the time they are present in the water (Figure 6-42 and Figure 6-31).

Hydraulic shadowing may affect listed fish by creating low velocity eddies that have the potential to increase predation and interfere with movement patterns.

6.3.4.1 Predation

In general, hydraulic shadowing has the potential to harm fish by creating low-velocity areas or eddies that enhance the foraging success of predaceous fish and birds. While all age classes of juvenile salmonids are vulnerable to predation, the greatest risk may be for subyearling salmonids (Pribyl et al. 2004). Yearling salmon move quickly and migrate when they are of a size that reduces vulnerability to predators. In contrast, subyearling salmon are slower and are of a size that increases their vulnerability to predation (Gray and Rondorf 1986). Additionally subyearling salmonids are highly dependent on low-velocity areas for rearing and resting. This overlaps with the preferred habitat type of northern pikeminnow, smallmouth bass, largemouth bass, and walleye (Pribyl et al. 2004), which are chief predators of juvenile salmon in the lower Columbia River (Gray and Rondorf 1986). Predation on juvenile salmonids by fish generally occurs at velocities of 4 fps or less (NMFS 2008g).



Source: CRC Hydraulic and Scour Parameters Report 2008

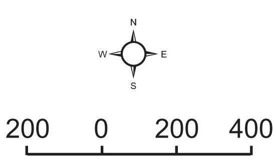
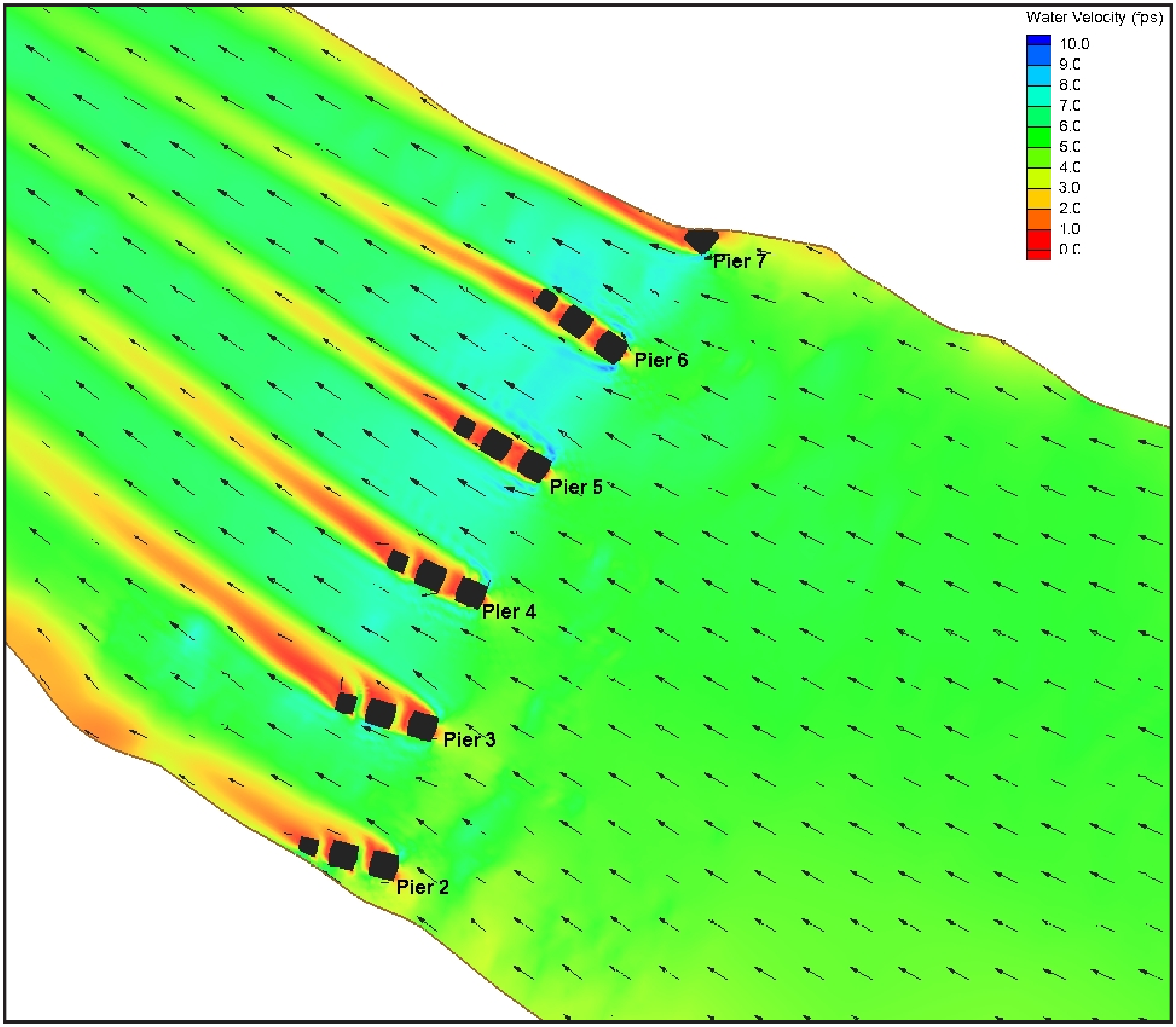
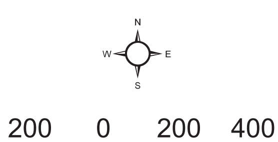


Figure 6-39. Velocity Vector Plot of Existing Structures in the Columbia River for 100-Year Flood

Columbia River CROSSING



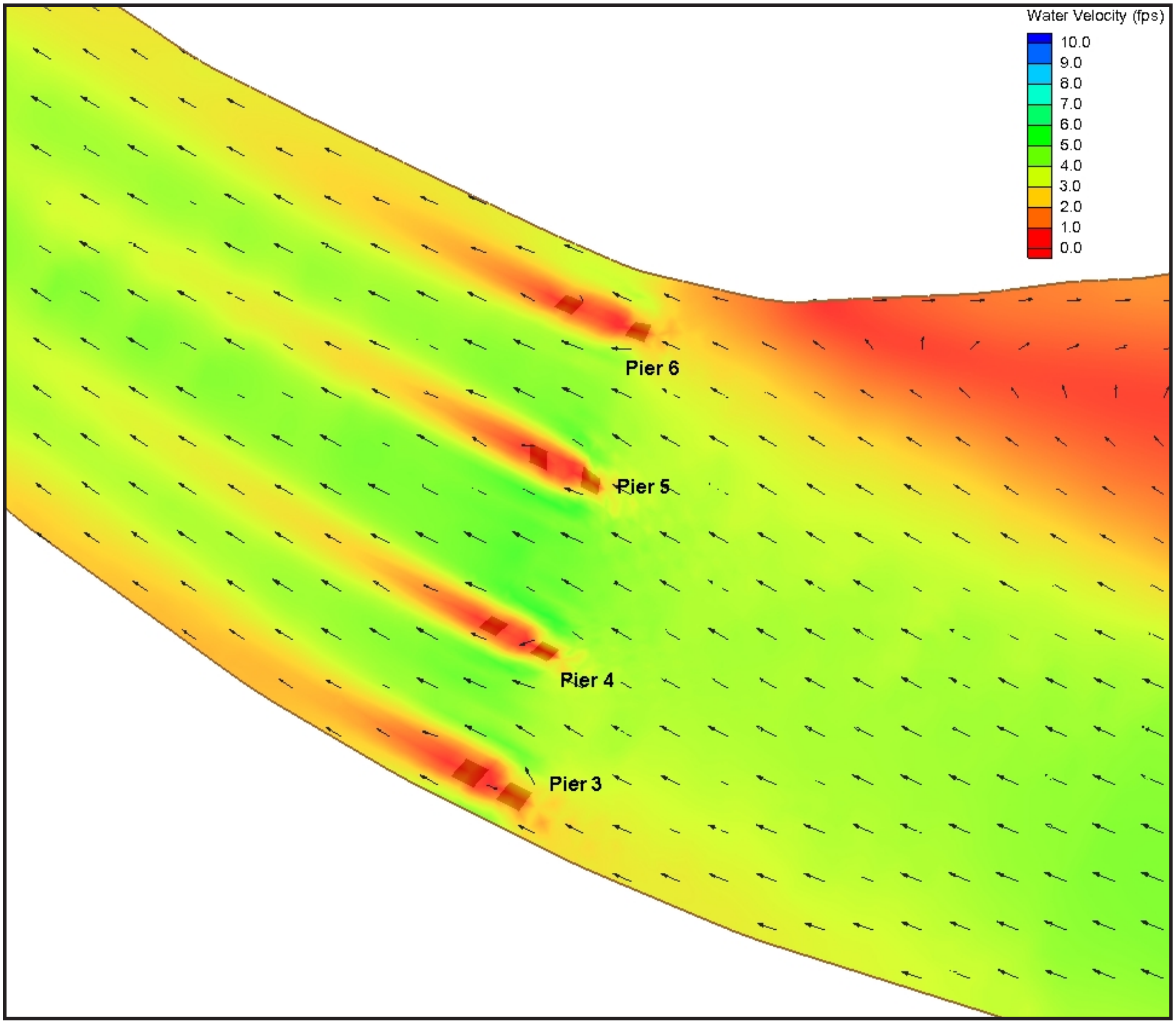
Source: CRC Hydraulic and Scour Parameters Report 2008



Scale is approximate.

Figure 6-40. Velocity Vector Plot of Proposed Structures in the Columbia River for 100-Year Flood

Columbia River CROSSING



Source: CRC Hydraulic and Scour Parameters Report 2008

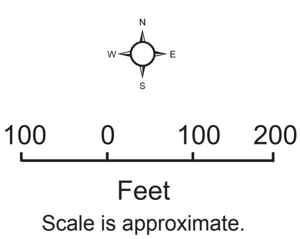


Figure 6-41. Velocity Vector Plot of Proposed Structures in the North Portland Harbor for 100-Year Flood

Columbia River CROSSING

Task Name	Start	Finish	Duration
Bridge Construction Scenario 2/5/13	**9/16/13**	**4/5/17**	**928 days**
Pier 2	**10/16/13**	**1/22/16**	**593 days**
Work Bridge (Approx. 350 s.f.)	10/16/13	10/13/14	259 days
Tower Crane (Aprox. 100 s.f.)	2/27/15	1/22/16	236 days
Barge Moorings (Approx. 45 s.f.)	10/16/13	1/22/16	593 days
Pier 3	**9/16/13**	**9/29/15**	**532 days**
Work Bridge (Approx. 600 s.f.)	9/16/13	9/26/14	270 days
Tower Crane (Approx. 100 s.f.)	9/29/14	9/29/15	262 days
Barge Moorings (Approx. 45 s.f.)	9/16/13	9/29/15	532 days
Pier 4	**11/15/13**	**10/20/15**	**503 days**
Work Bridge (Approx. 600 s.f.)	11/15/13	11/19/14	264 days
Tower Crane (Approx. 100 s.f.)	3/20/15	10/20/15	153 days
Barge Moorings (Approx. 45 s.f.)	11/15/13	10/20/15	503 days
Pier 5	**10/29/14**	**10/19/16**	**516 days**
Work Bridge (Approx. 600 s.f.)	10/29/14	10/27/15	260 days
Tower Crane (Approx. 100 s.f.)	3/21/16	10/19/16	153 days
Barge Moorings (Approx. 45 s.f.)	10/29/14	10/19/16	516 days
Pier 6	**12/1/14**	**4/5/17**	**613 days**
Work Bridge (Approx. 600 s.f.)	12/1/14	2/15/16	315 days
Tower Crane (Approx. 100 s.f.)	4/11/16	4/5/17	258 days
Barge Moorings (Approx. 45 s.f.)	12/1/14	4/5/17	613 days
Pier 7	**9/29/14**	**1/23/17**	**606 days**
Work Bridge (Approx. 350 s.f.)	9/29/14	10/13/15	272 days
Tower Crane (Aprox. 100 s.f.)	2/29/16	1/23/17	236 days
Barge Moorings (Approx. 200 s.f.)	9/29/14	1/23/17	606 days

Conceptual Schedule Only, March 2010
Note: This is a proposed schedule, so activity start and finish dates are likely to change.

Figure 6-42. Sequencing of In-Water Structures for Construction in the Columbia River

Columbia River CROSSING

Northern pikeminnow is the major predator of emigrating juvenile salmonids in the Lower Columbia (Poe et al. 1994; NMFS 2000b). Northern pikeminnow are associated with pilings and other in-water structures during most of the year (Pribyl et al. 2004; Petersen and Poe 1993). Northern pikeminnow select slower-velocity areas, generally avoiding velocities greater than 2.3 fps (NMFS 2000b). Petersen and Poe (1993) reported northern pikeminnow congregating at overwater structures, such as back eddies behind pilings. Consumption rates are especially high in areas where juvenile salmonids congregate.

The literature is not in complete agreement about northern pike minnow consumption rates of juvenile salmonids in the Lower Columbia basin. Buchanan et al. (1981, as cited in NMFS 2000b) reported that only 2 percent of northern pikeminnow found in free-flowing sections of the Willamette River contained salmonids in their diets. In a free-flowing reach of the lower Columbia River, Thompson (1959, as cited in NMFS 2000b) found that only 7.5 percent of northern pikeminnow contained salmonids in their diets. However, in a survey of the lower Columbia River from Bonneville Dam (RKm 235) to Jones Beach (RKm 71–77), Petersen and Poe (1993) found that catches of northern pikeminnow and the number of salmonid prey per pikeminnow were higher in free-flowing sections of the river than in impounded areas in John Day Reservoir. At a sampling site in Vancouver, the spring diet of northern pikeminnow was comprised of 70 percent fish, 92 percent of which were salmonid smolts. In summer, the diet was 25 percent fish, 84 percent of which were salmonid smolts (Petersen and Poe 1993). The study estimated that the average predation rate in spring at the Vancouver site was 1.3 smolts per pikeminnow. In summer, the predation rate in the same location was 1.7 smolts per pikeminnow. Zimmerman (1999) found that daily consumption of juvenile salmonids in unimpounded portions of the Columbia River were about 0.8 prey per northern pikeminnow in the spring and 1.6 in the summer.

Mean maximum length of salmon consumed was 167 mm, although northern pikeminnow consumed both steelhead and Chinook measuring more than 200 mm in length. Of the salmonid smolts consumed, the large majority were juvenile Chinook (64 percent of all fish consumed), but they also ate steelhead (2 percent of fish consumed), and “unidentified salmonids” (26 percent of fish consumed). In another study, NMFS (2000b) estimates that the ratio of northern pikeminnow to the number of salmon smolts consumed between Bonneville Dam to the mouth to the Columbia River is 0.09 smolts per day. Northern pikeminnow are especially abundant in free-flowing reaches of the lower Columbia River. In a 2-year predator sampling study of the Lower Columbia from Bonneville Dam to RKm 70, northern pikeminnow comprised over 90 percent of the predaceous fish species encountered (Poe et al. 1994). Other predators (smallmouth bass and largemouth bass) were few in the study area.

Smallmouth bass are known to exhibit strong cover-seeking behavior and typically seek out pools or deep areas behind rocks where the current is slack (Edwards et al. 1983; Pflug and Pauley 1984; Probst et al. 1984, as cited in Pribyl et al. 2004). They also associate with in-water structures such as pilings and riprap (Pribyl et al. 2004). In the Columbia River basin, smallmouth bass prey heavily on juvenile salmonids (Gray and Rondorf 1986). While Zimmerman (1999) found that the mean maximum length of smolts consumed was 119 mm, they may also ingest very large prey (up to 240 mm) (NMFS 2000b). Subyearling salmonids are at highest risk, not only because their shallow-water habitat overlaps with the preferred habitat of smallmouth bass in summer, but also because they are the ideal forage size for this species (Gray and Rondorf 1986). Rearing subyearling Chinook are particularly vulnerable (Poe at al. 1994;

NMFS 2000b). Zimmerman (1999) estimates that consumption rates exceeded 1.0 juvenile salmonids per smallmouth bass in both impounded and unimpounded reaches of the Columbia River. All of the prey items were either Chinook (12 percent of all fish consumed) or "unidentified salmonids" (3 percent of all fish consumed). No steelhead were detected.

Largemouth bass prefer low-velocity areas, such as backwaters, when in riverine environments (Wheeler and Allen 2003; Wydoski and Whitney 2003). Additionally, when located in high-velocity river channels they are associated with in-water structures (Pribyl et al. 2004). Largemouth bass are present in the Columbia system, but because their numbers are relatively low, they do not have the potential to significantly affect the abundance of juvenile salmonids (Gray and Rondorf 1986).

Walleye are present in the lower Columbia River, but there is disagreement about the impact of this species on the abundance of juvenile salmonids in this area (Gray and Rondorf 1986). Walleye are frequently associated with pilings, as they avoid strong current. During their spring spawning period, walleye may prey preferentially on smaller juvenile salmonids (less than 100 mm) where both overlap in shallow-water habitat (Gray and Rondorf 1986). At other times of the year, walleye may be spatially segregated from juvenile salmonids, occurring more frequently offshore in deep water (Pribyl et al. 2004). In a sampling study, Poe et al. (1994) found that walleye abundance was low in the Columbia River from Bonneville Dam to RKm 70, comprising only 2 percent of all piscivorous fish captured. Zimmerman (1999) also detected very few walleye in the same area and found that 12.5 percent of the walleye diet was Chinook, with no other salmonids species detected. In the lower Columbia River, NMFS (2002) research underscores this point, noting that non-salmonid fish dominated the walleye diet.

While predation may occur on juvenile salmonids at all in-water bridge elements and temporary in-water structures, predation on salmonids is likely to be higher at shallow-water structures where smaller juveniles are expected to congregate in the Columbia River, at Pier Complex 2 and 7 and associated temporary in-water structures (Figure 6-29 and Figure 6-30); in North Portland Harbor, at all new bents and associated temporary structures (Figure 6-31). At deep-water structures, Columbia River pier complexes 3 though 6 and their associated temporary in-water work structures (Figure 6-35), where smaller juveniles are not as common, predation is expected to be less. This effect is discussed in further detail in Sections 6.3.1 and 6.3.2.

It is not possible to quantify the number of individuals potentially exposed to increased predation. However, given that there is a net increase in the extent of suitable predator habitat, it is probable that the project will result in some level of increased predation on juvenile salmonids in the Columbia River and North Portland Harbor.

There are no specific data regarding the impact of hydraulic shadowing on predation rates of eulachon (reports do not specify prey items at the species level); however, because both adult and larval eulachon well within the size range (less than roughly 150 mm) consumed by common predators in the Columbia River, it cannot be discounted that hydraulic shadowing could also increase predation on adult and larval eulachon in the same manner as for juvenile salmonids.

The change in hydraulic footprint is not expected to increase predation on adult salmon and steelhead, adult and subadult bull trout, or adult and subadult green sturgeon, as predation on fish of these size classes is rare (Zimmerman 1999). Additionally, because of the extremely low numbers of bull trout and green sturgeon in this portion of the action area, risk of exposure to this effect is discountable.

6.3.4.2 Outmigration of Juvenile Salmonids

In general, hydraulic shadowing and resulting low-velocity areas have the potential to delay outmigration for smolts. Increased travel time exposes smolts to a variety of mortality vectors, including predation, disease, poor water quality, and thermal stress. Migration delays may also deplete energy reserves and disrupt arrival times in the lower estuary. The latter may cause salmonids to arrive in the estuary when predation levels are high and/or prey species are limited (NMFS 2008e). In the case of this project, effects to outmigration are expected to be slight. Although the size of the hydraulic shadow will increase, the range of velocities found in the hydraulic shadow is comparable to that which fish would encounter in the natural environment. Therefore, none of the juvenile fish addressed by this BA (see Figure 4-2) are likely to become trapped or significantly delayed by the hydraulic shadow. Additionally, none are likely to be directed towards or away from shallow-water habitat because the structures neither pose a complete physical blockage to the shallow-water habitat, produce water velocities low enough to trap fish, nor produce velocities high enough to direct fish into deeper water. The effects of hydraulic shadowing on juvenile migration will be insignificant.

