Location of Creosote-Treated Railroad Lines near Sensitive Near-Shore Aquatic Habitats in Washington State

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Cover photo: Newaukum River near Chehalis in Lewis County, WA

Location of Creosote-Treated Railroad Lines near Sensitive Near-Shore Aquatic Habitats in Washington State

by

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Water Resource Inventory Area (WRIA) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area: Statewide.

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Abstract

The purpose of this study was to identify sensitive aquatic areas (near-shore marine and freshwater) in Washington State that have the potential for the habitats to be impacted by polycyclic aromatic hydrocarbons (PAHs) originating from creosoted-treated wood used in the construction of railroad lines. The Washington State Department of Ecology released a Chemical Action Plan for PAHs that addresses all uses and releases of PAHs in the entire state. One of the Chemical Action Plan recommendations includes mapping railroad line locations near sensitive aquatic habitats.

Identification of sensitive aquatic areas near railroad operations with creosote-treated wood was conducted using Environmental Systems Research Institute (ESRI) ArcGIS10 program, a Geographic Information System (GIS).

Results of this study are discussed from two perspectives:

- Statewide proportion of sensitive habitat areas found near railroad lines.
- Miles of railroad lines near these areas of concern.

From a statewide perspective, about 1% of the sensitive habitat lies within a 300-foot buffer or 100-year flood zone near or intersected by railroad lines. For wetland areas, about 2% was intersected with railroad lines. In comparison, about 4% of Salmon Habitat included railroads with about 2% being active railroads lines.

Railroad lines near sensitive aquatic areas were found statewide. Over 150 miles of active railroads lines are located near protected salmonid habitat, and more than 2000 miles are near sensitive habitat. When including inactive railroad lines, the numbers of miles near these areas of concern nearly double.

Recommendations for follow-up actions are provided.

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Introduction

The Washington State Department of Ecology (Ecology) strives to reduce or eliminate threats to human health and the environment from persistent, bioaccumulative, toxic chemicals (PBTs). PBTs remain in the environment for long periods of time, are hazardous to the health of humans and wildlife, build up in the food chain, are transported long distances and readily move between air, land, and water. Polycyclic aromatic hydrocarbons (PAHs) have been identified as PBTs by the State of Washington (WAC 173-333) (Ecology, 2006).

PAHs are a class of organic compounds rather than an individual chemical. They are characterized by numerous fused aromatic rings of carbon and hydrogen. There are hundreds of PAH compounds, and they usually occur as mixtures.

In 2006, multiple agencies initiated an effort to evaluate sources of toxic chemicals (including PAHs) entering Puget Sound. This resulted in a multi-year study titled The Puget Sound Toxics Loading Analysis (PSTLA). Ecology and other agencies identified PAHs among the chemicals mostly likely to be found at concentrations where toxic effects are documented or at levels above criteria used to protect aquatic organisms and consumers of aquatic organisms (Ecology, 2006; Ecology and King County, 2011).

Both the United States Environmental Protection Agency (EPA) and the International Agency for the Research on Cancer (IARC) classify several PAH compounds/mixtures as known, possible, or probable carcinogens for humans (IARC, 2010; EPA, 2012). Other health effects include mortality, heart defects, reduced growth, immune-suppression, effects on reproduction, and population effects on diversity and abundance in ecosystems (Davies et al., 2012).

PAHs can be found in some natural sources like petroleum oil and coal. They are formed during the incomplete burning of organic matter such as coal, oil, gas, wood, garbage, and reside in other materials such as tobacco and meat (Davies et al., 2012).

Chemical Action Plan for PAHs

In 2012, Ecology released a Chemical Action Plan (CAP) for PAHs that addresses all uses and releases of PAHs in the entire state (Davies et al., 2012). The CAP found that the largest man-made sources to the environment are from wood burning stoves, creosote-treated wood, and vehicle emissions, including tire wear, improper motor oil disposal, and leaks. For most individuals, the largest exposures to PAHs are from food and smoking, with a lesser contribution from air emissions. The PAH CAP can be found at https://fortress.wa.gov/ecy/publications/SummaryPages/1207048.html.

The PAH CAP recommends a focus on sources of PAHs and calls for the mapping of railroad ties located near sensitive aquatic habitats. Creosote-treated wood is still used for the majority of railroad ties (93% nationally) (RTA, 2013). PAHs from creosote-treated wood near aquatic environments may potentially affect aquatic organisms.

Purpose of This Study

The purpose of this study is to address this recommendation by identifying sensitive aquatic habitat (near-shore marine water and freshwater) in Washington State that has the potential to be impacted by PAHs from creosoted-treated wood used in the construction of railroad lines. The information generated from this analysis will be used to help design a monitoring study to measure PAH levels in the areas identified.

Background - Creosote

Creosote is obtained by the distillation of a tar. It is that portion of the chemical products that remain heavier than water. There are two main types of creosote in industrial production (ATSDR, 2002):

- Wood-tar creosote has been used mainly in pharmaceutical preparations and is uncommon today, having been replaced by newer medicines.
- Coal-tar creosote is the most common form used in the United States and the most widely used wood preservative.

Creosote is a mixture of hundreds of chemicals, but PAHs make up over 75% of the mixture (ATSDR, 2002; WHO, 2004; Davies et al., 2012).