6.3.4.3 Velocity Refugia

Increased hydraulic shadowing may also benefit salmonids by creating larger velocity refugia for both adults and juveniles during periods or in reaches of high flow. A Bonneville Power Administration study showed that upstream passage through reaches with long, relatively uninterrupted stretches of high-velocity flow requires high levels of bio-energetic expenditure, similar to that of ascending a waterfall. Without resting areas, migrating adults use larger amounts of energy, posing risks for spawning success (Brown and Geist 2002). Velocity refugia allow fish to rest and replenish energy reserves. The CRC project area and vicinity consist of long relatively uninterrupted stretches of high-velocity flow. Presumably, the increased size of the hydraulic shadows will increase the area of flow refugia over the preproject condition. The extent to which this increase may benefit listed fish is impossible to quantify, but given that the increase in flow refugia is small relative to the large size of the Columbia River and North Portland Harbor, the effect is probably slight and therefore insignificant.

6.3.4.4 Sediment Transport

The hydraulic effect of the new bridges may alter sediment transport in the Columbia River and North Portland Harbor. Between bridge piers, water velocities are likely to increase, resulting in increased sediment transport. In lower-velocity areas behind the piers, sediment is likely to accumulate. Several new piers are located immediately adjacent to the shoreline (in the Columbia River: pier complexes 2 and 7; in North Portland Harbor, the six new nearshore bridge bents). Low-velocity areas behind these piers will likely accumulate sediment; therefore, the new bridge piers are not anticipated to result in shoreline erosion.

6.3.5 Critical Habitat

Critical habitat in the action area includes the 2005 salmon and steelhead critical habitat designation, the 1993 SR Chinook and sockeye critical habitat designation, and the 2010 proposed critical habitat designation for bull trout.

6.3.5.1 2005 Salmon and Steelhead Critical Habitat Designation

The 2005 critical habitat designation includes:

- Chinook (LCR, UWR, and UCR)
- CR chum
- Steelhead (UCR, SR, MCR, LCR, and UWR)

These critical habitat designations overlap the action area only in North Portland Harbor, the Columbia River, and lower Columbia Slough. These water bodies provide three PCEs:

- Spawning habitat for CR chum only.
- Limited rearing habitat for Chinook (LCR, UCR spring-run, and UWR), LCR coho, CR chum, and LCR steelhead.
- Significant migration habitat for all runs included in the designation.

The project is likely to affect these PCEs through six major pathways: underwater noise; turbidity generated by in-water and overwater work; water quality impacts associated with stormwater runoff; in-water work structures causing temporary partial barriers to juvenile migration; increase of in-water shade, possibly resulting in effects on juveniles in the action area; and traffic and land-use changes. Table 6-39 summarizes effects to these PCEs.

Table 6-39. Summary of Effects to PCEs for 2005 Salmon and Steelhead Critical Habitat Designation

PCE	Effect
Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development.	Applies only to CR chum; potential temporary hydroacoustic effects on spawning habitat.
Freshwater rearing sites with: (i) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, (ii) water quality and forage supporting juvenile development; and (iii) natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.	Applies to Chinook (LCR, UCR spring-run, UWR), LCR coho, CR chum, and LCR steelhead: • Hydroacoustic impacts may temporarily degrade. • Stormwater treatment may improve water quality. • Applies to runs above, except UWR: • Temporary impacts to water quality from turbidity. • Traffic changes will decrease congestion and ADTs,[a] potentially resulting in net benefit water quality. • Land use changes may increase PGIS,[a] but high level of required runoff treatment will minimize impact to water quality.

PCE	Effect
Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.	Hydroacoustic impacts may function as a passage barrier for all runs. For all runs except UWR: • Cofferdams and work platforms may temporarily degrade this PCE by delaying migration for and increasing predation on juveniles • Turbidity may have temporary, limited impact to water quality. • Permanent impact to water quality due to high level of stormwater treatment. • Traffic changes may cause reduction of congestion and ADTs, potentially resulting in net benefit water quality. • Future land use changes may increase PGIS, but high level of required runoff treatment will minimize impact to water quality.

a ADT = average daily traffic; PGIS = pollutant-generating impervious surface.

Underwater Noise

Underwater noise is certain to temporarily degrade all three PCEs during impact pile driving and vibratory pile driving. Section 6.1.1 and Appendix K quantify the areas that are likely to be subjected to elevated noise levels. The text below summarizes the extent, timing, and duration of elevated noise due to pile driving.

Figure 6-1 through Figure 6-13 depict the areas subjected to elevated noise due to impact pile driving. Impact pile driving is expected to occur within a 31–week period of each of the four in-water construction years. Each 31-week period will begin September 15 one year and extend to April 15 of the next (approximately week 38 of one year through week 16 of the following year). During this period, impact pile driving is expected to occur no more than 1 hour each day for 5 days a week. There will be a total of about 138 days of in-water impact pile driving in the Columbia River and 134 days in North Portland Harbor. For the large majority of this pile driving, a noise attenuation device will be use; however, unattenuated impact pile driving may occur for up to 7.5 minutes per week in the Columbia River and up to 5 minutes per week in North Portland Harbor to test the effectiveness of the noise attenuation device or in the case of unexpected equipment failure (Table 6-9 and Table 6-10).

Up to two impact pile drivers may operate at one time on the Columbia River, nearly always at the same pier complex. However, for up to 6 work days over the duration of the entire project, two pile drivers may operate at different pier complexes. No more than one impact pile driver will be used in North Portland Harbor.

The earliest anticipated start and stop dates for impact pile driving are September 2013 and October 2016. The latest anticipated start and stop dates are October 2014 and October 2017. Impact pile driving is expected to intersect up to four migrational/spawning cycles. Hydroacoustic modeling was conducted, as outlined in Section 6.1.1 and Appendix K. The modeling indicates that hydroacoustic impacts generated by impact pile driving may be divided into two geographic zones, based on the distance from the disturbance: the injury zone and the disturbance zone.

The *injury zone* is modeled as all areas within 5 to 446 m of active impact pile driving in the Columbia River and North Portland Harbor. The zone radius depends on the size and number of piles and whether or not a noise attenuation device is in use (Figure 6-1 through Figure 6-11, Table 6-5 through Table 6-6). Underwater noise will degrade the rearing and migration PCEs in this zone to the point where the PCEs may be non-functional during the time that impact pile driving is occurring.

The *disturbance zone* in the Columbia River is at least 858 m, extending up to approximately 8,851 m downstream and up to 20,166 m upstream from the proposed bridge (from approximately RM 101 to 118) (Figure 6-12, Figure 6-13, and Table 6-9). In North Portland Harbor, the disturbance zone is at least 858 m, extending up to approximately 3,058 m upstream and up to 5,632 m downstream from the existing bridge (Figure 6-12, Figure 6-13, and Table 6-10). The disturbance zone spans the width of both channels and encompasses an area of approximately 5,020 acres.

- In the disturbance zone, during impact pile driving, the project will degrade the rearing and migration PCEs shown in Table 6-39 for approximately 40 minutes per day during pile driving periods.
- The chum spawning habitat is located approximately 7 miles from pile driving at RM 113 (RKm 182) and occurs within the disturbance zone. The model predicts that noise will be at levels likely to degrade the spawning PCE only during unattenuated impact pile driving, anticipated to occur less than 7.5 minutes per week on the schedule outlined above. In actuality, the spawning area occurs in shallow water that tends to dampen the effects of noise, meaning that noise levels may actually be less. Also, shadowing from Government Island and mainland landforms may further attenuate noise. While noise may be above ambient levels in this area, it is not likely to prevent spawning or harm eggs. Therefore, this PCE will be degraded but functional for the duration of unattenuated pile driving.

Elevated noise will also occur during vibratory pile driving as described in Section 6.1.1 and Appendix K (Carlson 1996). This effect is likely to occur at any time of day up to 5 hours per day, 7 days per week, and year-round during the in-water construction period (about 40 to 50 months). In areas subjected to elevated noise due to vibratory pile driving, the rearing and migration PCEs will be temporary degraded for the duration of vibratory pile driving, but will likely still be functional.

Temporary Turbidity

In-water and overwater work may temporarily introduce sediments or contaminants to critical habitat in the Columbia River and North Portland Harbor. The pathways, magnitude, timing, and duration of these effects are discussed in detail in Section 6.1.5.2. In summary, turbidity will cause only slight, temporary degradation of small discrete portions of the rearing and migration PCEs. Due to the high dilution capacity of the Columbia River and North Portland Harbor and the limited extent of the turbidity, the PCEs will remain functional for the duration of the project. The spawning area is upstream of the project area; therefore, turbidity will not affect this PCE.

Stormwater Runoff Treatment

Stormwater runoff will permanently affect the rearing and migration PCEs. Stormwater effects are discussed in greater detail in Section 6.2.1. In summary, the project provides a high level of stormwater treatment and could potentially improve water quality in the Columbia River, North Portland Harbor, and Columbia Slough. Therefore, there may be a beneficial effect on these PCEs in perpetuity. Stormwater runoff will have no effect on the spawning PCE, as spawning occurs many miles upstream of all stormwater outfalls associated with the project.

Overwater Structures

Temporary work platforms and cofferdams in shallow water (at P2 and P7 in the Columbia River and at all new North Portland Harbor bents) may temporarily degrade the migration PCE. The pathways, magnitude, timing, and duration of these effects are discussed in detail in Sections 6.1.3 and 6.3.1. In summary, these structures may delay migration by causing a partial barrier for juvenile fish, which may potentially avoid passing under overwater structures. These structures will also increase shade, which may degrade the quality of rearing and migration PCE by increasing predation pressure. Overall, this aspect of the project is likely to degrade migration and rearing PCEs for all ESUs/DPSs except UWR Chinook and steelhead. (Work platforms and cofferdams do not occur in designated critical habitat for Upper Willamette runs.)

Land Use and Traffic Changes

The CRC project is likely to prompt land use changes in the future, including an increase in development in urban areas and a reduction in congestion and ADTs along the I-5 corridor. These elements could cause alteration of adjacent water bodies, including the Columbia River, North Portland Harbor, and Columbia Slough. However, numerous regulations protect these aquatic areas, and changes to the aquatic baseline are expected to be minimal. Section 6.2.2.4 outlines in greater detail the effects to habitat and the laws that will minimize harm to the environmental baseline in these water bodies. Overall, land use changes may affect but are not likely to adversely affect the rearing and migration PCEs for all of the ESUs/DPSs occurring in the action area except for the UWR ESUs/DPSs of Chinook and steelhead.

Land use changes will not cause any in-water work in, adjacent to, or within many miles of the UWR ESUs. Due to the high level of stormwater treatment, any effects due to stormwater runoff will likely be diluted to background levels before entering Upper Willamette ESUs, located approximately 5 miles from the nearest outfall associated with this element of the project. Therefore, land use changes will have no effect on designated critical habitat for UWR Chinook and steelhead.

Land use changes will also have no effect on the spawning PCE of chum, because chum spawn well upstream of the range of all potential effects.

6.3.5.2 1993 Snake River Sockeye and Chinook Critical Habitat Designation

This designation addresses critical habitat for SR spring/summer-run Chinook, SR fall-run Chinook, and SR sockeye. Critical habitat for these ESUs overlaps the action area only in the Columbia River and North Portland Harbor.

Two habitat components occur in the action area: juvenile migration corridors and adult migration corridors. The project is likely to affect the habitat components through the same pathways as for the 2005 designation (Section 6.3.5.1): underwater noise; turbidity generated by in-water and overwater work; water quality impacts associated with stormwater runoff; in-water work structures causing temporary barriers to juvenile migration; increase of in-water shade, possibly resulting in greater predation of juveniles in the action area (and reduction of safe passage); and traffic and land-use changes. The magnitude, timing, and duration of these effects are discussed in greater detail in Section 6.3.5.1.

Table 6-40 summarizes project impacts on the habitat components.

Table 6-40. Summary of Effect to Habitat Components for 1993 Salmon and Steelhead Critical Habitat Designation

PCE	Effect
Juvenile Migration Corridors	Hydroacoustic impacts may temporarily function as a passage barrier, degrading the safe passage essential habitat feature for SR spring/summer-run Chinook and SR fall-run Chinook. (Impact pile driving is not expected to occur during migration of SR sockeye. Therefore, no effect to this habitat component for SR sockeye.) For all runs: • Cofferdams and work platforms may temporarily degrade by delaying migration. • Potential permanent and temporary impacts to safe passage conditions (shading, hydraulic shadow, and structures in shallow water) may increase predation. • Temporary impacts to water quality from turbidity. • Permanent improvement to water quality due to high level of stormwater treatment. • Traffic changes may cause reduction of congestion and ADTs, with a benefit to water quality. • Future land use changes may increase PGIS, but high level of required runoff treatment will minimize impact to water quality. • Increase in hydraulic shadowing will result in temporary and permanent impacts to water velocity. • No effect on other habitat features (substrate, water quantity, water temperature, cover/shelter, food, riparian vegetation, and space).
Adult Migration Corridors	Hydroacoustic impacts may temporarily function as a passage barrier for SR spring/summer-run Chinook and SR fall-run Chinook. (Impact pile driving is not expected to occur during migration of SR sockeye. Therefore, no effect to this habitat component for SR sockeye.) For all runs: • Temporary impacts to water quality from turbidity. • Permanent improvement to water quality due to high level of stormwater treatment. • Traffic changes may cause reduction of congestion and ADTs, with a benefit to water quality. • Future land use changes may increase PGIS, but high level of required runoff treatment will minimize impact to water quality. • Increase in hydraulic shadowing will result in temporary and permanent impacts to water velocity. • No effect on other habitat features (substrate, water quantity, water temperature, cover/shelter, riparian vegetation, space, and safe passage).

6.3.5.3 Proposed Critical Habitat for Bull Trout

Proposed critical habitat for bull trout occurs within the action area in the Columbia River and North Portland Harbor. Six PCEs occur in the action area (Table 6-41). Only adult and subadult bull trout occur in the Columbia River and North Portland Harbor. Therefore, only PCEs related to adult and subadult bull trout apply to the CRC project.

Table 6-41. Summary of Effect to PCEs for Bull Trout Proposed Critical Habitat

PCE	Effect
Migratory habitat	Applies to adult migratory habitat only, as juveniles are not present in the action area. Hydroacoustic impacts may temporarily function as a passage barrier for adult and subadult bull trout. Temporary impacts to water quality from turbidity. Permanent improvement to water quality due to high level of stormwater treatment. Traffic changes may cause reduction of congestion and ADTs, with a benefit to water quality. Land use changes may increase PGIS, but high level of required runoff treatment will minimize impact to water quality.
Food base	Hydroacoustic impacts may temporarily reduce the number of forage fish available. Alternatively, hydroacoustic impacts may enhance foraging opportunities. Increase in in-water shading may cause extremely localized effects to primary productivity and the food web.
Complex aquatic environments	Temporary overwater structures will result in limited, temporary impacts to substrate, shallow-water habitat, and deep-water habitat. Net permanent increase in substrate may slightly enhance.
Water temperature	The project will have no effect on water temperature.
Hydrograph	The project will have no effect on the stream hydrograph.
Water quality and quantity	Temporary impacts to water quality from turbidity. Permanent improvement to water quality due to high level of stormwater treatment. Traffic changes may cause reduction of congestion and ADTs, with a benefit to water quality. Land use changes may increase PGIS, but high level of required runoff treatment will minimize impact to water quality.

Bull trout use of the portions of the action area exposed to these effects is extremely limited. Fewer than 20 individuals have been detected in the area in 40 years. Therefore, even though project-related activities will temporarily degrade some of the PCEs, the risk that the activities will interfere with actual habitat function is highly unlikely and therefore discountable.

Six PCEs occur in the action area: migratory habitat, water quality and quantity, food base, complex aquatic environments, temperature, and hydrograph. The largest area of impact will be from elevated noise levels, which may affect the migration PCE. Elevated noise will be limited in duration to 40 minutes per in-water work day and is not likely to occur when bull trout are present due to low probability of presence in areas subjected to elevated noise. Therefore, elevated noise does not represent significant degradation to the migratory PCE. Other effects to the migratory PCE and to the other three PCEs that occur in the action area will be either extremely slight or beneficial. Thus, the project will not measurably degrade these PCEs. Effects to these PCEs are discussed below and are summarized in Table 6-41.

Migratory Habitat

The project is likely to affect the migratory habitat PCEs through the same pathways as for the 2005 salmon and steelhead critical habitat designation (Section 6.3.5.1): underwater noise, turbidity generated by in-water and overwater work, water quality impacts associated with stormwater runoff, overwater structures, and traffic and land-use changes. The magnitude, timing, and duration of these effects are outlined in greater detail in Section 6.3.5.1. Bull trout use of the portions of the action area exposed to these effects is extremely limited, restricted to less than 20 detections in 40 years. Therefore, even though project-related activities will degrade the migratory habitat PCE, the risk that the activities will interfere with actual migration is highly unlikely and therefore discountable. Thus, the project is not likely to adversely affect this PCE.

Water Quality and Quantity

The project is likely to affect the water quality and quantity PCE through three pathways: temporary turbidity during the course of in-water construction, stormwater runoff treatment, and future land-use and traffic changes, as described in Section 6.3.5.1.

The pathways, magnitude, timing, and duration of the turbidity are discussed in detail in Section 6.1.5.2. In summary, turbidity will cause only slight, brief degradation of small, discrete portions of critical habitat in the Columbia River and North Portland Harbor. Effects are expected to be insignificant. Due to the high level of stormwater treatment, the project could improve water quality in the Columbia River and North Portland Harbor. The project may cause future land-use changes, but numerous environmental regulations will limit these impacts as described in Section 6.2.2.5. Average daily traffic is expected to decrease in areas that drain directly to the Columbia River and North Portland Harbor, potentially resulting in a net benefit to this PCE, but certainly not further degrading it. Overall, the project is not likely to adversely affect this PCE.

Food Base

Elevated levels of underwater noise may cause juvenile salmonids and other forage fish to experience injury or mortality or to avoid the CRC action area. Section 6.1.1 outlines the extent, timing, and duration of this activity, and provides an estimate of the effects as the percent of the juvenile salmonid run that may be affected. Effect to the prey base may be divided into two geographic zones, based on the distance from the disturbance: the injury zone and the disturbance zone.

The injury zone is modeled as all areas within 5 to 446 m of impact pile driving in the Columbia River and North Portland Harbor.

Table 6-4, Table 6-5, and Figure 6-1 through Figure 6-5, all of which occur in proposed critical habitat for bull trout. Underwater noise may injure or kill forage fish in this area. On one hand, injury or mortality of prey fish is likely to temporarily degrade the food base PCE, to the extent that bull trout forage in this portion of the action area. On the other hand, injured prey fish are more easily captured and more readily available for forage, improving the PCE.

In the Columbia River, the disturbance zone is at least 858 m and extends approximately 20,166 m upstream and 8,851 m downstream from the proposed bridge (from approximately RM 101 to 118). In North Portland Harbor, it extends approximately 3,058 m upstream and 5,632 m downstream from the existing bridge (Table 6-8, Figure 6-12, and Figure 6-13). The disturbance zone spans the width of both channels and encompasses a maximum area of approximately 5,020 acres. Prey fish could potentially avoid the disturbance zone, resulting in reduced foraging opportunities and temporarily degrading the PCE. On the other hand, elevated noise levels in this zone could cause prey fish to become disoriented or stunned, resulting in enhanced foraging opportunities and an enhancement to the PCE.

Effects will be limited to the time period when impact pile driving is taking place (Figure 6-14 through Figure 6-16, Table 6-9 and Table 6-10). Because of the limited duration of impact pile driving (no more than 40 minutes per day over the in-water construction period), effects to prey species are expected to be minimal.

Temporary and permanent bridge elements will both cause in-water shading that could result in extremely small and limited effects to primarily productivity and the food web, as outlined in Section 6.1.3.

Overall, the project is not likely to adversely affect this PCE.

Complex Aquatic Environments

The project will place numerous temporary structures throughout the Columbia River and North Portland Harbor stream channels. This will result in a temporary loss of substrate in both shallow-water and deep-water habitats. Table 6-15 shows the areal extent of these structures, and Figure 6-17 shows the timing and duration that they will be present in the Columbia River and North Portland Harbor. This corresponds to the extent, timing, and duration of effects to the PCE. The temporary loss of substrate is expected to cause only slight degradation of the PCE. These effects are outlined in greater detail in Section 6.3.1 and 6.3.2. In summary, lost substrate in the project area represents only a minuscule fraction of the remaining available substrate present for dozens of miles both upstream and downstream of the project area. Therefore, the effect to this PCE will be slight.