The behavior of creosote is complex and depends on the physical and chemical properties of the components, interaction with the matrix, and environmental conditions. Although creosote is distributed within all environmental compartments (air, water, sediment, soil, biota), the major environmental sinks of creosote components are sediment, soil, and groundwater (WHO, 2004).

Creosote components are released from creosote-treated wood by oil exudation (bleeding), leaching into water, or volatilization of the lighter fractions into the air (WHO, 2004). Bleeding may continue for many years and is enhanced on hot and sunny days.

Migration of creosote contaminants in soil appears to be slow and dependent on site-specific characteristics such as soil type, hydrogeology, amount of creosote released, transport processes (i.e., movement with bulk fluid), dispersion, adsorption, and decay (ATSDR, 2002; WHO, 2004).

Relatively little is known of the degradation and transformation of the creosote mixture because most studies have focused on its individual components. Generally, the majority of compounds are not completely degradable. Photochemical transformation of creosote seems to be the most important abiotic mechanism for transforming its components in the atmosphere, water, and soil (WHO, 2004; Poston, 2001). There are a variety of microbial metabolic pathways of degradation or transformation of creosote that involve the incorporation of oxygen-producing intermediate compounds that can be more persistent, mobile, and toxic (WHO, 2004; Brooks, 2004; Bandowe and Wilcke, 2010).

PAHs in Creosote

Most information available for creosote is for the PAH components. Generally, low-molecular-weight (2-3 ring structure) PAHs are found mainly in the gas phase in the atmosphere and partition selectively into the aqueous phase in water because they are generally more soluble and biodegradable than the high-molecular-weight (4-6 ring structure) PAHs. The high-molecular-weight PAHs tend to bind to particles in the air and dominate sediments (WHO, 2004; Poston, 2001).

Sediment characteristics can influence PAH levels. PAH concentrations are associated with organic matter, and rate of transport depends on biochemical influences and pore size. Silt and clay represent a more metabolized state of organic matter in which PAHs tend to transform to metabolites, move, or be bound.

Contaminated sediments are the largest concern for wildlife since sediment is where PAHs collect and can enter the aquatic food chain. Fine grain silt and or mud substrate characteristics are associated with marsh and wetland areas and pocket estuaries (connected lagoons and stream mouths) where juvenile salmon typically utilize these shallow water habitat with low wave energy (WDFW, 2010).

There is evidence that oxygen-containing PAHs (OPAHs) are more mobile, and their concentrations are frequently higher and more toxic than their parent PAH (Poston, 2001; WHO, 2004; Lundstedt, 2007; Shemer and Linden, 2007; Bandowe and Wilcke, 2010; Davies et al., 2012). They are direct-acting mutagens and carcinogens and produce reactive oxygen species responsible for oxidative stress causing health effects in salmonids (Lemieux et al., 2008). OPAHs are more soluble (higher polarity) than their parent PAHs, which attributes to mobility. Sources, concentrations, composition patterns, and fate of OPAHs in soil are not well studied in spite of their higher toxicity.

The PSTLA estimated that creosoted-treated wood accounts for approximately one-third of all PAH releases within Puget Sound, with marine pilings, railroad ties, and utility poles representing the major sources (Ecology and King County, 2011). Although these estimates are based on the best available information, releases and loads for some PAH sources remain incomplete or reflect high levels of uncertainty. The PSTLA recognizes that the conceptual model of PAH transport and fate following release is complex, and the limitations of PAH-loading estimates complicate the ability to draw conclusions.

Railroad operations are a larger portion of the total PAH releases statewide, compared to Puget Sound, because most of the railroad lines are not in the Puget Sound region (Ecology and King County, 2011; Davies et al., 2012).

Many railroads follow the contour of large streams and rivers, which leads to potential exposure of sensitive species and habitats from the creosote-treated wood leachate. However, crushed stone is often used as a base for support and drainage of the railroad line which would minimize water contact and leaching. To provide drainage, the ballast must be regularly cleaned and construction involves specific sub-grades, slopes, and technical requirements (American Rails, 2013). Interaction between the waterbody and railroad most likely would occur during a flooding event.

In NOAA's[1] (2009) recent guidelines for *The Use of Treated Wood Products in Aquatic Environments*, it is noted that the most likely sources of PAHs from railroads come from normal operations (e.g., exhaust from the engines, oils and greases, herbicides used along the tracks) and from coal dust. NOAA (2009) discusses results of a simulated wetland mesocosm by Brooks (2004) showing initial leaching of creosote from new railway ties to approximately 60 cm in depth, declining to depths around 10 cm after the first summer following installation. Brooks notes little movement horizontally. It should be noted that no analysis for PAH derivatives were conducted in Brook's study.

There is no comprehensive work to establish background levels of PAHs in soil in Washington State (Davies et al., 2012). Most of the work has been for investigation and cleanup of hazardous waste sites. Migration of PAHs from sources such as creosote-treated wood is also not well understood (ATSDR, 2002; Davies et al., 2012).

Spatial Characteristics of Contamination

The overall spatial characteristics of contamination from creosote-treated railroad operations is not well understood since, as mentioned above, relatively little is known of the degradation and transformation of the creosote mixture and most studies have focused on its individual components—largely individual PAHs. In general, the spatial extent of impacts is relatively small and limited to areas near structures made of creosote-treated wood.

Contamination can result from initial releases during new construction and ongoing leaching from the treated wood. Initial releases potentially affect all environments and biota near the site. Best management practices (BMPs) guide new projects to help reduce the initial impacts. The area of interest for this study is the ongoing release of PAHs from railroad sites and the potential impacts on nearby biota.

Areas that may be at risk from elevated concentrations of contaminants arising from creosote-treated wood in railroad operations include sensitive and protected near-shore habitat and protected species. Risk of contamination can be further categorized by certain site characteristics that increase the potential for accumulating these contaminants.

Site Characteristics

Most research confirms that sediments and soils are impacted by PAHs more than the water column in the long run. Aged creosote-treated wood has also been found to leach low concentrations of PAHs for decades following installation (Poston, 2001). Juvenile salmon migrating or feeding for extended periods of time (such as in nursery areas or estuaries) near creosote-treated wood could be exposed to toxics in sediment from consumption of contaminated prey (Poston, 2001).

[1] National Oceanic Atmospheric Administration's

Low-flow areas would be particularly susceptible to contaminated sediment deposition. Field studies have indicated that PAHs from creosote can accumulate to potentially deleterious concentrations in poorly circulated waterbodies or when the density of treated wood structures is high compared to the overall surface area of the waterbody (Stratus, 2006).

Some studies have examined the use of treated wood in over-water structures (e.g., bridges) and found the spatial extent based on increases in sediment PAH was localized to less than 10 meters (m) (33 feet (ft)) for small structures studied, but the sediment contamination is patchy and relatively mobile (Poston, 2001).

Temperature, Flow, and Precipitation

Increasing temperature is positively correlated with leaching, biodegradation, and toxicity of PAHs (Stratus, 2006; Poston, 2001; WHO, 2004; Celis et al., 2006). Furthermore, temperature was shown to be dependent on flow rate; temperature had an increased effect with an increase in flow rate. The combined effects of temperature and flow are greater than the effects of either alone (Stratus, 2006). Leaching was greatest in warm turbulent water. Temperature and flow are generally seasonal or episodic events.

Precipitation events that could flush contaminants bound to soil organic matter (SOM) or dissolved organic matter (DOM) could also be considered seasonal or episodic. Areas that would be susceptible to bank erosion could increase the potential for contaminant transport into critical areas defined above.

For the initial identification of potentially affected areas, this study did not use seasonal and episodic characteristics in the analysis because of increased variability and uncertainty. These characteristics should be addressed when selecting potentially impacted areas for sampling.

Methods

The primary objectives of this study were to identify and map primary sensitive habitats that could be affected by creosote-treated wood used in railroad operations. Analysis for this project used the Environmental Systems Research Institute (ESRI) ArcGIS10 program.

Analysis

The model schematic used for finding areas possibly affected by creosote-treated railroad lines can be found in Appendix A. The steps outlined in the model show the GIS process steps analyzed manually rather than using an automated GIS model.

Protected Species and Habitat

Sensitive biota and habitats were defined by using fish and wildlife (WDFW[2] and USFWS[3]) data for Salmonid Stock Inventory (SaSI), Priority Habitat and Species Areas (PHS), and National Wetlands Inventory (NWI). The SaSI data are represented as linear river or stream segments and reported in miles. The PHS and wetlands are represented as areas and reported in acres.

A layer was created using the SaSI location of salmon stock throughout Washington State. The inventory is a compilation of data on all wild stocks and a scientific determination of each stock's status as: healthy, depressed, critical, unknown, or extinct. Each stock is spatially described from the spawning locations of a stock down to the Pacific Ocean or the Columbia River.

Location of species listed for protection in the PHS and SaSI was used to create a layer for specifying sensitive habitats. The WDFW provides a PHS list of important fish, wildlife, and habitat information for management and preservation. The PHS list includes the WDFW Species of Concern List which includes all State Endangered, Threatened, Sensitive, and Candidate species. The PHS also includes the Federal Endangered, Threatened, and Candidate fish stocks. The list of these sensitive species is available from the WDFW at http://wdfw.wa.gov/conservation/phs/.

Riparian Habitats, Wetlands, and Flood Zones

Wetland and flood zone information was used to specify locations of sensitive near-shore areas. Not only aquatic biota depend on the wetland and flood riparian areas but, according to Cramer (2012), approximately 85% of Washington's terrestrial vertebrate wildlife species depend on riparian habitats for all or critical portions of their life histories.

To determine the distance used for a near-shore buffer around waterbodies, a literature search was conducted. An extensive literature review and science panel summarized recent work in the freshwater and marine environment on the relationship of habitat functions to buffer widths for

[2] Washington Department of Fish and Wildlife
[3] United States Fish and Wildlife Service

achieving a minimum of 80% effectiveness for several parameters. An average of 109 m (258 ft) buffer width with a range or 5–600 m for varying water quality parameters achieved 80% effectiveness (WDFW, 2009 and 2010).

For wetlands protection near high-impact land uses, Ecology recommended buffers of 300 ft for western Washington and 200 ft for eastern Washington as part of their guidance for Growth Management Act (GMA) (Granger et al., 2005). The difference between western and eastern Washington was based on literature that showed that wildlife species tend to concentrate more around wetlands and streams in arid climates and therefore are not as widely distributed.