In the Columbia River and North Portland Harbor, in-water bridge elements will permanently remove 12,950 sq. ft. of substrate. Demolition of the existing bridge will permanently restore 18,565 sq. ft. of substrate, and removal of an overwater structure at Red Lion at the Quay will permanently restore an unknown area of substrate. In any case, there will be a net gain of at least 5,615 sq. ft. of substrate, all of which occurs in proposed critical habitat for bull trout. This may result in a slight benefit to the PCE.

Neither temporary nor permanent structures are expected to affect habitat features such as large wood, side channels, or undercut banks, as these features are absent or rare in the project area.

Overall, the project is not likely to adversely affect this PCE.

Temperature

The project may slightly increase in-water shading in the action area, as outlined in Section 6.1.3. Shade may result in localized areas of cooler water temperatures where water velocities are slower. However, the large volume of the surrounding water bodies and the high level of mixing of shaded water with the surrounding water volume will likely overwhelm any decrease in temperature, so that increased shade will not measurably lower water temperatures.

The project will also remove a small amount of riparian vegetation along the shoreline of North Portland Harbor and the Columbia River, causing a very slight reduction of underwater shade in the action area, as outlined in Section 6.3.3. Due to the small amount of shade lost relative to the very large volume of the surrounding water bodies, this reduction in shade will not measurably raise water temperatures in the action area. Additionally, the project will replace the vegetation according to local ordinances, so that such effects will be temporary. The project will have no effect on this PCE.

Hydrograph

The hydrograph in the Columbia River and North Portland Harbor is dominated by numerous hydroelectric dams in the upstream direction and by the tidal influence of the Columbia River estuary and the Pacific Ocean in the downstream direction. Although the project will discharge stormwater runoff to the Columbia River and North Portland Harbor, these discharges are negligible relative to the large flow volume and existing hydrograph in these receiving water bodies. Therefore, the additional runoff will have no effect on the stream hydrograph.

Additionally, the project will construct temporary structures in the Columbia River and North Portland Harbor, adding a net volume of fill in these water bodies. However, the dams and the tidal influence will continue to dominate the hydrograph, so that the additional fill will have no effect on stream stage or flows in these water bodies.

The project will add permanent structures in the Columbia River and North Portland Harbor (approximately 12,960 cubic yards below OHW) and will remove the existing Columbia River structures (32,075 cubic yards below OHW), resulting in a net loss of fill (-19,110 cubic yards below OHW) in these water bodies. This will have no effect on the stream hydrograph.

6.4 EFFECTS TO STELLER SEA LIONS

This section provides a detailed analysis of effects to Steller sea lions. Appendix I, the Exposure Matrix, provides a tabular summary of each element of the project that is likely to affect Steller sea lions in the action area. It also provides the timing and duration of each project element as well as summarizing the overall effect that each element will have on Steller sea lions.

6.4.1 Acoustic Effects to Steller Sea Lions – Pile Driving

Project-generated noise, including impact and vibratory pile driving, may have impacts to Steller sea lions, which migrate through the project area. The following sections present background information about how sea lions respond to noise, criteria for noise levels likely to cause injury or disturbance to Steller sea lions, and an analysis of how pile-driving noise is likely to affect Steller sea lions present in CRC action area.

6.4.1.1 How Steller Sea Lions Respond to Noise

There are few studies that quantify reactions of pinnipeds to noise, and even fewer that have directly observed reactions of pinnipeds to pile-driving noise (Southall et al. 2007). (Pinnipeds are a taxonomic category of marine mammals that includes seals and sea lions.) Southall et al. (2007) performed a literature review of all known studies on the effects of noise on marine mammals. The review offers guidelines on how pinnipeds exhibit behavioral effects, temporary hearing loss, and injury resulting from elevated levels of underwater and airborne noise.

Behavioral Effects

Behavioral response to sound is dependent on a number of site-specific characteristics, including the intensity of the noise source, the distance between the noise source and the individual, and the ambient noise levels at the site (Southall et al. 2007). Behavioral response is also highly dependent on the characteristics of the individual animal. Marine mammals that have been previously exposed to noise may become habituated, and therefore may be less sensitive to noise. Such animals are less likely to elicit a behavioral response.

Behavioral responses have been observed experimentally and have been determined to be highly variable. In some cases, marine mammals may detect a sound and exhibit no obvious behavioral responses. In other cases, marine mammals may exhibit minor behavioral responses, including annoyance, alertness, visual orientation towards the sound, investigation of the sound, change in movement pattern or direction, habituation, alteration of feeding and social interaction, and temporary or permanent avoidance of the area affected by sound. Minor behavioral responses do not necessarily cause long-term effects to the individuals involved. Severe responses include panic, immediate movement away from the sound, and stampeding, which could potentially lead to injury or mortality (Southall et al. 2007).

In their comprehensive review of available literature, Southall et al. (2007) noted that quantitative studies on behavioral reactions of seals to underwater noise are rare. A subset of only three studies observed the response of pinnipeds to underwater multiple pulses of noise (a category of noise types that includes impact pile driving) and were also deemed by the authors as having results that are both measurable and representative.

- Harris et al. (2001) observed the response of ringed, bearded, and spotted seals to underwater operation of a single airgun and an eleven-gun array. Received exposure levels were 160 to 200 dB RMS re: (referenced to) 1 µPa. Results fit into two categories. In some instances, seals exhibited no response to noise. However, the study noted significantly fewer seals during operation of the full array in some instances. Additionally, the study noted some avoidance of the area within 150 m of the source during full array operations.
- Blackwell et al. (2004) is the only study directly related to pile driving. The study observed ringed seals during impact installation of steel pipe pile. Received underwater SPLs were measured at 151 dB RMS re: 1 µPa at 63 m. The seals exhibited either no response or only brief orientation response (defined as "investigation or visual orientation"). It should be noted that the observations were made after pile driving was already in progress. Therefore, it is possible that the low-level response was due to prior habituation.
- Miller et al. (2005) observed responses of ringed and bearded seals to a seismic airgun array. Received underwater sound levels were estimated at 160 to 200 dB RMS re: 1 µPa. There were fewer seals present close to the noise source during airgun operations in the first year, but in the second year the seals showed no avoidance. In some instances, seals were present in very close range of the noise. The authors concluded that there was "no observable behavioral response" to seismic airgun operations.

Southall et al. (2007) conclude that there is little evidence of avoidance of SPLs from pulsed noise ranging between 150 and 180 dB RMS re: 1 µPa. Additionally, they conclude that behavioral response in ringed seals is likely to occur at 190 dB RMS. It is unclear whether or not these data apply to Steller sea lions. Given that there are so few data available, it is difficult to draw conclusions about what specific behaviors pinnipeds will exhibit in response to underwater noise.

Southall et al. (2007) also compiled known studies of behavioral responses of marine mammals to airborne noise, noting that studies of pinniped response to airborne pulsed noises are exceedingly rare. The authors deemed only one study as having quantifiable results.

- Blackwell et al. (2004) studied the response of ringed seals within 500 m of impact driving of steel pipe pile. Received levels of airborne noise were measured at 93 dB RMS re: 20 µPa at a distance of 63 m. Seals had either no response or limited response to pile driving. Reactions were described as "indifferent" or "curious."

Due to the extremely limited data on this topic, it is not possible to draw definitive conclusions about what specific behaviors pinnipeds will exhibit in response to airborne noise generated by impact pile driving.

Several field observations indicate that sea lions exhibit mixed responses to elevated noise levels.

During a Caltrans installation demonstration project for retrofit work on the East Span of the San Francisco Oakland Bay Bridge, California, sea lions responded to pile driving by swimming rapidly out of the area, regardless of the size of the pile-driving hammer or the presence of sound attenuation devices (74 FR 63724).

Dyanna Lambourne, marine mammal research biologist at WDFW, noted that Steller sea lions generally avoid unfamiliar loud noises. In response to pile driving, they would be likely to exit areas exposed to elevated noise, unless there were a particularly strong attraction, such as an abundant food source (Lambourne 2010 personal communication). Lambourne also stated that Steller sea lions could become habituated to noises that are continuous and occurring over longer periods of time.

For the past 5 years, the USACE has conducted hazing of sea lions at Bonneville Dam in an attempt to decrease rates of predation on listed salmonids and sturgeon. The 2009 monitoring report (Stansell et al. 2009) documented the response of both California and Steller sea lions to several types of deterrents, including Acoustic Deterrent Devices (ADDs). These devices are deployed underwater and produce noise levels of 205 dB in the frequency range of 15 kHz. The crews also employed above-water pyrotechnics (cracker shells, screamer shells, or rockets) and underwater percussive devices called seal bombs. Hazing occurred seven days a week from March 2 to the end of May. The study did not differentiate between Steller sea lions and California sea lions, so it is uncertain whether these two species respond differently to hazing.

The observers reported that sea lions tended to spend more time underwater and temporarily avoided the area while hazing activities were occurring, but returned to forage soon after the activities ceased. They concluded that hazing only slowed the rate of predation, rather than effectively deterring it. The sea lions slightly shifted foraging times, preying more heavily at dawn and dusk, when hazing activities were beginning or ending. Nevertheless, despite active hazing, the rate of predation on salmon and sturgeon was still quite high. Observers noted that sea lions swam to within 20 feet of the ADDs to forage.

The explosive and percussive noises produced during these hazing activities are quite different from pile-driving noise, as they are abrupt and non-pulsed. These results may not be applicable to pile-driving projects; however, the results were included to demonstrate that high SPLs alone do not necessarily cause significant behavioral responses in sea lions. Also, the study is specific to sea lion behavior in the lower Columbia River, and it observed the same individuals that transit through the CRC project area. The results suggest that these individuals either are already habituated to some loud noises or could readily become habituated.

Temporary Threshold Shift

Temporary Threshold Shift (TTS) is reversible hearing loss caused by fatigue of hair cells and supporting structures in the inner ear. Technically, TTS is not considered injury, as it consists of fatigue to auditory structures rather than damage to them. Pinnipeds have demonstrated complete recovery from TTS after multiple exposures to intense noise, as described in the studies below (Kastak et al. 1999, 2005).

There are no studies of the underwater noise levels likely to cause TTS in Steller sea lions. However, TTS studies have been conducted on harbor seals, California sea lions, and northern elephant seals. Southall et al. (2007) report several studies on non-pulsed noise (a category that includes vibratory pile-driving noise), but only one study on pulsed noise.

- Finneran et al. (2003) studied responses of two individual California sea lions. The sea lions were exposed to single pulses of underwater noise, and experienced no detectable TTS at received noise level of 183 dB peak re: 1 μPa, and 163 dB SEL re: 1 μPa^2-s.

There were three studies of pinniped TTS in response to non-pulsed underwater noise. All of these studies were performed in the same lab and on the same test subjects, and therefore the results may not be applicable to all pinnipeds or in field settings.

- Kastak and Schusterman (1996) studied the response of harbor seals to non-pulsed construction noise, reporting TTS of about 8 dB.
- Kastak et al. (1999) exposed a harbor seal, California sea lion, and elephant seal to octave-band noise at 60 to 70 dB above their hearing thresholds. After 20 to 22 minutes, the subjects experienced TTS of 4 to 5 dB.
- Kastak et al. (2005) used the same test subjects above, exposing them to higher levels of noise for longer durations. The animals were exposed to octave-band noise for up to 50 minutes of net exposure.
    - The study reported that the harbor seal experienced TTS of 6 dB after a 25-minute exposure to 2.5 kHz of octave-band noise at 152 dB re: 1 μPa and 183 dB SEL re: 1 μPa^2-s.
    - The California sea lion demonstrated onset of TTS after exposure to 174 dB re: 1 μPa and 206 dB SEL re: 1 μPa^2-s.
    - The northern elephant seal demonstrated onset of TTS after exposure to 172 dB re: 1 μPa and 204 dB SEL re: 1 μPa^2-s.

Combining the above data, Southall et al. (2007) assume that pulses of underwater noise result in the onset of TTS in pinnipeds when underwater noise levels reach 212 dB peak or 171 dB SEL. They did not offer criteria for non-pulsed sounds.

Southall et al. 2007 reported only one study of TTS in pinnipeds resulting from airborne pulsed noise:

- Bowles et al. (unpublished data) exposed pinnipeds to simulated sonic booms. Harbor seals demonstrated TTS at 143 dB peak re: 20 µPa and 129 dB SEL re: 20 μPa^2-s. California sea lions and northern elephant seals experienced TTS at higher exposure levels than the harbor seals.

Two studies examined TTS in pinnipeds resulting from airborne non-pulsed noise. These studies may not be relevant to the CRC project, but are provided for general reference.

- Kastak et al. (2004) used the same test subjects as in Kastak et al. 2005, exposing the animals to non-pulsed noise (2.5 kHz octave-band noise) for 25 minutes.
    - The harbor seal demonstrated 6 dB of TTS after exposure to 99 dB re: 20 µPa and 131 dB SEL re: 20 μPa^2-s.
    - The California sea lion demonstrated onset of TTS at 122 dB re: 20 µPa and 154 dB SEL re: 20 μPa^2-s.
    - The northern elephant seal demonstrated onset of TTS at 121 dB re: 20 µPa and 163 dB SEL re: 20 μPa^2-s.
- Kastak et al. (2007) studied the same California sea lion as in Kastak et al. 2004 above, exposing this individual to 192 exposures of 2.5 kHz octave-band noise at levels ranging from 94 to 133 dB re: 20 µPa for 1.5 to 50 minutes of net exposure duration. The test subject experienced up to 30 dB of TTS. TTS onset occurred at 159 dB SEL re: 20 μPa^2-s. Recovery times ranged from several minutes to 3 days.

Southall et al. (2007) assume that multiple pulses of airborne noise result in the onset of TTS in pinnipeds when levels reach 143 dB peak or 129 dB SEL.

Lambourne (2010 personal communication) noted that, in a field setting, Steller sea lions are unlikely to remain in areas exposed to noise levels high enough to cause hearing loss, unless there is a particular attraction keeping them in the area.

Injury – Permanent Threshold Shift

Permanent threshold shift (PTS) is irreversible loss of hearing sensitivity at certain frequencies caused by exposure to intense noise. It is characterized by injury to or destruction of hair cells in the inner ear. Southall et al. (2007) note that there are no empirical studies demonstrating the noise levels that prompt PTS in marine mammals. Furthermore, they found that there is virtually no understanding of the relationship between TTS and PTS in marine mammals, as no studies have been performed.

Southall et al. (2007) propose that noise levels inducing 40 dB of TTS may result in onset of PTS in marine mammals. The authors present this threshold with precaution, as there are no specific studies to support it and because there is often recovery from TTS of this magnitude or greater. Because direct studies on marine mammals are lacking, the authors base these recommendations on studies performed on other mammals. Additionally, the authors assume that multiple pulses of underwater noise result in the onset of PTS in pinnipeds when levels reach 218 dB peak or 186 dB SEL. In air, noise levels are assumed to cause PTS in pinnipeds at 149 dB peak or 144 dB SEL (Southall et al. 2007).

6.4.1.2 Criteria for Injury and Disturbance

NMFS is currently developing comprehensive guidance on sound levels likely to cause injury and behavioral disruption in the context of the Marine Mammal Protection Act. Until formal guidance is available, NMFS uses conservative thresholds of sound pressure level likely to cause injury or disturbance to sea lions (Table 6-42) (NMFS 2008f; WSDOT 2009b).

Table 6-42. Injury and Disturbance Thresholds for Sea Lions

Type	Threshold
Underwater Injury	190 dB RMS re: 1 μPa
Underwater Disturbance – Impact Pile Driving	160 dB RMS re: 1 μPa
Underwater Disturbance – Vibratory Pile Driving	120 dB RMS re: 1 μPa
Abovewater Injury	None Designated
Abovewater Disturbance	100 dB RMS re: 20 μPa (unweighted)

Source: NMFS (2009), WSDOT (2009).

6.4.1.3 Estimating Noise Levels and Acoustic Area of Effect

The extent of in-water and airborne project-generated noise was calculated for the locations where pile driving will occur in the Columbia River and North Portland Harbor.

The extent of underwater noise was modeled for several pile driving scenarios:

- For two sizes of pile: 18- to 24-inch pile and 36- to 48-inch pile.
- For impact pile drivers operating both with and without an attenuation device. Use of an attenuation device was assumed to decrease initial SPLs by 10 dB, as outlined in Section 6.1.1 and Appendix K.
- For vibratory pile driving of pipe pile and sheet pile used for installation of temporary structures.

Although two impact pile drivers will operate simultaneously in close proximity to one another in the Columbia River, the two drivers are not expected to generate noise levels greater than a single pile driver. Pile strikes from both drivers would need to be synchronous (within 0.0 and approximately 0.1 seconds apart) in order to produce higher noise levels than a single pile driver operating alone. Because it is highly unlikely that two pile drivers will operate in exact synchronicity, , we assume that two pile drivers will not generate noise levels greater than that of a single pile driver. Therefore, initial noise levels for multiple pile drivers are assumed to be the same as for a single pile driver.

No data were available regarding the initial SPLs generated by vibratory installation of 10-foot diameter steel casings that are proposed for the drilled shafts. Therefore, the project team extrapolated initial SPLs from published values, as described in the subsection on vibratory pile driving below.

The extent of airborne noise was modeled for impact pile driving only.

Impact Pile Driving – Underwater Noise

Underwater noise thresholds for injury and disturbance to Steller sea lions are referenced to dB RMS re: 1 µPa. The Practical Spreading Loss Model was used to calculate the distances from the source at which impact pile driving noise is likely to exceed the underwater injury and disturbance thresholds. This model is described in detail in Appendix K. This model assumes 4.5 dB of transmission loss with each doubling distance, per the following equation:

$$\text{Distance 1} = \text{Distance 0} \times 10^{(TL/15)}$$

Where Distance 1 is the distance from the pile for which SPLs are being calculated, Distance 0 is the distance from the pile for which there is a known decibel level (typically 10 m from the pile), and TL (transmission loss) is the initial sound pressure level minus the relevant threshold level.

We estimated initial noise levels as 201 dB RMS for 36- to 48-inch pile and 189 dB RMS for 18- to 24-inch pile, as outlined in Section 6.1.1 and Appendix K.

For the smaller pile, the results indicate that noise levels will exceed the injury threshold within 2 m from the pile when a noise attenuation device is in use and within 9 m when no attenuation device is in use (Table 6-43 and Figure 6-43). Behavioral disturbance was estimated to occur within 185 m of the pile when a noise attenuation device is in use and within 858 m when no attenuation device is in use (Table 6-43 and Figure 6-44). As described in Appendix K, these numbers are estimates and may vary according to numerous site-specific factors.

Table 6-43. Distance to Underwater Noise Thresholds from Source – Impact Driving of 18- to 24-inch Piles – Calculated Distances

Threshold	Distance Without Attenuation Device (meters)	Distance With Attenuation Device (meters)
Injury: 190 dB RMS	9	2
Disturbance: 160 dB RMS	858	185

For the larger pile, the model calculated that noise levels will exceed the injury threshold within 12 m of the pile when a noise attenuation device is in use, and within 54 m when no attenuation device is in use (Table 6-44 and Figure 6-45). Behavioral disturbance was estimated to occur within 1,166 m of the pile when a noise attenuation device is in use, and within 5,412 m when no attenuation device is in use (Table 6-44 and Figure 6-46).

Table 6-44. Distance to Underwater Noise Thresholds from Source – Impact Driving of 36- to 48-inch Piles – Calculated Distances

Threshold	Distance Without Attenuation Device (meters)	Distance With Attenuation Device[a] (meters)
Injury: 190 dB RMS	54	12
Disturbance: 160 dB RMS	5,412	1,166

a Assumes 10 dB of noise attenuation.

Note that in both cases, the use of a noise attenuation device shrinks the distance at which noise exceeds the threshold by about 80 percent.