Similar guidance is given by the Shoreline Management Act (SMA) for Washington shorelines. The minimum shorelands area is the land within 200 ft of Ordinary High Water Mark (OHWM), and maximum jurisdiction for shorelands is the entire 100-year floodplain[4] plus any land necessary to buffer critical areas along shorelines (Ecology, 2009). On rivers, the area includes the entire floodway and contiguous floodplain areas landward 200 ft from the floodway. More information about shorelines and SMA can be found at www.ecy.wa.gov/programs/sea/shorelines/smp/handbook/index.html.

Synthesizing the above information, a buffer width of 300 ft around waterbodies was used for this analysis to represent the distance needed for water quality protection for critical habitats. By applying 300-ft buffers to waterbodies, a relatively conservative approach was taken to capture any possible contamination plume under varying conditions. Floodplains were used as buffers if they were greater than the 300-ft buffer.

Areas of Concern

Areas of concern in Washington State were determined by selecting and clipping the combined coverage of waterbodies and railroad lines (included a 300-foot buffer). Acres (polygon features) or miles (linear features) were calculated for statistical summaries.

Statewide, the proportion of sensitive habitat areas were estimated using the areas identified within 300 feet of railroad lines divided by the total sensitive habitat areas statewide. For comparison, sensitive habitat area proportions were estimated for all railroads in Washington State compared with the proportion estimated for just active railroads within the state.

For a second perspective, the proportion of railroads near (within 300 ft of) sensitive habitat was estimated and reported in miles of railroad lines. Railroad lines identified near-sensitive habitat were further categorized based on whether there were one, two, or three types of sensitive habitat nearby (i.e., salmon stock inventory, priority habitats, or wetlands). Priority levels of concern included railroad lines near:

- All three types of sensitive habitats.
- Two of the three types of sensitive habitats.
- Only one type.

[4]100-year floodplain as designated by the Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program.

Data Sources

Table 1 shows a list of data used in this study. The agency owning the data and the estimated time period the data was documented is given in the table also.

Table 1. GIS Digital Data Used to Map Areas at Risk for Creosote Contamination.

Digital Data by Theme	Description	Custodian	Scale (K)	Source Time Period	Data Last Updated
Cartographic	WA State Base Map	ECY	500	1990/09	1990/09
Elevation	Digital Elevation Model (DEM)	ECY	24	2010/10	2010/10
Fish and Wildlife	Priority Habitat and Species Areas (PHS)	WDFW	24	2009	2009
Fish and Wildlife	Salmonid Stock Inventory (SaSI)	WDFW	24	2007/01	2007/01
Hydrology	National Hydrography Dataset v2.1 (NHD Flowline)	USGS, EPA, USDA, others	24	2012/01	2012/01
Hydrology	National Hydrography Dataset v2.1 (NHD Waterbody)	USGS, EPA, USDA, others	24	2012/01	2012/01
Shorelines	FEMA Flood Hazard Zones (Q3 Flood)	FEMA	24	1999	1999
Transportation	Railroads at 24K	WSDOT	24	1996-present	2012/2013
Wetlands	National Wetlands Inventory (NWI)	USFW	24	1977-present	2012

K: 1000
ECY: Ecology
EPA: Environmental Protection Agency
FEMA: Federal Emergency Management Agency
NRCS: Natural Resources Conservation Services
USDA: United States Department of Agriculture
USFWS: United States Fish and Wildlife Service
USGS: United States Geological Survey
WDFW: Washington Department of Fish and Wildlife
WSDOT: Washington State Department of Transportation

Some data are under license agreements restricting their distribution, and requests must be made directly to the appropriate agency (e.g., owner of the data). More information and access to some of the GIS data used in this study can be found at www.ecy.wa.gov/services/gis/data/data.htm.

Data were downloaded into a file geodatabase, and a Lambert Conformal Conic projection with North American Datum (NAD) 1983 HARN was applied, at a 1:24,000 scale.

Data Quality

The data were obtained through Ecology's GIS database (Ecology, 2013). Most metadata for the files used in this study claim to have the best-known data available for that file. Although the metadata reports that professional researchers were employed for the collection and documentation of these data, no claim is made as to the completeness of the data. Environmental data is dynamic, and users must recognize the data reflects a snapshot in time rather than absolute condition. Gaps in the data are inevitable. Overall, this was not a deterrent since this study is a broad approach to find areas with sensitive biota adjacent to railroad lines—a mapping exercise. See Appendix B for more information regarding data quality.

Results and Discussion

This project analyzed over 5600 miles of railroad lines listed in the spatial dataset by the Washington State by the Department of Transportation (WSDOT). An estimated 55% (3100 miles) are listed as active railroads. Waterbodies buffered for shoreline protection covered over 38 million acres in Washington. Sensitive areas included over 25 million acres of priority habitat for protected species and over a million acres of wetlands featured in the spatial data. Additionally, an estimate of over 30 thousand miles of rivers and streams were included in the Sensitive Salmon Stock Inventory dataset used in this evaluation.

Results of this study are discussed from two perspectives:

1. Statewide proportion of sensitive habitat areas found near railroad lines.
2. Miles of railroad lines near these areas of concern.

Using a buffer width of 300 ft around waterbodies, a conservative approach was taken for water quality protection for critical habitats. For the remainder of this report, "near"-sensitive habitat refers to a 300-ft buffer as described above.