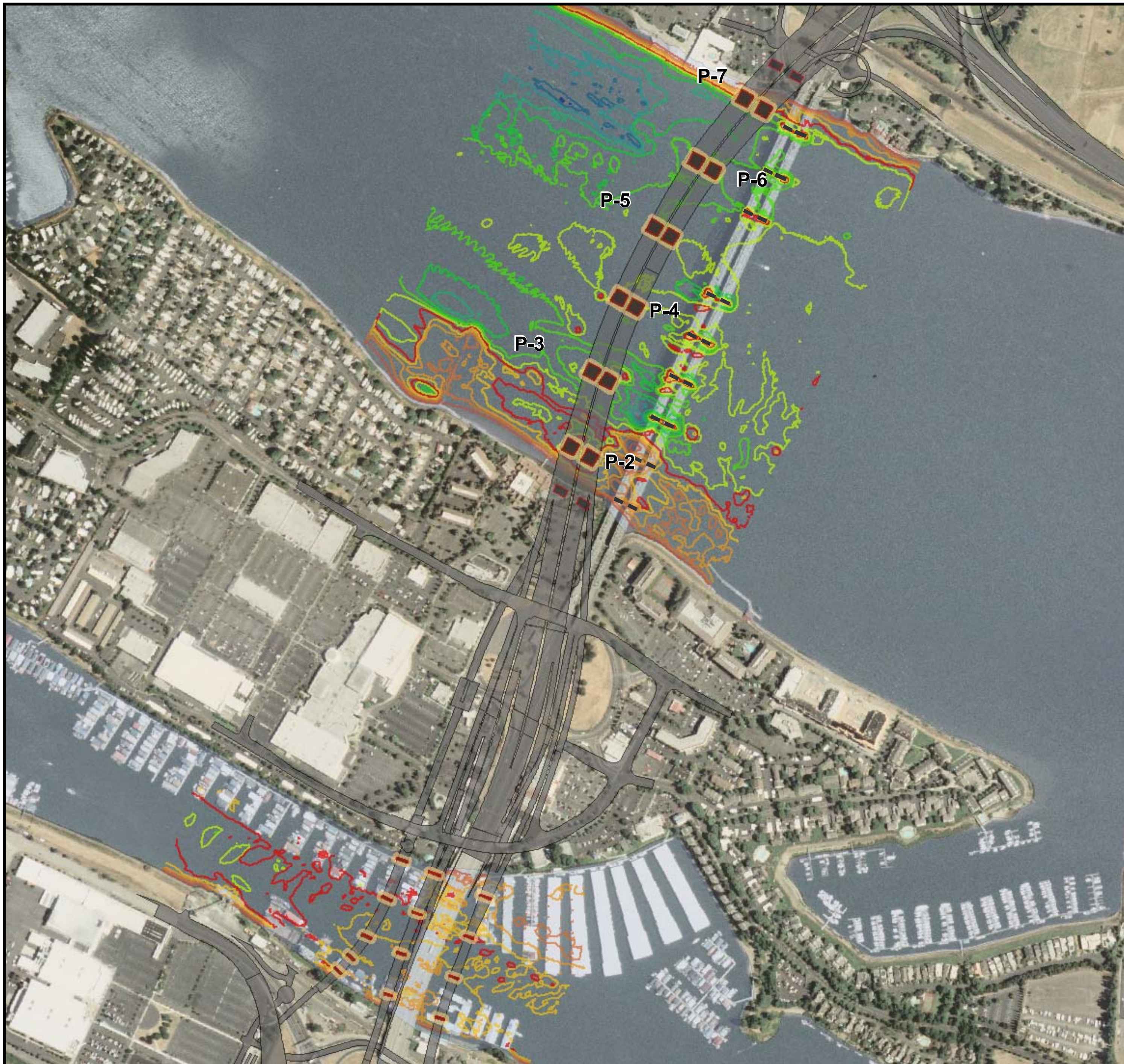


Figure 6-43. Extent of underwater impact pile-driving noise exceeding 190 dB RMS injury threshold for Steller sea lions, 18 to 24-inch pile

Distance to Exceedance of Threshold
- 2 meters with attenuation device
- 9 meters without attenuation device

Bathymetry

Depth (CRD, ft.)
0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

Design Shapes
- Project Bridge Piers
- Project Design

N E S W

0 500 1,000
Feet

Columbia River CROSSING

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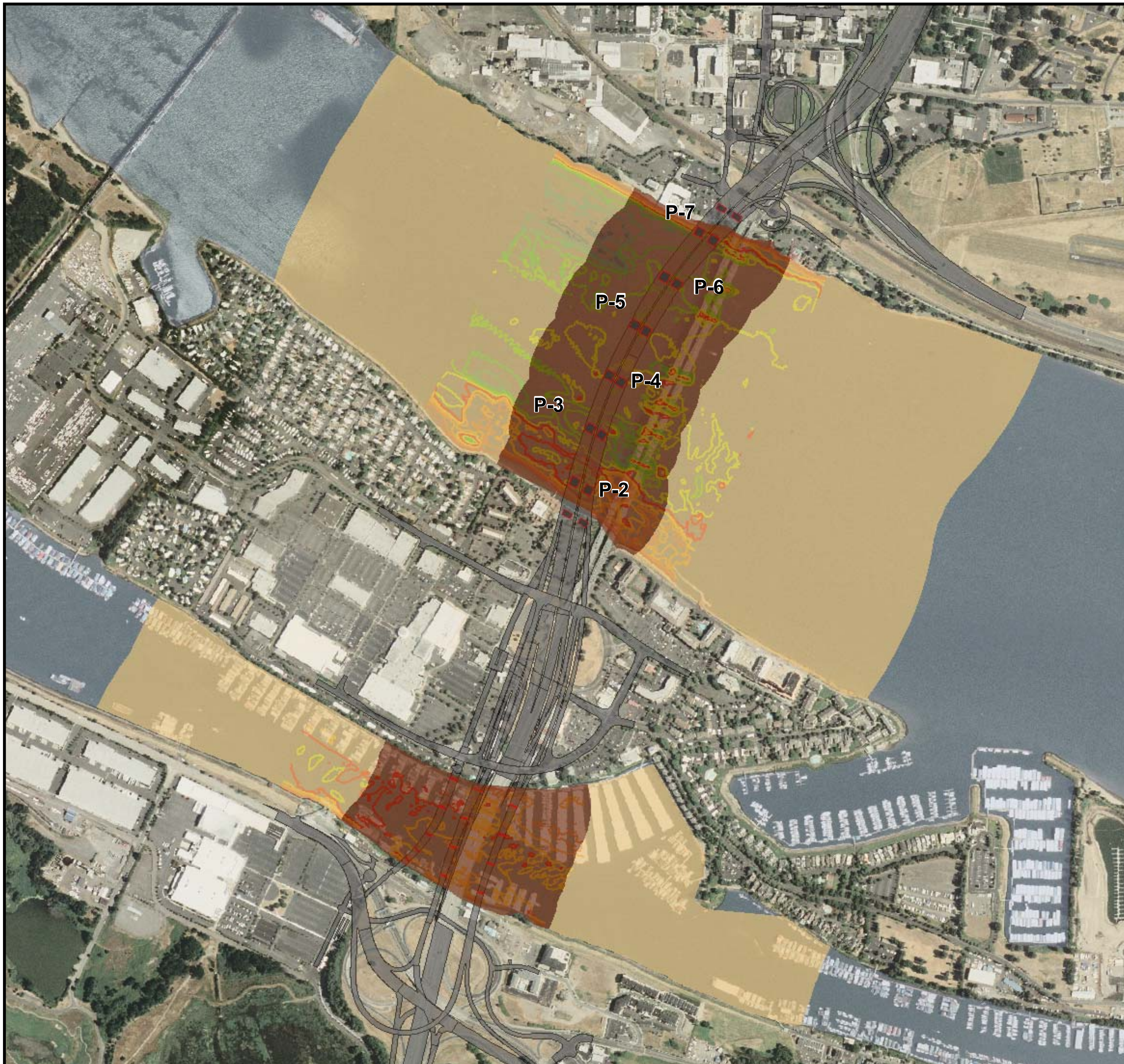

Figure 6-44. Extent of underwater impact pile-driving noise exceeding 160 dB RMS disturbance threshold for Steller sea lions 18 to 24-inch pile

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Table 6-43 and Table 6-44 show calculated distances, assuming a free field of spreading with no obstructions. In North Portland Harbor, noise will encounter landforms and dissipate to ambient levels before reaching some of these calculated distances. Table 6-45 shows noise attenuation to threshold levels during impact pile driving of 36- to 48-inch pile in North Portland Harbor, accounting for the distances at which noise will encounter landforms (Figure 6-45 and Figure 6-46).

Table 6-45. Distance to Underwater Noise Thresholds from Source for Impact Driving of 36- to 48-inch Pile in North Portland Harbor

Threshold	Distance Without Attenuation Device (meters)	Distance With Attenuation Device (meters)
Injury: 190 dB RMS	54	12
Disturbance: 160 dB RMS		
Upstream	3,058	1,166
Downstream	5,412	1,166

For 18- to 24-inch pile in both water bodies, and for 36- to 48-inch pile in the Columbia River, the actual, site-specific distances are the same as the calculated distances (Table 6-43, Table 6-44, Figure 6-43, and Figure 6-44).

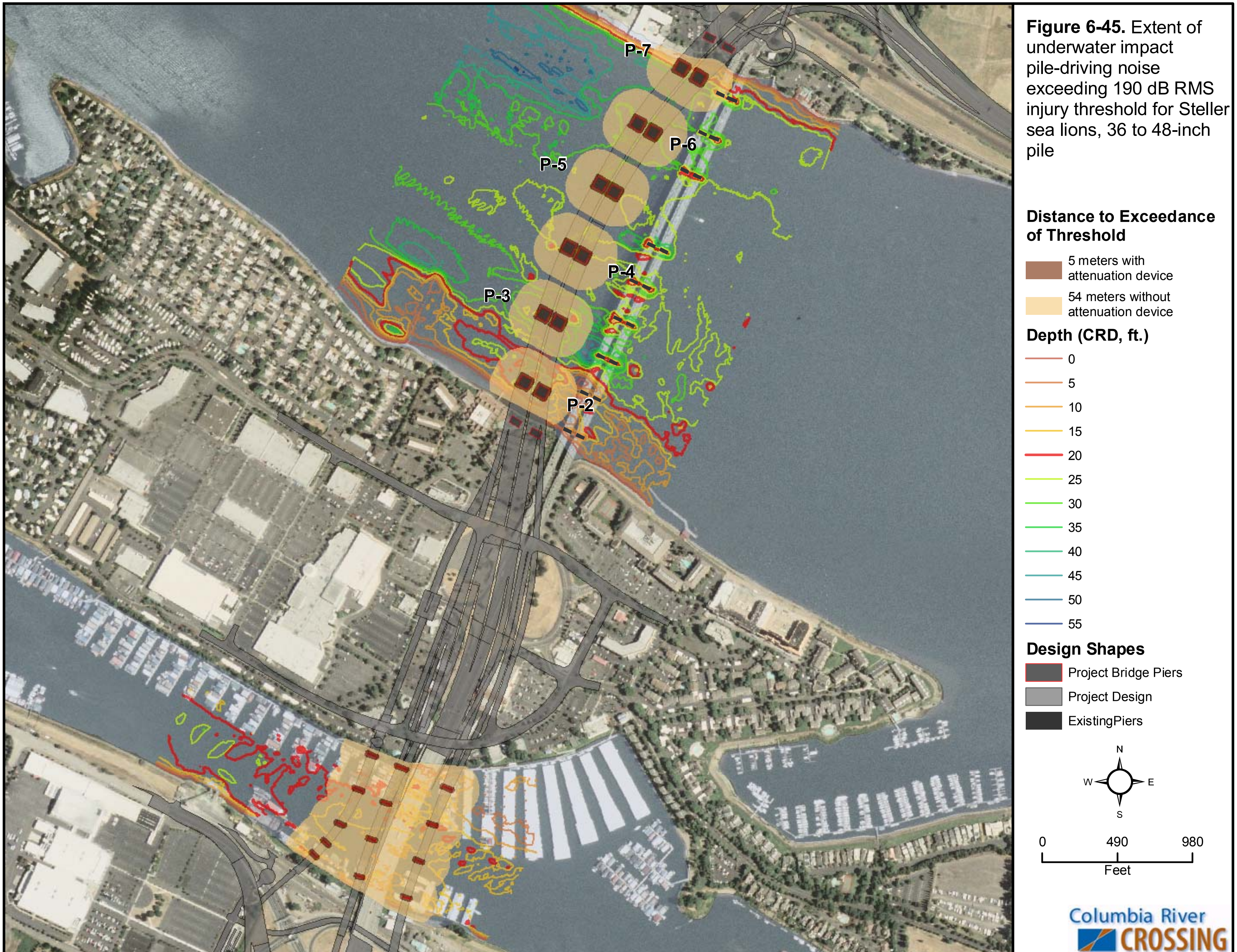

Figure 6-45. Extent of underwater impact pile-driving noise exceeding 190 dB RMS injury threshold for Steller sea lions, 36 to 48-inch pile

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Figure 6-46. Extent of underwater impact pile-driving noise exceeding 160 dB RMS disturbance threshold for Steller sea lions, 36 to 48-inch pile

Distance to Exceedance of Threshold

- 541 meters with attenuation device
- 5,412 meters without attenuation device

Depth (CRD, ft.)

0
5
10
15
20
25
30
35
40
45
50
55

Design Shapes

- Project Bridge Piers
- Project Design
- ExistingPiers

N W E S

0 2,800 5,600
Feet

Columbia River CROSSING

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Vibratory Pile Driving – Underwater Noise

No studies were available that measured site-specific initial noise levels generated by vibratory pile driving in the CRC action area. However, Table 6-46 outlines a range of typical noise levels produced by vibratory pile driving as measured by Caltrans during hydroacoustic monitoring of several construction projects (Caltrans 2009).

Table 6-46. Summary of Unattenuated Underwater Sound Pressures for Vibratory Pile Driving

Pile Type and Approximate Size	Water Depth (meters)	SPLs (dB RMS)[a]
0.30-meter (12-inch) steel H-type	<5	150
0.30-meter (12-inch) steel pipe pile	<5	155
1-meter (36-inch) steel pipe pile – typical	~5	170
0.6-meter (24-inch) AZ steel sheet – typical	~15	160
0.6-meter (24-inch) AZ steel sheet – loudest	~15	165
1-meter (36-inch) steel pipe pile – loudest	~5	175
1.8-meter (72-inch) steel pipe pile – typical	~5	170
1.8-meter (72-inch) steel pipe pile – loudest	~5	180

Source: Caltrans 2009, Appendix I.
a Impulse level (35 millisecond average).

<u>Pipe Pile</u>

We estimated a worst-case scenario of installing 48-inch steel pipe pile (the largest pile size to be used on the CRC project) at the loudest measured SPLs. Since there were no data for 48-inch pile, we assumed that noise levels for 48-inch pile would be intermediate between noise levels generated by 36-inch pile and 72-inch pile (Table 6-46). Thus, we assumed that initial SPLs for vibratory driving of pipe pile would range from 175 to 180 dB RMS. Thus, this activity is not expected to exceed the 190 dB RMS injury threshold. Table 6-47 shows the distances at which noise is expected to attenuate to the 120 dB RMS vibratory pile driving disturbance threshold, as per the Practical Spreading Model.

Table 6-47. Distance to Underwater Noise Thresholds from Source for Vibratory Driving of Pipe Pile – Calculated Values

	Distance from Source (m)	
Estimated Noise Level (dB RMS)	Initial SPLs 175 dB RMS at 5 Meters	Initial SPLs 180 dB RMS at 5 Meters
120	23,208	50,000

Landforms in the Columbia River and North Portland Harbor will completely block underwater noise well before it reaches either of these distances. Table 6-48 shows site-specific values for the maximum distance at which noise is likely to exceed the 120 dB RMS disturbance threshold until contact with landforms, assuming initial SPLs of 180 dB RMS as a worst-case scenario (Figure 6-47).

Table 6-48. Distance to Underwater Noise Thresholds from Source for Vibratory Driving of Pipe Pile – Site-Specific Values

Water Body	Direction	Distance (m)
Columbia River	Upstream	20,166
	Downstream	8,851
North Portland Harbor	Upstream	3,058
	Downstream	5,632

Sheet Pile

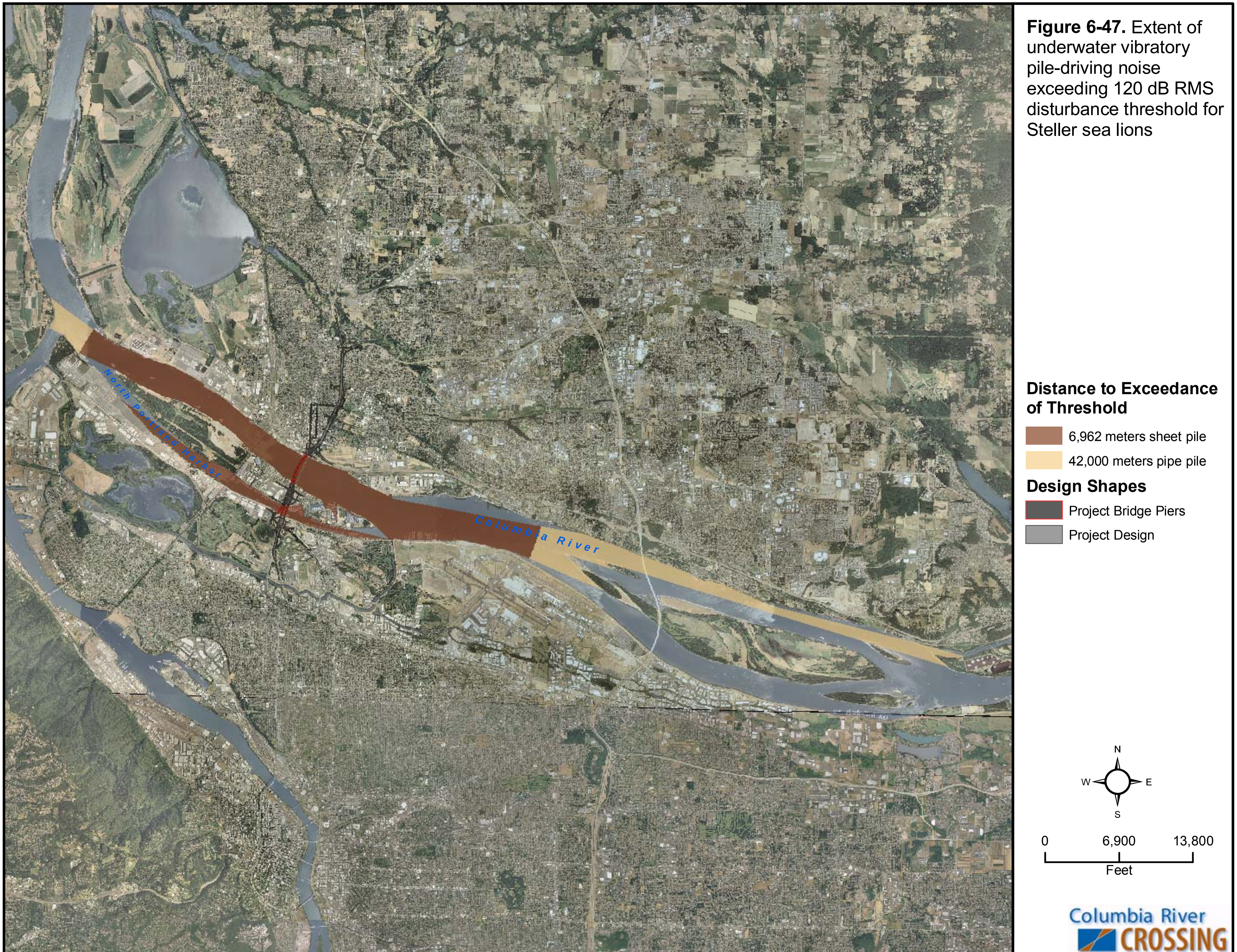
The project may also install sheet pile in numerous locations in the Columbia River. In general, installation of sheet pile produces lower SPLs than pipe pile. Using the Practical Spreading Loss Model, assuming initial SPLs of 160 to 165 dB RMS at a distance of 15 m (from Caltrans data in Table 6-46), we estimated that noise from vibratory driving of sheet pile will likely attenuate to the 120 dB disturbance threshold at a distance of 6,962 to 15,000 m from the source (Table 6-49). In the Columbia River, noise will not attenuate to the threshold before encountering landforms, and therefore the site-specific values are the same as the calculated values.