Sensitive Habitat Areas

Statewide sensitive areas near railroad lines were found to be widely distributed. This is not surprising since sensitive biota is located statewide and railroad lines cover most areas of the state. Figure 1 shows the location of sensitive areas for salmon (using SaSI), PHS, and wetlands located near railroad lines listed by WSDOT.

The areas marking the salmon inventory reflect only those species listed for protection under state and federal law. These categories included candidate, threatened, and endangered for Endangered Species Act (ESA) listings and depressed, critical, and extinct for the state listings. Many of the wetland areas are small and not visible within this statewide extent.

From a statewide perspective, the buffered areas (NHD[5] Waterbodies and Flowline plus Flood Zones) were estimated to be about 1% of the total riparian (flood zone) areas analyzed within the state (Table 2).

Sensitive habitat areas near railroad lines consisted of less than 5% of the PHS habitat and about 2% of wetland areas statewide. These PHS and wetland areas were areas found within the buffer zone that was defined for riparian habitat (i.e., 300 ft and flood zones around waterbodies).

Although the proportion of sensitive areas near active railroad lines decrease (roughly half) when compared to all railroad lines, many miles of river or stream habitat that support salmonids (>500) and many acres of PHS and wetland habitats (>90,000 and >15,000 respectively) were near active railroads.

[5] National Hydrography Dataset

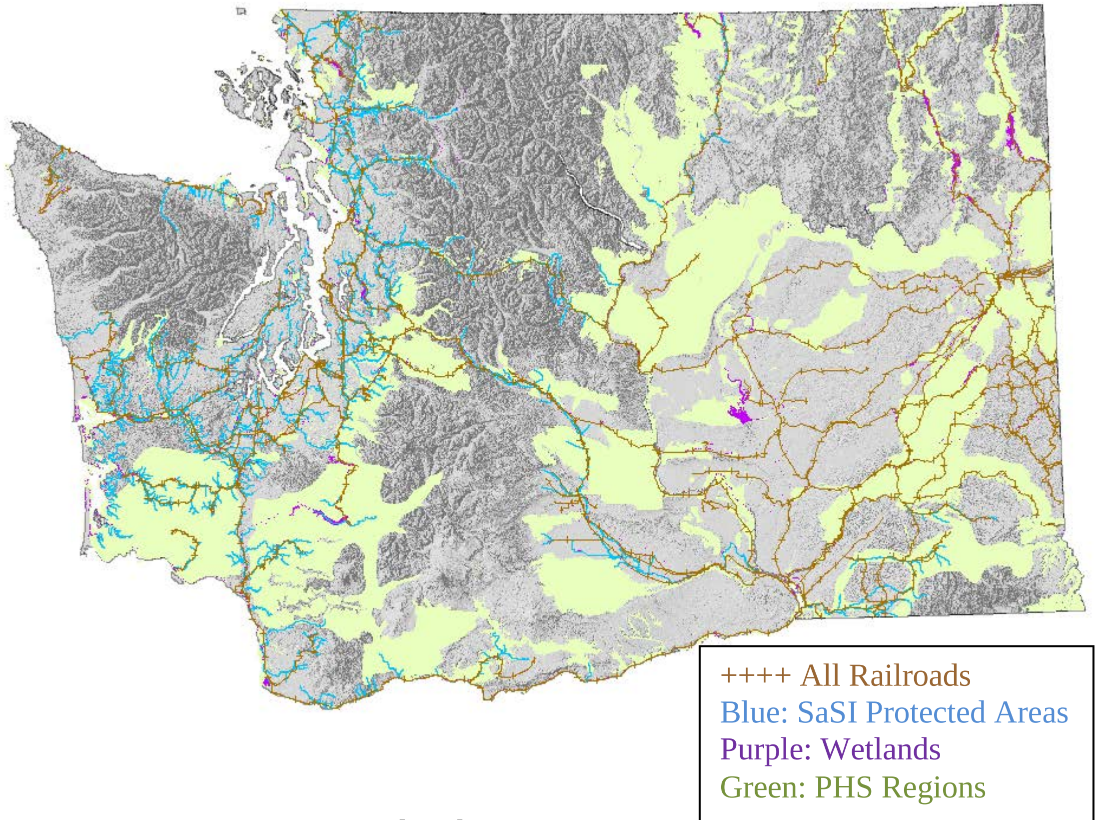


Figure 1. Sensitive Areas near Railroad Lines.

SaSI = Salmonid Stock Inventory; PHS = Priority Habitat and Species Areas.

Table 2. Sensitive Habitat Areas Evaluated Within 300 Feet of Railroad Lines in Washington State.

Area Name	**Unit**	**Statewide Total**	**All Railroads**		**Active Railroads**	
			Amount Used in Analysis	**%**	**Amount Used in Analysis**	**%**
Sensitive Salmonid Stock Inventory	Miles	30,500	1,120	4	533	2
Priority Habitat and Species	Acres	25,600,000	185,000	1	94,400	0.4
National Wetlands Inventory	Acres	1,140,000	25,500	2	15,800	1
NHD Waterbodies and Flowline plus Flood Zones	Acres	38,200,000	350,000	0.9	192,000	0.5

Sensitive Salmonid Stock Inventory (SaSI) is a subset of SaSI listed under state and federal governments. Categories: ESA listing candidate, threatened, and endangered. State listing depressed, critical, and extinct.