Vibratory installation of sheet pile is not expected to exceed the 190 dB RMS injury threshold.

Table 6-49. Distance to 120 dB RMS Underwater Noise Threshold for Vibratory Driving of Sheet Pile in the Columbia River

Estimated Noise Level (dB RMS)	Distance from Source (m)	
	Initial SPLs 160 dB RMS at 15 Meters	Initial SPLs at 165 dB RMS at 15 Meters
120	6,962	15,000

Figure 6-47. Extent of underwater vibratory pile-driving noise exceeding 120 dB RMS disturbance threshold for Steller sea lions



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Steel Casings

Vibration may also be used to install the 10-foot-diameter steel casings for the drilled shafts of the permanent structures in the Columbia River and North Portland Harbor. No data were available regarding the initial SPLs generated by installation of steel casings of this size. Therefore, the design team extrapolated from published values, assuming that vibratory driving of 10-foot casings would generate noise at levels of up to 10 dB RMS (an order of magnitude) higher than the highest value for vibratory installation of a 72-inch pile (as shown in Table 6-46). That is, vibratory installation of 10-foot diameter steel casing may yield a maximum value of 190 dB RMS at 5 m from the pile.

Therefore, it is assumed that vibratory installation of 10-foot-diameter steel pile will exceed the 190 dB RMS injury threshold for Steller sea lions at 5 m from the source (Table 6-50). Table 6-50 also shows the distance within which noise is calculated to attenuate to the 120 dB RMS vibratory pile driving disturbance threshold, as per the Practical Spreading Model.

Table 6-50 Distance to Underwater Noise Thresholds from Source for Vibratory Driving of Steel Casings

Estimated Noise Level (dB RMS)	Distance from Source (m) Initial SPL 190 dB RMS at 5 m
190 (injury threshold)	5
120 (disturbance threshold)	233,000

Landforms in the Columbia River and North Portland Harbor will completely block underwater noise well before it reaches the 233,000-m distance calculated for the 120 dB RMS disturbance threshold. Table 6-51 shows site-specific values for the maximum distance at which noise is likely to exceed the injury and disturbance thresholds.

Table 6-51 Distance to Underwater Noise Thresholds for Vibratory Driving of Steel Casings – Site-Specific Values

Estimated Noise Level (dB RMS)	Distance from Source (m)	
	Columbia River	North Portland Harbor
190 (injury threshold)	5	5
120 (disturbance threshold)	20,166 Upstream 8,851 Downstream	3,058 Upstream 5,632 Downstream

Without a precise estimate of initial SPLs, the values shown in Table 6-51 are rough estimates. To refine these estimates, the CRC team proposes to perform hydroacoustic monitoring during vibratory installation of the first steel casing in order to verify: 1) the initial SPLs generated by this activity and 2) the potential injury zone for Steller sea lions. Additionally, hydroacoustic monitoring is likely to be required under the terms of a Letter of Authorization issued by NMFS under the Marine Mammal Protection Act.

Airborne Noise

For calculating the levels and extent of project-generated airborne noise, we assumed a point noise source and hard-site conditions because pile drivers will be stationary and work will largely occur over open water and adjacent to an urbanized landscape. Thus, calculations assumed that pile driving noise will attenuate at a rate of 6 dB per doubling distance, based on a spherical spreading model. The following formula was used to determine the distances at which pile-driving noise attenuates to the 100 dB RMS airborne disturbance threshold:

$$D_1 = D_0 * 10^{((\text{initial SPL} - \text{airborne disturbance threshold})/\alpha)}$$

Where D_1 is the distance from the pile at which noise attenuates to 100 dB RMS, D_0 is the distance from the pile at which the initial SPLs were measured, and α is the variable for soft-site or hard-site conditions. These calculations used $\alpha = 20$ for hard-site conditions.

Appendix K defines the terms used above and outlines these assumptions in greater detail.

Our estimate of initial noise level is based on the results of noise monitoring performed by WSDOT during pile driving at Friday Harbor Ferry Terminal in the town of Friday Harbor, Washington (Laughlin 2005b). The results showed airborne RMS noise levels of 112 dB RMS re: 20 µPa taken at 160 feet from the source during impact pile driving. This project drove 24-inch steel pipe pile, which is only half the size of the largest pile proposed for use on the CRC project. However, airborne noise levels are independent of the size of the pile (Michael Minor 2009 personal communication), and therefore the noise levels encountered at Friday Harbor are applicable to the CRC project.

The model used 112 dB RMS at 48.8 m (160 feet) from the source as the initial noise level for a single pile driver. Because multiple pile drivers will not strike piles synchronously, operation of multiple pile drivers will not generate noise louder than that of a single pile driver. Therefore, initial noise levels for multiple pile drivers were assumed to be the same as for a single pile driver.

The project is not likely to use an airborne noise-attenuation device. Therefore, we did not model transmission of airborne noise with use of an airborne attenuation device. Table 6-52 and Figure 6-48 show that noise generated by impact pile driving in the Columbia River and North Portland Harbor is likely to exceed the airborne disturbance threshold within 195 m of the source.

Table 6-52. Airborne Noise Attenuation to 100 dB Disturbance Threshold During Impact Pile Driving

Distance	Noise Attenuation (-6 dB per Doubling Distance)
49 m (160 ft)	112 dB RMS
98 m (320 ft)	106 dB RMS
195 m (640 ft)	100 dB RMS

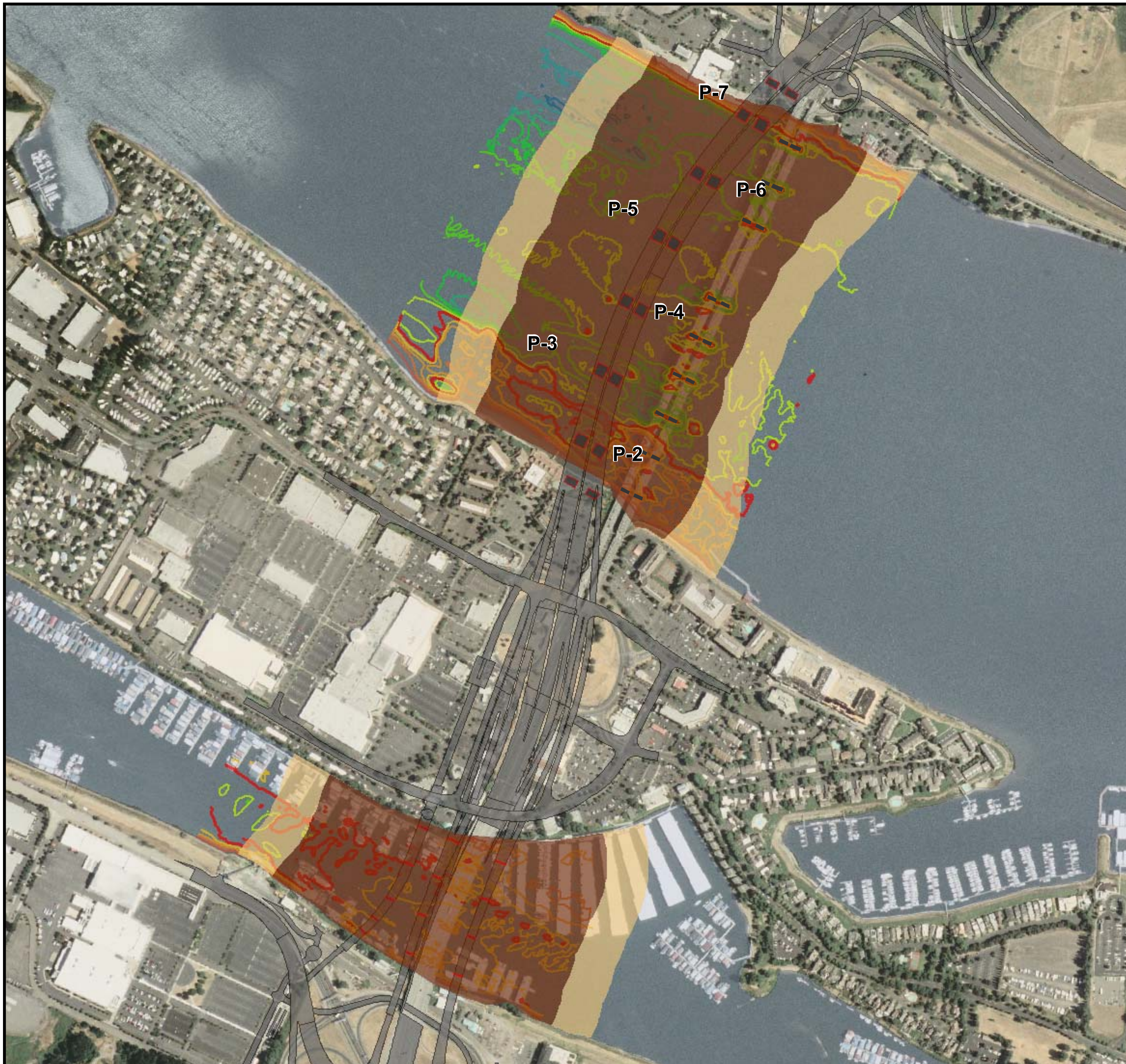

Figure 6-48. Extent of airborne impact pile-driving noise exceeding 100 dB RMS disturbance threshold for Steller sea lions

Distance to Exceedance of Threshold

- 195 meters - single pile driver
- 274 meters - multiple pile drivers

Bathymetry

Depth (CRD, ft.)

0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55

Design Shapes

- Project Bridge Piers
- Project Design

N, E, S, W

0 530 1,060

Feet

Columbia River CROSSING

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6.4.1.4 Analysis of Effect

Steller sea lions are likely to be exposed to elevated noise levels in the action area. Exposure is likely to occur from November through May when primarily adult and subadult male Steller sea lions typically forage at Bonneville Dam. Steller sea lions are known to migrate through the action area between the dam and the ocean during this time period, often making multiple round-trip journeys. Individual sea lions also are occasionally present from October to November (Tackley et al. 2008). Therefore, exposure during this time is possible, but less likely.

It is not certain how many sea lions will be exposed to elevated noise levels. As of February 5, 2010, 16 Steller sea lions have been reported at Bonneville Dam (Columbia Basin Bulletin 2010). Since counts at the dam began in 2002, numbers have ranged from 2 to 26 individuals (Stansell et al. 2009). Presumably, the number of sea lions present in the action area at the time of the project will be at least 26 individuals per year. While it is impossible to exactly predict the behavior of transiting sea lions in the action area several years in advance, we estimate that approximately 35 sea lions will transit through the action area, making 10 trips (5 round trips) each year during the approximately 4-year in-water construction period. The total population of the Eastern stock of Steller sea lions is estimated at 45,095 to 55,832 individuals (Angliss and Allen 2007); therefore, effects will only extend to a very small fraction of the total population.

There are no Steller sea lion haulouts or breeding sites in areas likely to be exposed to elevated noise. The nearest known haulout is located approximately 32 miles upstream of the project area (Tennis 2009b personal communication). The nearest breeding site is located more than 200 miles from the project area (NMFS 2008g). Therefore, elevated noise levels will have no effect on individuals at breeding or haulout sites.

Sea lions use the action area primarily for transiting only and are expected to be highly mobile when present in portions of the action area exposed to noise above the threshold levels for injury and disturbance. Additionally, Lambourne (2010 personal communication) notes that Steller sea lions are likely to avoid unfamiliar noises, unless there is a particular attraction keeping them in the area. As the CRC project area does not contain any such attractions (for example, an especially rich food source, breeding area, or haulout site), Steller sea lions will presumably avoid portions of the action area exposed to high levels of elevated noise (for example, noise generated by impact pile driving). Therefore, they will likely experience only brief, temporary behavioral disturbance or harassment as a result of impact pile-driving noise. Lambourne (2010 personal communication) also added that Steller sea lions could become habituated to noises that are continuous and occurring over longer periods of time (such as vibratory pile-driving noise).

Exposure to Underwater Impact Pile-Driving Noise

Table 6-53 and Table 6-54 below quantify the extent, timing, and duration of impact pile-driving noise that will exceed threshold levels for disturbance and injury to sea lions. Impact pile driving is expected to take place over the approximately 4-year in-water construction period. During each year, work will likely occur within a 31-week in-water work window, ranging from week 38 of one year to week 16 of the next (or approximately from September 15 to April 15). There will be a total of about 138 days of impact pile driving in the Columbia River and about 134 days of impact pile driving in North Portland Harbor over the approximately 4-year construction period (Figure 6-14). Impact pile driving will be restricted to approximately 40 minutes per 12-hour work day. During most of this 40-minute period, pile driving will occur only with the use of a noise attenuation device; however, for a short duration (about 7.5 minutes per week in the Columbia River and roughly 2.5 to 5 minutes per week in North Portland Harbor), unattenuated pile driving may occur either during routine testing of the attenuation device. Each work day will include a period of at least 12 consecutive hours with no impact pile driving in order to minimize disturbance to aquatic animals. Likewise, each 7-day work week will include a period of at least 2 days during which no impact pile driving will occur. Impact pile driving will occur only during daylight hours.

Table 6-53. Summary of Extent, Timing, and Duration of Impact Pile-Driving Noise Above 190 dB RMS Underwater Injury Threshold [a]

	Columbia River			North Portland Harbor		
Pile Size and Number	**Distance (m)**	**Duration**	**No. Days**	**Distance (m)**	**Duration**	**No. Days**
Without Attenuation Device						
18- to 24-inch pile	9	7.5 min/week	38	9	2.5 – 5 min/week	18
36- to 48-inch pile	54	7.5 min/week	38	54	2.5 – 5 min/week	31
With Attenuation Device						
18- to 24-inch pile	2	40 min/day	138	2	40 min/day	72
36- to 48-inch pile	12	40 min/day	138	12	40 min/day	62

Note: Elevated noise levels will occur throughout the approximately 4-year in-water construction period. Potential exposure may only occur from approximately October to May, when Steller sea lions are typically present in the action area.

a Sea lions will actually not be exposed to injurious levels of noise, because impact pile driving will stop when sea lions are present in the injury zone.

Table 6-54. Summary of Extent, Timing, and Duration of Impact Pile-Driving Noise Above 160 dB RMS Underwater Disturbance Threshold

	Columbia River			North Portland Harbor		
Pile Size and Number	**Distance (m)**	**Duration**	**No. Days**	**Distance (m)**	**Duration**	**No. Days**
Without Attenuation Device						
18- to 24-inch pile	858	7.5 min/week	38	858	2.5 – 5 min/week	18
36- to 48-inch pile	5,412	7.5 min/week	38	3,058 - U 5,412 - D	2.5 – 5 min/week	31
With Attenuation Device						
18- to 24-inch pile	185	40 min/day	138	185	40 min/day	72
36- to 48-inch pile	1,166	40 min/day	138	1,166	40 min/day	62

U = upstream, D = downstream.

Note: Elevated noise levels will occur throughout the approximately 4-year in-water construction period. Potential exposure may only occur from approximately October to May, when Steller sea lions are typically present in the action area.

Exposure to Underwater Vibratory Pile-Driving Noise

Pipe Pile and Sheet Pile

Table 6-55 summarizes the extent, timing, and duration of noise above the 120 dB RMS disturbance threshold generated by vibratory pile driving during installation of pipe pile and sheet pile. Vibratory driving of pipe pile and sheet pile is not expected to exceed the 190 dB RMS injury threshold, but it is likely to exceed the 120 dB RMS disturbance threshold.

Vibratory driving of pipe pile is likely to occur intermittently throughout the entire in-water project area during construction of all new in-water piers or bents (Figure 6-14 and Figure 6-15). This activity will occur continually throughout the 4-year in-water construction period over approximately 49 to 54 months. This activity is not restricted to an in-water work window, and therefore may take place during any of the 52 weeks of the year. Figure 6-47 shows the estimated extent of in-water noise above the 120 dB RMS disturbance threshold during vibratory driving of pipe pile and sheet pile for construction activities. Table 6-55 shows the estimated extent, timing, and duration of this effect.

Vibratory driving of pipe pile and sheet pile is also likely to occur during demolition of the existing Columbia River bridge piers to install barge moorings and cofferdams. Pipe piles for barge moorings will be installed and removed continuously throughout the entire 18-month demolition period, during any of the 52 weeks of the year (Figure 6-16). Cofferdams will each require about 10 days to install and will likely be installed during the last 13 months of the 18-month demolition period (Figure 6-16). Figure 6-47 shows the estimated extent of in-water noise above the 120 dB RMS disturbance threshold during vibratory driving of pipe pile and sheet pile during demolition. Table 6-55 shows the estimated extent, timing, and duration of this effect.

Table 6-55. Summary of Exposure to Vibratory Pile-Driving Noise Above 120 dB RMS Disturbance Threshold – Pipe Pile and Sheet Pile

		Columbia River			North Portland Harbor		
Pile Type	Timing	Distance (m)	Hours/ Day	No. Days	Distance (m)	Hours/ Day	No. Days
Pipe Pile	Year-round	20,166 - U 8,851 - D	Up to 5	1,470–1,620	3,058 - U 5,632 - D	Up to 5	~334
Sheet Pile	Year-round	6,962	Up to 24	99	N/A	N/A	N/A

U = upstream, D= downstream

Note: Elevated noise levels will occur throughout the approximately 4-year in-water construction period. Potential exposure may only occur from approximately October to May when Steller sea lions are typically present in the action area.

Steel Casings

Table 6-56 summarizes the extent, timing, and duration of noise above the injury and disturbance thresholds during vibratory installation of steel casings. The design team estimates that vibratory installation of 10-foot casings will take approximately 90 days in the Columbia River and 31 days in North Portland Harbor. Vibratory installation of 10-foot casings is not restricted to the in-water work window and therefore may take place any time during the four-year in-water construction period.

Table 6-56. Summary of Exposure to Vibratory Pile Driving Noise Above Disturbance and Injury Thresholds – Steel Casings

		Columbia River		North Portland Harbor	
Threshold	Timing	Distance (m)	No. Days	Distance (m)	No. Days
120 dB RMS	Year-round	20,166 - U 8,851 - D	90	3,058 - U 5,632 - D	31
190 dB RMS	Year-round	5	90	5	31

U = upstream, D= downstream

Note: Elevated noise levels will occur throughout the 4-year in-water construction period. Potential exposure may only occur from approximately October to May when Steller sea lions are typically present in the action area.

As stated earlier, hydroacoustic monitoring will be conducted to field verify the distances within which noise exceeds these thresholds.

Exposure to Airborne Pile-Driving Noise

Figure 6-48 and Table 6-57 summarize the extent, timing, and duration of airborne noise. Airborne noise effects will occur on the same schedule as those described for impact pile driving above.

Table 6-57. Summary of Exposure to Airborne Impact Pile-Driving Noise Above 100 dB RMS Disturbance Threshold

Location	Distance from Source (m)	Mins/Day	No. Days
Columbia River	195	≤40	138
North Portland Harbor	195	≤40	134

Note: Elevated noise levels will occur throughout the approximately 4-year in-water construction period. Potential exposure may only occur from approximately October to May, when Steller sea lions are typically present in the action area.

Injury

The project is not likely to injure Steller sea lions. Although underwater impact pile driving noise is likely to exceed the injury threshold, this effect will be limited to an estimated distance of 2 to 54 m from the noise source, depending on the number and size of the piles or whether a noise attenuation device is in use (Table 6-53). Additionally, as impact pile driving noise will be sporadic, occurring only about 40 minutes per day, Steller sea lions will likely avoid it as an unfamiliar source of disturbance. We would therefore expect them to avoid the injury zone rather than becoming habituated, thus reducing the potential for exposure.

The project will further limit the potential for injury to Steller sea lions through the implementation of a monitoring plan. As an initial worst-case scenario, marine-mammal monitors will ensure that the project curtails pile driving if sea lions are present within the largest area estimated to be exposed to noise above the 190 dB RMS injury threshold. For impact pile driving, this includes all areas within 54 m of the source (Table 6-53). For vibratory driving of steel casings, this includes all areas within roughly 5 m of the source.

The actual extent of injurious underwater noise will be verified in the field through hydroacoustic monitoring (Section 7.2.3.4). This may result in an adjustment in the size of the injury zone to be monitored for presence of Steller sea lions.

Because injurious noise levels will extend only a short distance and because marine mammals will be readily visible within these areas, it is reasonable to expect that qualified marine-mammal monitors will be able to detect sea lions within the injury zones. Impact pile driving is not anticipated to occur at night, making the probability of detection very high. Vibratory driving of 10-foot-diameter steel casings may occur at night. If it is determined that this activity will result in injurious noise levels, marine mammal monitors will use night-vision/night-detection equipment to ensure detection of Steller sea lions within the injury zone while this activity is taking place. For these reasons, we believe that avoidance of injury through implementation of a monitoring plan is an attainable goal. While injury is theoretically possible, it is not probable. Therefore, project-generated noise is not likely to injure sea lions.

Behavioral Effects

The project is likely to create noise above threshold levels for airborne and underwater behavioral disturbance to Steller sea lions. Table 6-54 through Table 6-57 outline the extent, timing, and duration of this effect.

Because studies on behavioral effects to sea lions are limited, and because the few available studies show wide variation in response to noise, it is difficult to quantify exactly how pile driving noise will affect Steller sea lions. The literature shows that elevated noise levels could prompt a range of effects, including no obvious visible response, brief visual orientation towards the noise, curiosity (or movement towards the source), or habituation to the sound (Southall et al. 2007). Southall et al. note that there is little evidence that high levels of pulsed noise will prompt avoidance of an area; however, given the paucity of data on the subject, we cannot rule out the probability that avoidance of the action area could occur.

Overall, we presume that noise generated by pile driving is likely to cause brief temporary harassment of Steller sea lions transiting the action area, potentially causing minor disruption of migration and feeding. Because the Steller sea lions use the action area primarily for transiting only, exposure is likely to be brief. Additionally, because many of the individuals transiting the area are already habituated to high ambient disturbance levels and to hazing at Bonneville Dam, we expect that they will not be especially sensitive to pile driving noise. In fact, they could eventually become habituated to continuous noise sources (such as vibratory pile driving), as they have at Bonneville Dam. Although brief, temporary, harassment will occur within the disturbance threshold areas, it is expected that elevated noise will have only a negligible effect on foraging and migration of individual sea lions, and no effect on the overall population.

Temporary Threshold Shift

Unattenuated impact pile driving will produce maximum initial pulsed noise levels estimated at 214 dB peak and 186 dB SEL. These noise levels are above the levels observed by Southall et al. (2007) for onset of TTS in pinnipeds (212 dB peak and 171 dB SEL). Attenuated impact pile driving is not expected to exceed these levels. Although Southall et al. (2007) suggested criteria have not been adopted by any regulatory body, they are presented as a starting point to discuss the likelihood of TTS on this project.

The literature has not drawn conclusions on levels of underwater non-pulsed noise (for example, vibratory pile driving) likely to cause TTS. We estimate that the extent of the area in which noise levels could potentially cause TTS is somewhere in between the extent of the injury zone and the extent of the disturbance zone (74 FR 63724).

Although underwater noise levels produced by the CRC project may exceed levels that have produced TTS in pinnipeds in other studies (Southall et al. 2007), there is a general lack of controlled, quantifiable field studies related to this phenomenon, and even those studies that have been conducted have had varied results. Therefore, it is difficult to extrapolate from these data to site-specific conditions on the CRC project. For example, because most of the studies have been conducted in laboratories, rather than in field settings, the data are not conclusive whether noise will cause sea lions to avoid the action area, thereby reducing the likelihood of TTS, or whether noise will attract sea lions, increasing the likelihood of TTS. In any case, there are no universally accepted standards for the amount of exposure time likely to induce TTS. Lambourne (2010 personal communication) posits that, in most circumstances, free-roaming sea lions are not likely to remain in areas subjected to high noise levels long enough to experience TTS. While we may infer that TTS could conceivably result from the project, it is impossible to exactly quantify the magnitude of exposure, the duration of the effect, or the number of individuals likely to be affected.

Impact pile driving will produce initial airborne noise levels of approximately 112 dB peak at 160 feet from the source, as compared to the level suggested by Southall et al. (2007) of 143 dB peak for onset of TTS in pinnipeds during multiple pulses of airborne noise. It is not expected that airborne noise levels will prompt TTS in Steller sea lions.

Exposure is likely to be brief because sea lions use the action area chiefly for transiting, rather than breeding or hauling out. In summary, we expect that elevated noise will have only a negligible probability of causing TTS in individual sea lions.

6.4.1.5 Conclusion

Injury to Steller sea lions is avoidable through the implementation of a monitoring plan that requires a cessation of impact pile driving before individuals enter the underwater injury zone, defined as from 2 to 54 m from the noise source. Additionally, if vibratory installation of 10-foot-diameter steel casings produces noise above the injury threshold, this activity will cease before Steller sea lions enter the potential injury zone (anticipated to be 5 m from the activity).

Noise above the behavioral disturbance threshold is likely unavoidable during both impact and vibratory pile driving, but effects to sea lions are expected to be brief and temporary, impacting only a small number of adult and subadult sea lions transiting the action area. No noise disturbance will occur at breeding areas or haulouts. Noise is not expected to significantly interfere with foraging, transiting, breathing, or other essential life functions.

6.4.2 Noise from Underwater Debris Removal

Debris removal in North Portland Harbor is likely to create noise above ambient levels in portions of the underwater action area. The following sections provide background information on typical underwater noise levels produced by underwater excavation, outline the extent of exposure to Steller sea lions, and analyze the potential effects of such exposure. Most of the information about noise and underwater excavation refers to dredging; thus, noise level studies below all refer to dredging studies.

6.4.2.1 Noise Levels Produced by Dredging

Few studies have been conducted on noise emissions produced by underwater dredging (Thomsen et al. 2009). In a literature review of available information, Thomsen et al. (2009) and OSPAR (2009) both found that noise from dredging operations ranged from 168 to 186 dB RMS at 1 m. It should be noted that the majority of these studies were related to trailing suction hopper dredger operations, which produce the highest noise levels of any of the dredge types, including those produced by the grab dredger (also known as a bucket dredger) that will be used on the CRC project. Of the studies reviewed in Thomsen et al. (2009), only one studied grab dredging. Clarke et al. (2002, as cited in Thomsen et al. 2009) monitored grab dredging with a 10 m^3 bucket, measuring 124 dB re: 1 µPa at 150 m (back-calculated as 142 dB at 10 m). Additionally, Dickerson et al. (2001) found that bucket dredging noise produced at most 124 dB RMS at 158 m (142 dB RMS at 10 m) in coarse sand and gravel. Miles et al. (1986, 1987, as cited in Richardson et al. 2005) reported that bucket dredging noise ranged from 150 to 162 dB at 1 m (or 135 to 147 dB at 10 m). Combining the available data sources, we estimate that underwater debris removal will produce noise in the range of 135 dB to 147 dB RMS at 10 m.

The research cited above suggests that underwater debris removal noise will not exceed the 190 dB RMS injury threshold. However, this activity is likely to exceed the 120 dB RMS disturbance threshold within areas approximately 631 m from the source (Table 6-58).

Table 6-58. Underwater Noise Attenuation for Debris Removal Noise – Calculated Values

	Distance from Source (m)
Noise Level (dB RMS)	Bucket Dredge Initial SPL 147 at 10 m
150	7
140	30
130	136
120	**631**

Underwater debris removal is not expected to generate significant airborne noise. The air-water interface creates a substantial sound barrier and reduces the intensity of underwater sound waves by a factor of more than a thousand when they cross the water surface. The above-water environment is thus virtually insulated from the effects of underwater noise (Hildebrand 2005). Therefore, we do not expect underwater debris removal to measurably increase ambient airborne noise.

6.4.2.2 Potential Exposure of Steller Sea Lions to Underwater Debris Removal Noise

Table 6-59 summarizes potential exposure of Steller sea lions to underwater debris removal noise in the North Portland Harbor. Exposure is presented as an overlap of the areal extent of noise above the 120 dB RMS disturbance threshold, combined with the duration and timing of the impact and the time periods when Steller sea lions are likely to be present in the action area.

Debris removal is not certain to occur, but is included to present the fullest disclosure of effects. Debris removal is discussed in more detail in Section 6.1.1.2. It is possible that debris removal will occur in North Portland harbor at the location of each of the new piers where there is anecdotal evidence that riprap occurs within the pier footprints. The exact location of this material is unknown, but as a worst-case scenario, this activity will remove approximately 90 cubic yards of material over an area of approximately 2,433 sq. ft. from all piers combined.

Table 6-59. Summary of Potential Steller Sea Lion Exposure to Debris Removal Noise Above the 120 dB RMS Disturbance Threshold

Noise Source	Location[a]	Underwater Distance (m)	Hours/ Day	Number of Days	Timing[b]
Bucket dredge	Potentially at all new NPH piers	631	≤12	up to 7 days	Nov 1 – Feb 28

a NPH = North Portland Harbor
b Over the course of in-water construction and demolition period: 2013 to 2018.

6.4.2.3 Effects of Exposure to Debris Removal Noise

The reactions of pinnipeds to dredging noise have received virtually no study. Previous studies indicate that dredging noise has resulted in avoidance reactions in marine mammals; however, the number of studies is few, limited to only a handful of locations. Thomsen et al. (2009) caution that, given the limited number of studies, the existing published data may not be representative and that it is therefore impossible to extrapolate the potential effects from one area to the next.

In a review of the available literature regarding the effects of dredging noise on marine mammals, Richardson et al. (2005) found only studies related to whales and porpoises, and none related to pinnipeds. The review did, however, find studies related to the response of pinnipeds to "other construction activities," which may be applicable to dredging noise. Three studies of ringed seals during construction of artificial islands in Alaska showed mostly mild reactions ranging from negligible to temporary local displacement. Green and Johnson (1983, as cited in Richardson et al. (2005)) observed that some ringed seals moved away from the disturbance source within a few kilometers of construction. Frost and Lowry (1988, as cited in Richardson et al. (2005)) and Frost et al. (1988, as cited in Richardson et al. 2005) noted that ringed seal density within 3.7 Km of construction was less than seal density in areas located more than 3.7 Km away. Harbor seals in Kachemak Bay, Alaska, continued to haul out despite construction of hydroelectric facilities located 1,600 m away. Finally, Gentry and Gilman (1990) reported that the strongest reaction to quarrying operations on St. George Island in the Bering Sea was an alert posture when heavy equipment occurred within 100 m of northern fur seals.

In their study about sea lion hazing at Bonneville Dam, Stansell et al. (2009) note that sea lions showed only temporary behavioral responses to loud noise, which did not cause any measurable interference with foraging or transiting. Sea lions quickly habituated to the noise, some foraging within 20 feet of intense noise. The results suggest that some of individuals that transit through the action area either are already habituated to some loud noises or could readily become habituated.

6.4.2.4 Effect of Exposure at the CRC Project

There are no established levels of underwater debris removal noise shown to cause injury to sea lions. However, since the maximum expected debris removal noise levels on the CRC project are below any known injury thresholds (190 dB RMS, for impulsive noises), it seems probable that this activity will not produce noise levels that are injurious to sea lions. Additionally, the limited body of literature does not include a single report of injuries caused by noise from underwater excavation.

Debris removal noise is likely to exceed the disturbance threshold (120 dB RMS for non-pulsed continuous noises) for only a short distance from the source (approximately 631 m). We presume that specific responses to noise above this level may range from no response to avoidance to minor disruption of migration and/or feeding. Alternatively, Steller sea lions may become habituated to elevated noise levels (NMFS 2005b; Stansell 2009). This is consistent with the literature, which reports only the following behavioral responses to these types of noise sources: no reaction, alertness, avoidance, and habituation. NMFS (2005b) posits that continuous noise levels of 120 dB RMS re: 1 μPa may elicit responses such as avoidance, diving, or changing foraging locations.

Behavioral disturbance is expected to be brief and temporary, restricted to individuals that are transiting the action area and occurring for no more than seven days during the 4-year in-water construction period. Because many of the individuals transiting the area are already habituated to hazing at Bonneville Dam and to high levels of existing noise throughout the lower Columbia River, we expect that they will not be especially sensitive to a marginal increase in existing noise. Therefore, they may eventually become habituated to noise at the CRC project.

Alternatively, because debris removal noise occurs over such a short duration, it is possible that Steller sea lions will not be present in this portion of the action area at the time of the activity, and therefore may experience any exposure to this type of noise.

6.4.3 Vessel Noise

Various types of vessels, including barges, tug boats, and small craft, will likely be present in the project area at various times. Vessel traffic will continually traverse the in-water project area, with activities centered on Piers 2 through 7 of the Columbia River and the new North Portland Harbor bents. Such vessels already use the action area in moderately high numbers, and therefore the vessels to be used in the CRC action area do not represent a new noise source, only a potential increase in the frequency and duration of existing noise levels.

There are very few controlled tests or repeatable observations related to the reactions of pinnipeds to vessel noise and no known studies specifically related to Steller sea lions. However, Richardson et al. (1995) reviewed the literature on reactions of pinnipeds to vessels, concluding overall that seals and sea lions showed high tolerance to vessel noise. One study showed that, in water, sea lions tolerated frequent approach of vessels at close range, sometimes even congregating around fishing vessels.

Because the CRC action area is heavily traveled by commercial and recreational craft, it seems likely that Steller sea lions will become habituated to the additional vessels present in the project vicinity during the course of the project. Therefore, this aspect of the project is not likely to adversely affect the Steller sea lion.

6.4.4 Physical Disturbance

Vessels, in-water structures, and over-water structures have the potential to cause physical disturbance to Steller sea lions.

Various types of vessels already use the action area in high numbers, and therefore the vessels to be used on the CRC project do not represent a new disturbance, only an increase in the existing level of disturbance. Tug boats and barges are slow moving and follow a predictable course. Sea lions will be able to easily avoid these vessels while transiting through the action area, and they are probably already habituated to the presence of numerous vessels, as the lower Columbia River and North Portland Harbor receive high levels of commercial and recreational vessel traffic. Therefore, vessel strikes are extremely unlikely and therefore discountable. Potential encounters will likely be limited to brief, sporadic behavioral disturbance, if any at all. Such disturbances will have only insignificant effects on sea lions.

Figure 6-42 shows the location, timing, and duration of in-water and overwater structures in the Columbia River and North Portland Harbor, including barges, moorings, tower cranes, cofferdams, and work platforms. Although there will be many such structures in the CRC action area, they will cover no more than 20 percent of the entire channel width at one time. There will still be ample room for Steller sea lions to navigate around these structures. Sea lions may need to slightly alter their migration course to avoid these structures, but there is no potential for physical structures to completely block upstream and downstream movement. Due to the small size of the structures relative to the remaining portion of the river available, delays to the migration will be negligible. Therefore, the effect of in-water and overwater structures on sea lions will be insignificant.

6.4.5 Effects on Prey

The prey base of the Steller sea lion consists chiefly of salmon, steelhead, and sturgeon, all of which occur in the action area and may be affected by the project. Effects to each of these species of fish are outlined in detail in Sections 6.1 to 6.3 of this BA.

6.4.5.1 Prey Quality

Prey quality may be affected by levels of turbidity, contaminated sediments, or other contaminants in the water column. The CRC project will minimize, avoid, or contain all potential sources of contamination, minimizing the risk of exposure to prey species of the Steller sea lion.

The CRC project involves several activities that could potentially generate turbidity in the Columbia River and North Portland Harbor, including pile driving, pile removal, installation and removal of cofferdams, installation of steel casings for drilled shafts, and debris removal. These activities are described in greater detail in Section 6.1.5.2. Table 6-16 summarizes the locations, areal extent, and duration of turbidity generated by these activities. Turbidity is not expected to cause mortality in the fish species using this portion of the action area, and effects will probably be limited to temporary avoidance of the discrete areas of elevated turbidity for approximately 4 to 6 hours at a time. Therefore, turbidity will have only insignificant effects to the prey base and insignificant effects on the Steller sea lion.

In-water work is extremely unlikely to mobilize contaminated sediments, as detailed in Section 6.1.5.3. Well in advance of in-water work, the project team will perform an extensive search for evidence of contamination, pinpointing the location, extent, and concentration of the contaminants. The project will then implement BMPs to ensure that the project either (1) avoids areas of contaminated sediment or (2) enables responsible parties to initiate cleanup activities for contaminated sediments occurring within the project construction areas. These BMPs will be developed and implemented in coordination with regulatory agencies. Because the project will identify the locations of contaminated sediments and use BMPs to ensure that they do not become mobilized, there is little risk that the Steller sea lion prey base will be exposed to contaminated sediments. Therefore, this aspect of the project is not likely to adversely affect the Steller sea lion.

In-water and near-water construction will employ numerous BMPs and will comply with numerous regulatory permits to ensure that contaminants do not enter surface water bodies. In the unlikely event of accidental release, numerous BMPs and a Pollution Control and Contamination Plan will be implemented to ensure that contaminants are prevented from spreading and are cleaned up quickly. (These methods are described in greater detail in Section 7.) Section 6.1.5.1 outlines the possible effects of construction-related contaminants on fish that make up the prey base of the Steller sea lion. This section concludes that contaminants are not likely to significantly affect these species of fish. Therefore, effects on the quality of the Steller sea lion prey base will also be insignificant.

6.4.5.2 Prey Quantity

The project is likely to impact a small percentage of all the runs of salmon and steelhead, using the action area through in-water pile driving, as described in Section 6.1.1 and Appendix K. This does not represent a large part of the Steller sea lion prey base in comparison to prey available through the entirety of their foraging range, which includes the Columbia River from Bonneville Dam to the mouth and thousands of square miles of foraging grounds off the Pacific Coast. Overall, effects to the prey base will be temporary, limited to the in-water work period over the project duration, and will not cause measurable changes in the quantity of prey available to sea lions. These effects are therefore insignificant.

6.5 CUMULATIVE EFFECTS

Cumulative effects include state, tribal, local, and private activities that are reasonably certain to occur within the action area and are likely to affect the species considered in this BA. Cumulative effects do not include any federal actions.

State and local government actions include land use planning and permitting (such as, zoning and shoreline management plans); floodplain and watershed management (for example in-stream flow rules and regulations, water acquisitions; HPAs and other permitting, and culvert replacements); water quality management (such as NPDES permitting); recreational and commercial fishing permitting and management; hatchery management; transportation projects; and habitat restoration projects.

Roadside and commercial development, as well as maintenance and upgrading of existing infrastructure, are likely to occur in the foreseeable future within the action area. However, only one known project was identified as reasonably certain to occur. The Gramor Development project is located immediately to the west of the I-5 facility just south of Evergreen Boulevard. This development is a joint public/private partnership. This project is early in the planning stages and therefore it is not possible to quantify effects to listed species at this time. However, at this stage it is safe to assume that the project will involve the following activities: addition of new PGIS, riparian disturbance and revegetation, and potential in-water pile removal. If these activities occur, effects will be similar to those outlined in Sections 6.1.5 (Temporary Effects to Water Quality), 6.2.1 (Stormwater Effects), and 6.3.3 (Riparian Habitat).

Recreational and commercial fishing occurs in the Columbia River and North Portland Harbor within the action area. In addition, recreational and commercial fishing occurs in the Pacific Ocean portion of the action area associated with killer whales. Both of these activities are reasonably certain to occur, affect the listed fish species addressed by this BA, and will lead to the continued mortality of listed fish. At this point, it is impossible to quantify the number of individual fish that will be affected, exact extent of the area of effect, or the timing and duration of the effect.