Railroad Lines

The risk of creosote-treated railroad tie contamination affecting biota due to chronic exposure increases with such a broad spatial extent. Railroad lines made with creosote-treated wood are found throughout the state. Railroad line miles and proportion near sensitive habitat areas of concern are listed in Table 3.

Table 3. Railroad Lines Miles Within 300 Feet of Areas of Concern.

Area Name	All RR		Active RR	
	(miles)[1]	(%)	(miles)[2]	(%)
Sensitive Salmonid Stock Inventory	436	8%	187	6%
Priority Habitat and Species	2365	42%	1282	41%
National Wetlands Inventory	1687	30%	1055	34%

1. Total of all railroad lines is 5614 miles.
2. Total of active railroad lines is 3135 miles.

More than 150 miles (about 6%) of the active railroads are located near protected salmonids, and more than 1000 miles (over a third of active railroad lines statewide) are near sensitive habitat. When all railroad lines are considered, the numbers of miles near these areas of concern were nearly double.

Priority Areas of Concern

Areas were prioritized for levels of concern depending on the location of the railroad lines next to three types of sensitive habitat: salmon stock inventory, priority habitats, or wetlands (Figure 2).

Lengths of railroad lines located near all three types of sensitive habitat were identified as Priority 1 level of concern. Priority 2 is railroad lines near two types of sensitive habitat. Railroad lines near only one type of sensitive habitat were categorized as Priority 3. Priority 2 and 3 are found statewide, whereas Priority 1 is clustered in the central, western, and southern portion of the state, where salmonids are found.

For all railroad lines, over 300 miles were identified as Priority 1. Many more miles of railroad lines statewide fell into the Priority 2 and 3 categories (>2000 and >3000, respectively). This represents roughly half of the railroad lines listed in Washington State.

For active railroad lines, nearly 200 miles were listed as Priority 1, over 1000 miles were Priority 2, and over 2000 miles were Priority 3 (Figure 3).

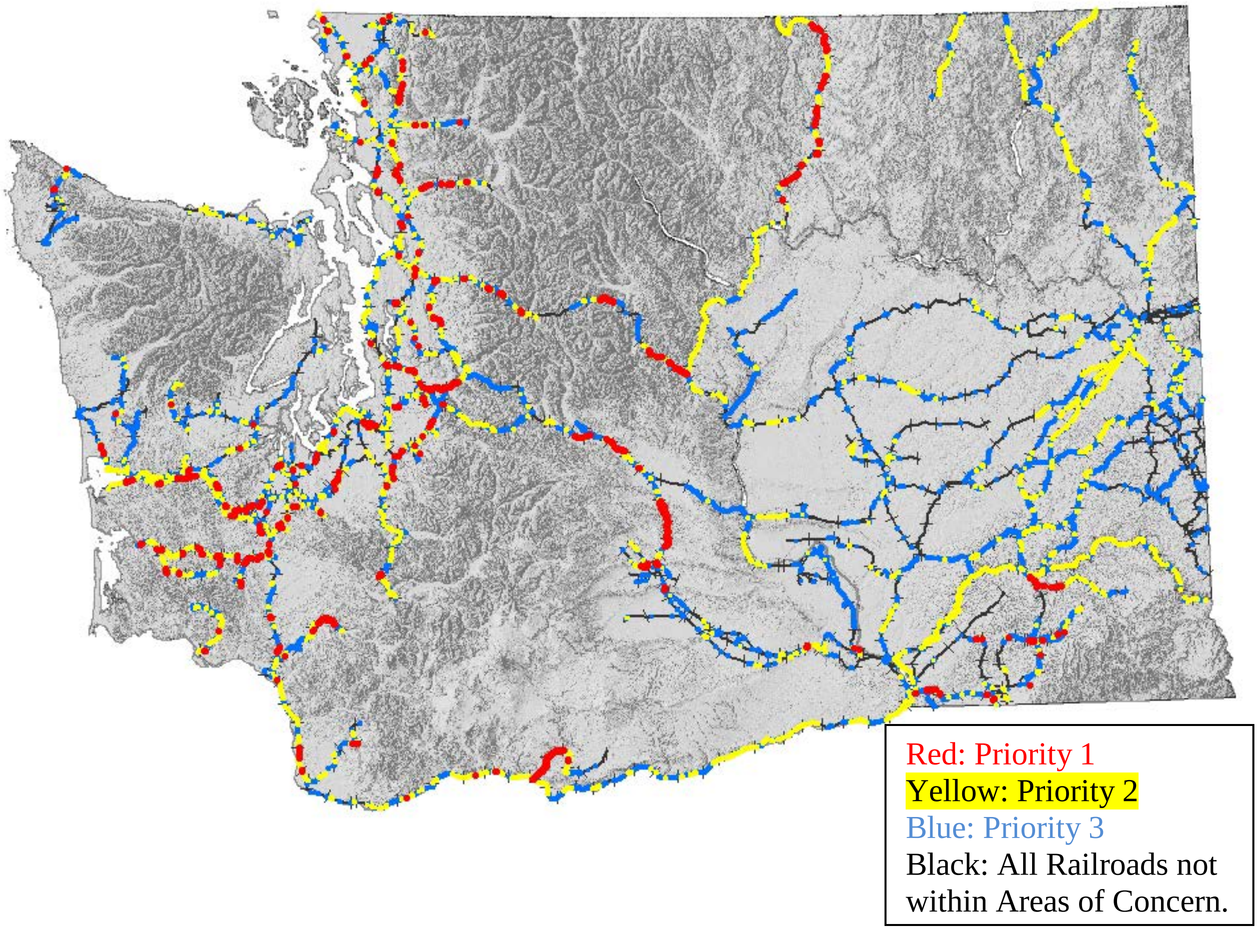


Figure 2. Priority Level of Concern for Railroad Lines near Sensitive Habitats.