In addition, ongoing climate change will likely cause alterations to hydrologic conditions within the action area. Based on a review of the literature, the general trend predicted in the Pacific Northwest is for warmer, wetter winters with less snow and higher peak flows, and drier summers with lower summer base flows (JISAO 2002; Hamlet et al. 2003; OSU 2006; Mote et al. 2008; Doppelt et al. 2009). The predictions indicate that climate change will result in a decrease in snowpack, which is a significant factor in Pacific Northwest hydrology (Hamlet et al. 2003). Climate change in the region may result in alterations to salmonid run-timing, productivity, and survival. In smaller systems, it is possible to generate models that predict changes to river flow, but the Columbia River is a highly managed system, and the network of dams and reservoirs could mitigate the potential changes in river hydrology (Hamlet et al. 2003). In addition, new methods of river management, such as groundwater injection, may also play an important role in future river management strategies (DWR 2008). To date, the best available science does not allow for predictions about the potential effect of global climate change on hydrology in the Columbia River and North Portland Harbor.

The actions described above are ongoing and likely to continue in the future. Even though there will almost certainly be future restoration projects that improve habitat for listed species, the overall cumulative effects described above will have adverse impacts on listed species in the action area; however, these effects are difficult if not impossible to quantify.

6.6 EFFECTS FROM INTERRELATED AND INTERDEPENDENT ACTIONS

A BA analyzes the effect of interrelated and interdependent actions together with the effect of the larger action under consultation. This section analyzes the direct and indirect effects of interrelated and interdependent actions. The following have been identified as interrelated and interdependent actions, as described in Section 3.14: compensatory mitigation sites, maintenance and operation of the completed project, utility relocation, unanticipated staging and casting areas, design and operation of a pump station in Columbia Slough, and displacement of floating homes in North Portland Harbor.

6.6.1 Compensatory Mitigation Sites

The project will be required to offset impacts to aquatic habitat by performing compensatory mitigation as required by Section 404 of the Clean Water Act, a WDFW HPA, Oregon Removal/Fill law, and other regulations. The project proposes two mitigation sites: the Lower Hood River Powerdale Corridor Off-Channel Wetland Reconnection and the Lewis River Confluence Side Channel Restoration.

This BA analyzes the effects of the mitigation sites on listed species and critical habitat as required under Section 7. However, this analysis does not represent Section 7 consultation on these mitigation sites. Each site will undergo a separate Section 7 consultation submitted by USACE as an independent federal action.

The following sections outline the occurrence of listed fish and critical habitat in these areas and provide an analysis of effects

6.6.1.1 Oregon Compensatory Mitigation: Lower Hood River Powerdale Corridor Off-Channel Wetland Reconnection

Because state and USACE compensatory mitigation is required to construct the bridges over the Columbia River and North Portland Harbor in Oregon, CRC is providing funding for design and implementation of restoration at the Lower Hood River Powerdale Corridor Off-Channel Wetland Reconnection site. The entire site is owned by Columbia Land Trust and will be constructed and maintained by them. The site is undergoing a separate section 7 consultation as an independent federal action submitted by the USACE.

Listed Species and Critical Habitat Occurrence

CRC evaluated listed species and designated or proposed critical habitats potentially present in the area of the mitigation site; the upstream connection of the side channel with Hood River 100 feet upstream to the downstream end of the connection of the side channel with Hood River and an additional 300 feet downstream based on the NMFS website,[12] the USFWS county species lists obtained for Hood River County, Oregon (USFWS 2010a), information from Hood River Watershed Council, and a site visit conducted on February 23, 2010.

Salmon and Steelhead (and Critical Habitat)

NMFS website lists the following ESUs/DPSs as present in the mainstem Hood River and adjacent to the compensatory mitigation site: LCR Chinook, LCR steelhead, and LCR coho. Designated critical habitat is present in the lower Hood River for LCR Chinook and LCR steelhead (70 FR 52630). The lower Hood River contains the following three PCEs for all salmon and steelhead listings in the lower mainstem Hood River:

- Spawning habitat for LCR Chinook.
- Rearing habitat.
- Migration habitat.

[12] Available at: http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Index.cfm.

Bull Trout (and Critical Habitat)

The USFWS county list indicates bull trout are potentially present and critical habitat is designated in the mainstem Hood River (75 FR 2270). In addition, on January 14, 2010, critical habitat for bull trout was proposed in the mainstem Hood River (75 FR 2270). The following PCEs of designated critical habitat are present within the mitigation site's action area:

- Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) provide thermal refugia and contribute to water quality and quantity.
- Migratory habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
- An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
- Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structures.
- Suitable water temperatures ranging from 2 to 15ºC (36 to 59ºF), with adequate thermal refugia available for temperatures at the upper end of this range.
- A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, they minimize departures from a natural hydrograph.
- Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

One PCE is not present in the action area because the mitigation site is not located in upper river reaches where bull trout spawn and fry and juveniles rear: Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival.

The 2010 proposal for critical habitat includes the PCEs listed above and an additional PCE: Few or no non-native predatory (e.g., lake trout, walleye, northern pike, and smallmouth bass), inbreeding (e.g., brook trout), or competitive (e.g., brown trout) species present.

Effects to Listed Species

Temporary adverse impacts could potentially occur during and following construction until the site is stabilized. In preparation for the channel reconnection, the work area will be isolated and juvenile fish that are present will be captured and handled. There will be a temporary increase in water temperatures and total suspended sediment during the channel reconnection as a result of that "first flush" of standing water isolated behind the MHRR tracks. A temporary decrease in forage and cover will occur when vegetation along the existing bank is excavated. Loss of resting, holding, and prey items may occur for fish migrating or rearing in the area. The effect from the decrease in forage and cover will be temporary until the newly planted riparian and wetland vegetation is established. Migrating and holding adult and migrating and rearing juvenile LCR Chinook, LCR coho, and LCR steelhead, as well as adult and subadult bull trout may be exposed to this localized, temporary effect. Adult and subadult bull trout are only documented in very low numbers in the lower Columbia River (see Appendix J) and are expected to be present only in low numbers in the lower Hood River. Bull trout fry or juveniles do not occur in the lower reaches of Hood River.

In-water work, including installation of work area isolation measures, fish handling and removal of the railroad berm separating the side channel from the river and installation of the downstream and then the upstream connections (e.g. bridge or trestle) will only occur during the in-water work window when adult salmon and steelhead and adult and subadult bull trout are not expected to be present. Migrating and rearing juveniles of the following ESUs/DPSs could potentially be exposed: LCR Chinook, LCR coho, and LCR steelhead. The temporary increase in water temperature and total suspended sediment that will occur when the side channel is physically reconnected to the river can have adverse effects to juvenile LCR Chinook, LCR coho, and LCR steelhead. Handling of juvenile salmonids during fish capture and removal in the work isolation areas can have adverse effects. These effects can reduce growth, increase susceptibility to disease, increase competition, and inhibit movements necessary for rearing and migration. However, fish handling and degradation to water quality from sediment inputs during channel re-connection will be temporary, short in duration, and will be spatially limited.

After construction of the mitigation site, some increases in suspended sediment may occur intermittently for weeks or months until restoration plantings are established. Migrating and holding adult and migrating and rearing juveniles of LCR Chinook, LCR coho, and LCR steelhead, as well as migrating and holding adult and subadult bull trout, may be exposed to this localized and temporary effect. Due to the limited number of bull trout in the system and the limited duration and extent of impacts associated with the described activities, all effects would be discountable for bull trout. The longer term effects of the mitigation project will be beneficial due to restoration of river functions through a better functioning floodplain and riparian area. Permanent beneficial effects are listed below.

- Increased spawning and rearing habitat for salmon and steelhead.
- Restoration of the riparian and wetland area through reconnection with the river and plantings will provide allochthonous inputs into the channel, cover, and shade which will improve foraging, rearing, holding, and migrating adult and juvenile salmon and steelhead and adult and subadult bull trout.
- Improvements to the hydrological function in the main channel and restoration in the side channel will result in improved rearing habitat for salmon and steelhead juveniles by creating high flow refuges, potentially improving base flows, attenuating peak flow, and likely improving water quality from flow attenuation and wetland reconnection.
- Placement of large woody debris will create habitat complexity and provide improved rearing and holding conditions for adult and juvenile salmon and steelhead and subadult and adult bull trout.

In the short term, this action is likely to adversely affect salmon and steelhead due to temporary turbidity. Over the long term, however, this action will improve habitat, resulting in an overall beneficial effect to salmon and steelhead.

Due to the extremely low numbers of bull trout potentially occurring in this portion of the action area, risks of exposure to this action are discountable. Therefore, the Hood River compensatory mitigation site may affect, but is not likely to adversely affect bull trout.

Effects to LCR Chinook and LCR Steelhead Critical Habitat

Designated critical habitat for LCR Chinook and LCR steelhead in the mitigation site's action area contains spawning, rearing, and migration PCEs. Anticipated effects to these PCEs from construction and restoration of the mitigation site are described by PCE below.

Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Turbidity as a result of construction and reconnection of the side channel where it comes into contact with Hood River at the upstream and downstream ends of the project will cause only slight, temporary degradation of small discrete portions of the spawning PCE in the mainstem Hood River. The location of the downstream reconnection outfalls to a large gravel bar used by fall-run LCR Chinook for spawning, but will not be present at the time of reconnection (July 15-August 31). Due to the high dilution capacity of the lower Hood River during the period of side channel reconnection (July 15-August 31) and the fact the river is flowing high with glacial melt water and carrying a large bedload of glacial till the proposed project would have limited effect on in-stream turbidity 100 feet upstream or 300 feet downstream from the reconnection locations. The PCE will remain functional for the duration of the project. The 21 acres of restored side channel habitat will provide additional spawning habitat and larval development. Reconnection of the main channel Hood River with the wetland and side channel area will restore a more natural hydrograph and may prevent high flow events from scouring redds. Overall, this action will have beneficial effects to this PCE.

Freshwater rearing sites with: (1) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, (2) water quality and forage supporting juvenile development; and (3) natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Turbidity will cause slight, temporary degradation of small discrete portions of the rearing PCE. Due to the high dilution capacity of the lower Hood River during the period of side channel reconnection (July 15–August 31) and the fact the river is flowing high with glacial melt water and carrying a large bedload of glacial till the proposed project would have limited effect on in-stream turbidity 100 feet upstream or 300 feet downstream from the reconnection locations. The PCE will remain functional for the duration of the project. Reconnection of Hood River floodplain habitat with the 21 acres of side channel and associated wetland area will increase rearing area for juveniles, high flow refuge, potentially improving base flows, attenuating peak flow, and likely improving water quality and quantity from flow attenuation and wetland reconnection. Riparian and wetland plantings and addition of large woody debris will provide allochthonous inputs into the channel, cover, and shade which will improve rearing habitat by increasing forage and natural cover.

This action will have a short-term, localized adverse effect to this PCE due to temporary turbidity. Over the long term, however, it will improve rearing habitat and therefore will have an overall beneficial effect to this PCE.

Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival. Turbidity will cause slight, temporary degradation of small discrete portions of the migration PCE for the same reasons as described for the rearing PCE above. Reconnection of Hood River floodplain habitat with the 21 acres of side channel and associated wetland area will increase migrating area for adults and juveniles, as well as provide a high flow refuge during migration, potentially improve base flows, attenuating peak flow, and likely improving water quality and quantity from flow attenuation and wetland reconnection. Restoration of the riparian and wetland area through reconnection with the river, plantings, and addition of large woody debris will provide allochthonous inputs into the channel, cover, and shade which will improve migration habitat by increasing forage and natural cover, and overall habitat complexity.

This action will have a short-term, localized adverse effect to this PCE due to temporary turbidity. Over the long term, however, it will improve migration habitat and therefore will have an overall beneficial effect to this PCE.

Effects to Bull Trout Critical Habitat

Designated and proposed critical habitat for bull trout occurs within the action area of the mitigation site. Only adult and subadult bull trout occur in the lower Hood River; therefore, only PCEs related to adult and subadult bull trout apply. Anticipated effects to bull trout designated and proposed critical habitat are described by PCE below.

Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to provide thermal refugia and contribute to water quality and quantity. The proposed mitigation will reconnect a 21-acre wetland and isolated river side channel with the mainstem Hood River. The reconnection of the wetland to the main channel is expected to improve subsurface water connectivity, contribute to water quality improvements through reconnection of wetland water quality functions, and contribute to thermal refugia from the increase in subsurface flow connections. This action will have a beneficial effect on this PCE.

Migratory habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers. No physical, biological, or water quality impediments are currently present in the action area that disconnect spawning, rearing, overwintering, and freshwater and marine foraging habitats. This action will have no effect on this PCE.

An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish. The proposed mitigation will allow contribution of allochthonous input from side channel and wetland productivity, which contribute to stream productivity. Benefits to salmonid spawning, rearing, and migration habitat will benefit the bull trout prey base. These benefits include: side channel improvements for habitat complexity, including placement of large woody debris, increased shading, off channel refugia, hydrology benefits (likely increases in base flows and reductions in peak flows), and the increase in spawning and rearing habitat for fall-run Chinook, coho, and steelhead. This action will have a beneficial effect on this PCE.

Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structures. The proposed mitigation will reconnect 1 mile of side channel and a 21-acre wetland with the mainstem Hood River. Channel-enhancing restoration, such as the addition of large woody debris, will add complexity resulting in channel forming processes creating a variety of depths, gradients, velocities, and structures. This action will have a beneficial effect on this PCE.

Suitable water temperatures ranging from 2 to 15ºC (36 to 59ºF), with adequate thermal refugia available for temperatures at the upper end of this range. Reconnection to the historic wetland will help maintain base flows, which benefits stream summer temperatures. Riparian restoration plantings will shade the mainstem and off-channel areas, which will help maintain in-stream temperatures. This action will have a beneficial effect on this PCE.

A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, they minimize departures from a natural hydrograph. Reconnection of 1 mile of side channel and connection of the main river channel to the wetland will result in a more natural hydrograph as the mainstem river will be more connected to the floodplain. Reconnection to the wetland area may enhance base flows and alleviate channel incision caused from high flows. This action will have a beneficial effect on this PCE.

Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited. Turbidity will cause slight, temporary degradation of small discrete portions of this PCE for a short duration during reconnection of the side channel. Due to the high bedload of glacial till, the turbidity would be limited and the PCE will remain functional for the duration of the project. The increase in turbidity will not inhibit normal reproduction, growth, or survival and therefore, is not likely to adversely affect bull trout. Wetlands provide retention of peak flows, replenish base flows, and provide function to filter sediment and toxicants from entering waterways. The side channel proposed as part of the project will offer refuge from high flows, and provide greater connectivity so that water quantity during high flows is attenuated with the extra volume provided by the side channel. Turbidity from this action is not likely to adversely affect bull trout in the short term. Over the long term, the action will improve habitat and therefore will have an overall beneficial effect to this PCE.

Few or no non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), inbreeding (e.g., brook trout), or competitive (e.g., brown trout) species present (applies to proposed critical habitat only). The proposed mitigation will not affect this PCE.

Overall, this action is not likely to adversely affect bull trout critical habitat in the short term, and will have beneficial effects in the long term.

Relationship of Mitigation Project to Conservation and Recovery Plans

In addition to the beneficial effects listed above, this mitigation project addresses the following limiting factors as identified in the NMFS Columbia River Estuary ESA Recovery Plan Module and ODFW's Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead: reduced spawning and rearing habitat, reduced off-channel habitat opportunity, reduced off-channel complexity (e.g., pools and woody debris) and impaired passage. The proposed project will provide increased spawning and rearing habitat availability and be of direct benefit to LCR Chinook, LCR coho, and LCR steelhead. Due to its close proximity to the Columbia River, it is possible that juveniles from other interior basin ESUs/DPSs may utilize the restored habitat for rearing on their downriver migration. Specific examples of how this project will address recovery measures or critical limiting factors such as those identified in the Basin Recovery Plan Module or the Watershed Assessment and Action Plan include:

- **Restoration of habitat quality and diversity.** Railroad construction and related channelization has reduced habitat quality in much of the lower Hood River. Channelization, road fill, and bank armoring have narrowed stream channels and limited meanders along the mainstem Hood River. This has created shorter channels, steeper gradients, higher velocities, bed armoring, entrenchment, lack of large wood recruitment, and other effects (Coccoli 2004). Channel modifications interact with each flood event to further aggravate these channel changes. The resultant impaired physical habitat quality is a key concern for Hood River coho, fall Chinook, and winter and summer steelhead (ODFW 2009). Pool area, complexity, and frequency are very low in most streams. Flood refuge, hiding cover, overwintering and productive early rearing habitats (i.e., shallow lateral habitats, side channels) are lacking (ODFW 2009). These shallow lateral habitats and side channels have the highest potential for quality fish habitat development, but also are most sensitive to disturbance (Hood River Watershed Action Plan 2008). This mitigation project directly addresses these issues with side channel and floodplain restoration, improved physical habitat quality and complexity, high flow refuge, cover, overwintering, and productive early rearing habitat.
- **Restoration of historic spawning and rearing habitat.** Suitable spawning habitat for Chinook is geographically restricted mostly to the West Fork sub-watersheds, because the East and Middle Fork mainstems are less suitable for fall spawning due to glacial sediment loads (Coccoli 2004). Restoring off-channel habitat and/or access to off-channel habitat will provide rearing habitat for coho and winter steelhead (ODFW 2009). This mitigation project directly addresses restoration of historic spawning and rearing habitat.

Conclusion

Salmon and Steelhead (and Critical Habitat)

The Hood River compensatory mitigation project may affect, and is ***likely to adversely affect*** LCR Chinook, LCR steelhead, and LCR coho due to temporary, limited turbidity that will occur as a result of construction. Over the long term, it will have beneficial effects on these species.

This mitigation project may affect and is ***likely to adversely affect*** designated critical habitat for LCR Chinook and steelhead due to temporary, limited turbidity that will occur as a result of construction. Over the long term, it may have beneficial effects on critical habitat for LCR Chinook and steelhead.

Bull Trout (and Critical Habitat)

Due to the extremely low numbers of bull trout potentially occurring in this portion of the action area, risks of exposure to project activities are discountable. Therefore, the Hood River compensatory mitigation site ***may affect***, but is ***not likely to adversely affect*** bull trout.

Over the short term, the mitigation project ***may affect***, but is ***not likely to adversely affect*** bull trout critical habitat due to temporary turbidity. Over the long term, the mitigation project will have beneficial effects to bull trout critical habitat.

6.6.1.2 Washington Compensatory Mitigation: Lewis River Confluence Side Channel Restoration

Because state and USACE compensatory mitigation is required to construct the bridges over the Columbia River in Washington, CRC is purchasing a conservation easement at the private Lewis River Confluence Side Channel Restoration site. The 700-acre Lewis River restoration site is owned by Wildlands of Washington and will be constructed and maintained by them. The Lewis River restoration site is undergoing a separate Section 7 consultation as an independent Federal action submitted by the USACE.

Listed Species and Critical Habitat Occurrence

CRC evaluated listed species and designated or proposed critical habitats potentially present in the mitigation site's action area based on the NMFS website,[12] the USFWS county species list (USFWS 2010b), information from Wildlands of Washington, and a site visit conducted on March 18, 2010.

Salmon and Steelhead (and Critical Habitat)

NMFS website lists the following ESUs/DPSs as present in the mainstem Lewis River: LCR Chinook, CR chum, and LCR steelhead. All the ESUs/DPSs addressed in this BA are present in the mainstem Columbia River.

Critical habitat was established under two designations: 1) the 1993 critical habitat designation for SR spring/summer-run Chinook, SR fall-run Chinook, and SR sockeye (58 FR 68543), and 2) the 2005 salmon and steelhead critical habitat designation (70 FR 52630) for all of the other runs addressed in this BA. Critical habitat is present in the mainstem Lewis River for LCR Chinook, CR chum, and LCR steelhead (70 FR 52630). The Columbia River contains designated critical habitat for all other listed salmon and steelhead addressed in this BA with the exception of LCR coho, for which critical habitat is not designated (58 FR 68543, 64 FR 57399, 70 FR 52630). The lower mainstem Lewis River and lower Columbia River contain the following three PCEs for the 2005 salmon and steelhead critical habitat designation (70 FR 52630):

- Spawning habitat for LCR Chinook, LCR coho, LCR steelhead, and potentially CR chum.
- Rearing habitat.
- Migration habitat.

Two PCEs occur in the mitigation projects action area for the 1993 SR spring/summer-run Chinook, SR fall-run Chinook, and SR sockeye critical habitat designation: juvenile migration corridors and adult migration corridors.

Eulachon

NMFS website lists the Southern DPS of eulachon as potentially present in the lower Lewis River and lower mainstem Columbia River. Critical habitat is not proposed or designated for eulachon.

Green Sturgeon

The website also lists the Southern DPS of green sturgeon as present in the lower Columbia River. Critical habitat for green sturgeon does not occur in this part of the river.

Bull Trout (and Critical Habitat)

USFWS (2010b) indicates critical habitat has been designated in the mainstem Lewis River (75 FR 2270). In addition, on January 14, 2010 critical habitat for bull trout was proposed in the mainstem Lewis River (75 FR 2270). The following PCEs of designated critical habitat are present within the mitigation site's action area:

- Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to provide thermal refugia and contribute to water quality and quantity.
- Migratory habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
- An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.
- Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structures.
- Suitable water temperatures ranging from 2 to 15ºC (36 to 59ºF), with adequate thermal refugia available for temperatures at the upper end of this range.
- A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, they minimize departures from a natural hydrograph.
- Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited.

One PCE is not present in the action area because the mitigation site is not located in upper river reaches where bull trout spawn and fry and juveniles rear: Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival.

The 2010 proposal for critical habitat includes the PCEs listed above and an additional PCE: Few or no non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), inbreeding (e.g., brook trout), or competitive (e.g., brown trout) species present.

Although currently bull trout occur above existing dams in the Lewis River, due to a recent settlement agreement by FERC, connectivity to the mainstem Lewis River will be provided in the future (USFWS 2009). Therefore, bull trout potentially will be present in the lower Lewis River and lower Columbia River in future years.

Effects to Listed Species and Critical Habitats

Temporary adverse impacts could potentially occur during construction from capture and handling of juvenile and adult fish and a temporary increase in total suspended sediment during channel reconnection. These activities will only occur during the in-water work window when adult and juvenile salmon and steelhead, and adult and subadult bull trout are least likely to be present. Bull trout fry or juveniles do not occur in the lower reaches of the Lewis or Columbia Rivers and adult and subadult bull trout would not be expected during the August in-water work window. Therefore, exposure to bull trout from these effects would be discountable. Adult and subadult green sturgeon and adult and larval eulachon are expected in the Columbia River during this time, but numbers are not expected to be high and exposure would be discountable (see Section 4.17 for distribution). Migrating and rearing juvenile LCR, UCR, and SR Chinook; LCR steelhead; SR sockeye; and LCR coho could potentially be exposed (see Figure 4-2). Migrating adult LCR, UCR, and SR Chinook; LCR, MCR, UCR, and SR steelhead; SR sockeye; and LCR coho could be potentially exposed (see Figure 4-1). However, fish handling and degradation to water quality from sediment inputs during channel re-connection will be temporary, short in duration, and will be spatially limited.

<u>Effects to Salmon and Steelhead and their Critical Habitats</u>

After project construction, some increases in suspended sediment may occur intermittently for weeks or months until restoration plantings are established. Migrating and holding adult and migrating and rearing juveniles of all salmon and steelhead listed DPSs/ESUs may be exposed. This is an adverse effect.

The longer term effects of the mitigation project will be beneficial due to restoration of river functions through the creation of side channel habitat, increased habitat complexity, and a better functioning floodplain and riparian area. Beneficial effects are listed below.

- Increase in spawning and rearing habitat for LCR Chinook, LCR coho, LCR steelhead, and potentially CR chum.
- Restoration of the riparian and side-channel areas will provide allochthonous inputs into the channel, cover, and shade which will improve foraging, rearing, holding, and migrating habitat for adult and juvenile salmon and steelhead and adult and subadult bull trout.
- Improving hydrological function with the additional side channel acreage will result in improved rearing habitat for all salmon and steelhead juveniles by creating high flow refuge, potentially improving base flows, attenuating peak flow, and likely improving quantity from flow attenuation.
- Placement of large woody debris will create habitat complexity and provide improved rearing and holding conditions for adult and juvenile salmon and steelhead and subadult and adult bull trout.

Critical habitat designated in 2005 for salmon and steelhead in the mitigation site's action area contains spawning, rearing, and migration PCEs. Anticipated effects to these PCEs from construction and restoration of the mitigation site are described by PCE below.

Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development (LCR Chinook and potentially CR chum only). Turbidity will cause only slight, temporary degradation of small discrete portions of the spawning PCE in the Lewis and Columbia Rivers at a time when spawning does not occur in this portion of the action area. Due to the high dilution capacity of the two rivers and the limited extent of the turbidity (100 feet upstream or 300 feet downstream from the reconnection locations), the PCE will remain functional for the duration of the project and effects to spawning, incubation and larval development are discountable. The 18.5 acres of restored side channel habitat will provide additional spawning habitat for LCR Chinook, LCR steelhead, and potentially CR chum. Reconnection of the side-channel areas will restore a more natural hydrograph and may prevent high flow events from scouring redds. In the short term, the turbidity may affect, but is not likely to adversely affect this PCE. Over the long term, the overall action will have a beneficial effect on this PCE.

Freshwater rearing sites with: (1) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, (2) water quality and forage supporting juvenile development; and (3) natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks (all ESUs/DPSs in 2005 critical habitat designation, but especially LCR Chinook, CR chum, and LCR steelhead). Turbidity will cause slight, temporary degradation of small discrete portions of the rearing PCE in the Lewis and Columbia Rivers. Due to the high dilution capacity of the Lewis River and the limited extent of the turbidity (100 feet upstream and 300 feet downstream from the reconnection locations), the PCE will remain functional for the duration of the project and effects to rearing are discountable. Reconnection of the Lewis and Columbia Rivers to floodplain habitat in the side channels will increase rearing area for rearing LCR Chinook, CR chum, and LCR steelhead juveniles. High flow refuge, potential improvements to base flows, attenuation of peak flows, and likely improvements to water quality and quantity from flow attenuation with the additional side channel acreage will occur for lower river ESUs/DPSs, but will also occur for all other ESUs/DPSs as well. In addition, riparian plantings and addition of large woody debris will provide allochthonous inputs into the channel, cover, and shade which will improve rearing habitat by increasing forage and natural cover for all LCR Chinook, CR chum, and LCR steelhead. In the short term, the turbidity is likely to adversely affect this PCE. Over the long term, the action will have a beneficial effect on this PCE.

Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival (all ESUs/DPSs in 2005 critical habitat designation, but especially LCR Chinook, CR chum, and LCR steelhead). Turbidity will cause slight, temporary degradation of small discrete portions of the migration PCE for the same reasons as described for the spawning and rearing PCEs above. Reconnection of the 18.5 acres of side channels will increase migrating area for adults and juvenile LCR Chinook and LCR steelhead in the Lewis River, as well as provide high flow refuge during migration, potentially improve base flows, attenuate peak flows, and likely improve water quality and quantity from flow attenuation and the additional acreage of the side channels for lower river ESUs/DPSs, but will also occur for all other ESUs/DPSs as well. Restoration of the riparian and wetland area through reconnection with the river, plantings, and addition of large woody debris will provide allochthonous inputs into the channel, cover, and shade which will improve migration habitat by increasing forage and natural cover, and overall habitat complexity. In the short term, the turbidity is likely to adversely affect this PCE. Over the long term, the action will have a beneficial effect on this PCE.

Designated critical habitat for SR spring/summer-run Chinook, SR fall-run Chinook, and SR sockeye occurs in the Columbia River portion of the mitigation site's action area. Two PCEs occur in the action area: juvenile migration corridors and adult migration corridors. Anticipated effects to designated critical habitat are the same as those described in the freshwater migration PCE for the 2005 critical habitat designation.

Overall, the action is likely to adversely affect designated critical habitat for salmon and steelhead in the short term, but will have beneficial effects in the long term.

Effects to Bull Trout and Critical Habitats

Due to the extremely low numbers of bull trout found in this portion of the action area, risks of exposure to project activities are discountable. If adult and subadult bull trout are being transported past the Lewis River dams by this time, numbers are expected to be limited and potential exposure to localized and temporary increases in sediment and turbidity are discountable. Therefore, the Lewis River compensatory mitigation project is not likely to adversely affect bull trout.

Designated and proposed critical habitat for bull trout occurs within the lower Columbia River and Lewis River portion of the mitigation site. Only adult and subadult bull trout will potentially occur in the Columbia or Lewis Rivers; therefore, only PCEs related to adult and subadult bull trout apply. Anticipated effects to bull designated and proposed critical habitat are described by PCE below.

Springs, seeps, groundwater sources, and subsurface water connectivity (hyporheic flows) to provide thermal refugia and contribute to water quality and quantity. The proposed mitigation will reconnect 18.5-acres of side channels with the Lewis and Columbia Rivers. The reconnection of the side channels is expected to improve subsurface water connectivity and contribute to thermal refugia. The action will have a beneficial effect on this PCE.

Migratory habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers. No physical, biological, or water quality impediments are currently present in the mitigation site's action area that disconnect spawning, rearing, overwintering, and freshwater and marine foraging habitats. The action will have no effect on this PCE.

An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish. The proposed mitigation will allow contribution of allochthonous input from side channels, which contribute to stream productivity. Benefits to salmonids spawning, rearing, and migration habitat will benefit the bull trout prey base. These benefits include: side channel improvements for habitat complexity, including placement of large woody debris, increased shading, off-channel refugia, hydrology benefits (likely increases in base flows and reductions in peak flows), and the increase in spawning and rearing habitat for fall Chinook, coho, steelhead, and potentially chum. The action will have a beneficial effect on this PCE.

Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structures. The proposed mitigation will reconnect 21,100 linear feet of side channels with the Lewis and Columbia Rivers. Channel enhancing restoration, such as the addition of large woody debris, will add complexity resulting in channel forming processes creating a variety of depths, gradients, velocities, and structures. The action will have a beneficial effect on this PCE.

Suitable water temperatures ranging from 2 to 15ºC (36 to 59ºF), with adequate thermal refugia available for temperatures at the upper end of this range. Reconnection of the historic channels will allow access to thermal refugia in the cooler Lewis River waters for fish in the Columbia River during high summer temperatures. Riparian restoration plantings will shade the off-channel areas, which will help maintain in-stream temperatures. The action will have a beneficial effect on this PCE.

A natural hydrograph, including peak, high, low, and base flows within historic and seasonal ranges or, if flows are controlled, they minimize departures from a natural hydrograph. Turbidity will cause slight, temporary degradation of small discrete portions of this PCE for a short duration during reconnection of the side channel. Due to the high bedload of glacial till, the turbidity will be limited, and the PCE will remain functional for the duration of the project. The increase in turbidity will not inhibit normal reproduction, growth, or survival and therefore, is not likely to adversely affect bull trout. Over the long term, reconnection of the side channels will result in a more natural hydrograph because the mainstem Lewis and Columbia Rivers will be more connected to their floodplain. Reconnection of the side channels may enhance base flows and alleviate channel incision caused from high flows. The project-generated turbidity is not likely to adversely affect bull trout in the short term. Over the long term, the action will improve the hydrograph and therefore will have an overall beneficial effect to this PCE.

Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited. The side channels will offer refuge from high flows, and provide greater connectivity so that water quantity during high flows is attenuated with the extra volume provided by the side channel. The action will have a beneficial effect on this PCE.

Few or no non-native predatory (e.g., lake trout, walleye, northern pike, smallmouth bass), inbreeding (e.g., brook trout), or competitive (e.g., brown trout) species present (applies to proposed critical habitat only). The proposed mitigation will not affect this PCE.

<u>Effects to Green Sturgeon and Eulachon</u>

Due to the extremely low numbers of green sturgeon and eulachon potentially occurring in this portion of the action area, risks of exposure to project activities are discountable. Therefore, the Lewis River compensatory mitigation is not likely to adversely affect green sturgeon.

The Lewis River compensatory mitigation site may potentially increase incubation and spawning habitat for eulachon. Spawning habitats for eulachon are generally described as coarse grained, but developing eggs are sticky and have been found on substrates with a greater range of particle sizes (Smith and Saalfeld 1955; Romano et al. 2002). Therefore, eggs may be deposited in the restored channels. Adults are reported to "shut down" migration activity when waters are too cold or hot (less than 3 or greater than 11°C) (Langness 2009 personal communication; Smith and Saalfeld 1955). Whether they would seek these mitigation habitats cannot be known. However, it is reasonable to expect some exploration if adults are present in the vicinity, regardless of thermal regime. The creation of additional in-stream habitats and channel volume may be reasonably expected to be utilized by more than one eulachon life-stage. However, the extent of utilization and the magnitude and mechanisms of potential biological responses cannot be known or estimated at this time.

Relationship of Mitigation Project to Conservation and Recovery Plans

NMFS's Columbia River Estuary ESA Recovery Plan Module and LCFRB's Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan identified the following as limiting factors in the lower Columbia River: spawning and rearing habitat, reduced off-channel habitat opportunity, reduced off-channel complexity (e.g., tidal swamp and other shallow water habitats), reduced macrodetrital inputs, and impaired passage. Because of their longer Columbia River estuary residence times and tendency to use shallow-water habitats, ocean-type ESUs (e.g., LCR fall Chinook, LCR chum) are more affected by flow alterations that structure habitat and/or provide access to wetland or floodplain areas than stream-type ESUs, such as coho (LCREP 2007a). Rationale for selection of the Lewis River Confluence Side Channel Restoration project by CRC includes:

- **Restoration of spawning and rearing habitat, off-channel habitat, off-channel complexity, and macrodetrital inputs.** Dikes and channel filling activities have significantly altered the size and function of the Columbia River estuary. Dikes are thought to have caused more habitat conversion in the estuary than any other human or natural factor (Thomas 1983, as cited in NPCCl 2004) and are identified as a primary threat to ocean-type and stream-type salmonids (LCREP 2007a). Removal of the dredge spoil fill in the historic side channels will restore essential off-channel habitat, identified as a limiting factor in the Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead (LCREP 2007a).

- **Restoration of lowland floodplain function, riparian function, and stream habitat diversity of the lower mainstem reach.** In the East Fork Lewis River, critical fish habitat problems include loss of habitat diversity, low summer flow, increased sediment, high summer temperature, and channel instability due to extensive historical gravel mining activities in the lower river (LCFRB 2010). Restoration of lowland floodplain function, riparian function, and stream habitat diversity of the lower mainstem reach has been designated high priority for improvements to fall Chinook, chum and coho (LCFRB 2010). This mitigation project will restore these elements in the lower mainstem to benefit all DPSs/ESUs.

- **Restoration of side channels in the Lower Lewis River.** Peak flow reductions created by the Lewis River hydropower systems limit the occurrence of channel-forming flows that may be important for the formation and maintenance of key habitat types such as river side-channels and backwater areas (LCFRB 2004). Removal of the dredge spoils will restore side channels. The hydrologic analysis of the river system under its present management will direct the restoration methodology to insure the side channels are self-maintaining.
- **Addition of cold water refuge for juvenile salmonids.** The practice of releasing flows from the bottom of Merwin, Yale, and Swift Reservoirs has resulted in lower water temperatures in summer in the North Fork Lewis River (LCFRB 2004). Elevated temperatures of water entering the estuary are a threat to salmon and steelhead. Summer water temperatures entering the estuary are on average 4 degrees warmer today than they were in 1938 (LCFRB 2004). The restoration of historic side channels of the Lewis River will provide cold water refuge for juvenile salmonids (ocean- and stream-type life forms) and upriver migrating adults.

Conclusion

Salmon and Steelhead (and Designated Critical Habitat)

The Lewis River compensatory mitigation site ***may affect*** and is ***likely to adversely affect*** LCR Chinook, CR chum, and LCR steelhead. Elements of the project that are likely to adversely affect these species include: direct handling of fish and temporary turbidity during in-water work. Over the long term, this project will have beneficial effects on these species.

This mitigation project ***may affect*** and is ***likely to adversely affect*** designated critical habitat for salmon and steelhead including the following ESUs/DPSs:

- Chinook (LCR, UCR spring run, SR fall run, and SR spring/summer run)
- Steelhead (LCR, MCR, UCR, SR)
- CR chum
- SR sockeye

Adverse effects are limited to temporary turbidity occurring within 100 to 300 feet from in-water construction. Over the long term, this action may have beneficial effects on these critical habitat units.

Eulachon, Bull Trout, and Green Sturgeon

Due to the extremely low numbers of eulachon, bull trout, and green sturgeon found in this portion of the action area, risks of exposure to project activities are discountable. Therefore, the Lewis River compensatory mitigation site ***may affect***, but is ***not likely to adversely affect*** eulachon, bull trout, and green sturgeon.

Bull trout Critical Habitat

The action will ***not destroy*** or ***adversely modify*** proposed critical habitat for bull trout. In the event that proposed critical habitat is designated before completion of the project, a provisional effect determination of ***may affect, not likely to adversely affect,*** is warranted.

Over the short term, the mitigation project ***may affect,*** but is ***not likely to adversely affect*** bull trout designated critical habitat due to temporary turbidity. Over the long term, the mitigation project will have beneficial effects to bull trout critical habitat.

6.6.2 Maintenance and Operation of New Project

Elements of the completed project, including the roadway, bridges, stormwater treatment facilities, stormwater conveyances, and others, will require continual maintenance for the foreseeable future. Maintenance is likely to include in-water and over-water work such as deck repairs, pavement rehabilitation, bridge washing, or culvert maintenance. All maintenance work will occur only after obtaining all required regulatory permits. If work may affect listed species or critical habitat, these maintenance projects will either undergo individual Section 7 consultation with NMFS or will be performed under the aegis of programmatic agreements with NMFS for road maintenance activities under Section 4(d) of the ESA (e.g., WSDOT's Road Maintenance ESA Guidelines; ODOT's Routine Road Maintenance – Water Quality and Habitat Guide BMPs).

6.6.3 Utility Relocation

Utility relocation is not expected to affect listed species or critical habitat. This work involves little, if any, excavation and will employ BMPs to ensure that discharge of sediments or other contaminants to water bodies will not occur.

6.6.4 Unanticipated Staging and Casting Areas

Should the project require additional staging and casting areas not addressed in this BA, these areas will be selected such that their construction and operation will be extremely unlikely to have effects on listed fish or critical habitat. Staging and casting will occur on land only, and operations will follow standard BMPs to ensure that sediments, chemicals, and other contaminants do not enter surface water bodies. Such conservation measures will include, but will not be limited to, an ESCP, a SPCC, and maintaining setback buffers from waterways.

6.6.5 Design and Operation of Rebuilt Pump Station

A pump station, operated by Peninsula Drainage District No. 1, moves water from a drainage ditch into the Columbia Slough; this pump station will require upgrading in the near future. The upgrade may increase the capacity of the pump if deemed necessary to accommodate additional runoff that discharges from the CRC project into the drainage area served by this pump station.

Potential effects from the capture, treatment, and release of stormwater from the CRC project into the Columbia Slough Watershed are discussed in Section 6.2.1. In summary, stormwater runoff is not expected to degrade water quality in the Columbia Slough because of the high level of stormwater treatment proposed and because dilution and absorption will dissipate pollutants to ambient levels before discharging to the Slough. Any additional pumping capacity occurring after the CRC project is not expected to result in effects to the Columbia Slough not already addressed by Section 6.2.1. That is, despite the increased capacity, pollutants will still be subjected to high levels of dilution and absorption, dissipating to background levels before entering the Slough. Thus, any additional pumping capacity required would not likely have adverse effects on the Columbia Slough baseline or on listed species of fish.

6.6.6 Floating Home Displacement

Up to 32 floating homes in the Portland Harbor would be displaced by the project. The displaced floating homes will need to be moved to other locations. These locations could be within North Portland Harbor, but may be in other portions of the lower Columbia River subbasin. Other suitable locations would likely be located in shallow, slow-moving waters similar to North Portland Harbor, Multnomah Channel, or portions of the lower Willamette River.

Effects from floating homes, regardless of site location, include shading of the water column, perturbations in near-surface flow, and associated riverbank development. These activities may adversely affect listed fish and their habitat. Effects on shading that could result from the displacement of floating homes are discussed in more detail in Sections 6.1.3.2 and 6.1.3.3.