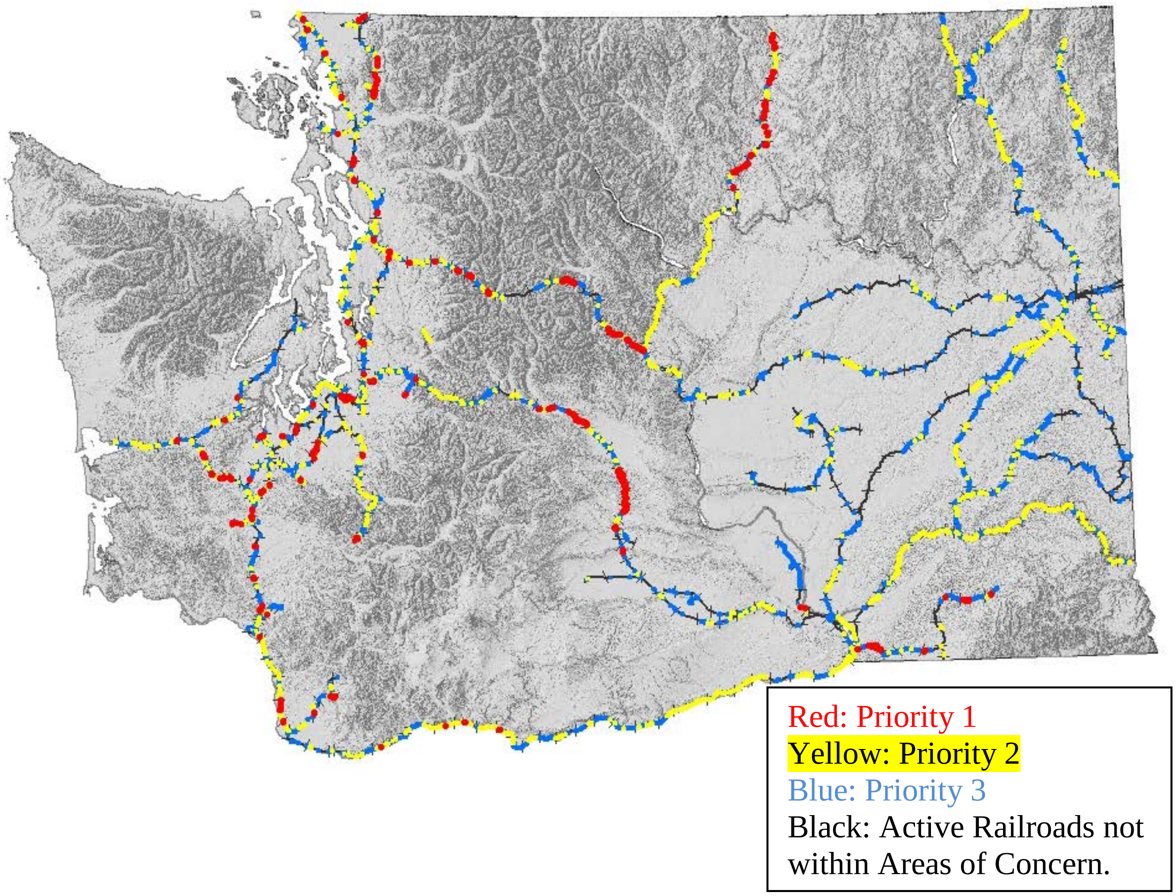


Figure 3. Priority Level of Concern for Active Railroad Lines near Sensitive Habitats.

The high proportion of railroad lines running near areas of concern is not surprising since railroad lines incorporate so much of the state and tend to be located in the more flat areas, which is where surface waters pool. Furthermore, given the millions of acres of sensitive habitat and thousands of miles of salmon streams, chances of railroad lines being located near some type of sensitive habitat seem likely.

The risk of adverse biological effects may be limited in spatial scale in many environmental settings and vary dramatically depending on site-specific characteristics. Site conditions affecting migration will be different at different locations.

The reader is reminded that this prioritization is designed to identify potential areas for sampling, not as a designation of actual risk.

Data Gaps and Uncertainty

There are many unanswered questions and data gaps regarding the potential impact from creosote-treated wood used in railroad operations. Because of this, the reported results of this analysis contain a degree of uncertainty and should be viewed as estimates. Most of the limitations and uncertainties fall into three categories:

1. Limited information on the fate and transport of creosote from treated wood products.
2. Limitations and uncertainties within the original datasets used in this project.
3. Assumptions used in the model for analyses.

Sources of uncertainty and data gaps identified are given below:

- The behavior of creosote is complex and depends on the physical and chemical properties of the components, interaction with matrix properties, and environmental conditions. Relatively little is known of the degradation and transformation of the creosote mixture because most studies have focused on its individual components such as individual PAHs rather than multiple PAHs or the creosote mixture itself.

- The FEMA Q3 flood data are currently being replaced by the new Digital Flood Insurance Rate Maps (DFIRM), but DFIRM is not yet available statewide. The DFIRM will replace the older (1999) FEMA Q3 flood data by county. A statewide digital file could be made once all the county DFIRM maps are available.

- Some uncertainty exists in calculating geometry from polygons and linear features. Even though the data were projected, a certain amount of variability is inherent when compared to absolute values taken from field surveys. The values for acres and miles should be viewed as best estimates of the data.

- The assumption is made that all railroad lines have creosoted railroad ties within the dataset available. The railroad line data do not contain information pertaining to the construction of the railroad, which is needed for identifying railroad lines that contain creosote-treated wood versus other materials. However, it is likely that the railroad ties are creosote-treated wood because only 6.5% of ties are made of concrete and the wood preservative, ammoniacal copper zinc arsenate (ACZA), has only been recently approved (Davies et al., 2012; RTA, 2013). An accurate inventory of railroad line construction materials would be necessary for further identifying specific locations of creosote-treated wood used in railroad operations within Washington State.

- Another assumption is that polygon and polyline analyses are topographically correct. Overestimation and underestimation bias could result from the way the model applies its calculation. Each step of the analyses was evaluated using best professional judgment, by comparing other data files to the mapped result, and by using the measuring tool within the model's workspace.

In an effort to reduce variability in identifying areas of concern, only non-seasonal and non-episodic data were used for analyses. An additional study may incorporate such data when identifying sampling locations within the areas reported here. The reader should view the results as a tool with which to design a sampling scheme under varying site conditions.

Follow-up Study

The present study is the first step in gathering and compiling information on areas that may be affected by contamination from creosote-treated railroad lines. The next step would be to use the information generated in the present analysis to conduct a small pilot study to evaluate if elevated concentrations of PAHs are present in the identified areas of concern.

Priority 1 areas of concern would be the first choice for sampling sites. Sites selected from Priority 2 should be included to increase the extent of sampling statewide in areas where salmonids are not present. Other factors to consider in selecting sampling sites for the pilot study might include:

- Railroad lines crossing streams
- Active flood zones
- High or unstable slopes near water
- Low flow conditions
- Solar availability
- Precipitation events
- Silt and clay soil and sediment substrate

These site characteristics may influence the mobility or presence of creosote components. Sample comparison between certain factors, such as active and inactive flood zones, and high and low solar and precipitation events, may be necessary since information is limited for creosote transport and fate. Additionally, sampling at different distances from the creosote-treated wood could help ascertain which buffer size is most appropriate in relation to defined sensitive habitat. Other local sources of creosote components (e.g., PAH), past or present, could contribute to sediment contamination and must be considered.

Conclusions

The analyses presented in this report demonstrate that creosote-treated wood used in railroad operations are located near sensitive habitat areas. Roughly half of the railroad lines are located near sensitive habitats that were prioritized as areas of concern in Washington State.

PAHs that leach from creosote-treated wood used for railroad lines have the potential to accumulate in the environment. However, the risk of adverse biological effects may be limited to the contaminant's potential to migrate and may vary dramatically depending on site-specific characteristics.

Railroad lines were prioritized as a concern for contamination according to whether they were near one, two, or three types of sensitive habitats: salmonid stock inventory (SaSI), priority habitats (PHS), or wetlands. Priority 1 consisted of railroad lines located near three types of sensitive habitats whereas Priority 2 and 3 had railroad lines near two or one sensitive habitats respectively.

Monitoring is recommended to evaluate whether contamination from creosote-treated wood used in railroad operations is elevated in the priority areas identified.

Recommendations

- A pilot study should be conducted to determine if elevated levels of PAHs are present in Priority 1 and 2 areas of concern for both active and inactive railroad lines. Priority 1 consists of railroad lines located near three types of sensitive habitats: salmonid stock inventory (SaSI), priority habitats (PHS), or wetlands. Railroad lines near two types of sensitive habitats are categorized as Priority 2. Selection of sampling locations could incorporate site characteristics (e.g., railroad lines crossing streams, active flood zones, high or unstable slopes near water, or more as listed above) that may increase mobility or presence of the contaminant. Analysis of PAH derivatives, along with parent compounds, should be included.

- If elevated levels of PAHs are discovered in the chemical sampling, an evaluation of biological impacts should be considered. This could include toxicity testing and macro invertebrate assessment.

- Data needs include background levels of PAHs and derivatives, more complete spatial data for railroad ties near sensitive areas, and statewide coverage for the most recent DFIRM flood data.

- Models should be developed to predict impacts of creosote-treated wood used in railroad operations in the environment if data suggest the need for models.

References

American Rails. 2013. Website. Copyright 2007-2013 American-Rails.com. www.american-rails.com. Accessed January 2013.

(ATSDR) Agency for Toxic Substances and Disease Registry, 2002. Toxicological Profile for Wood Creosote, Coal Tar Creosote, Coal Tar, Coal Tar Pitch, and Coal Tar Pitch Volatiles. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. www.atsdr.cdc.gov/toxprofiles/tp85.pdf. Accessed August 8, 2012.

Bandowe, B.A.M. and W. Wilcke. 2010. Analysis of Polycyclic Aromatic Hydrocarbons and Their Oxygen-Containing Derivatives and Metabolites in Soils. Journal of Environmental Quality. 39(4):1349-1358. https://www.agronomy.org/publications/jeq/abstracts/39/4/1349. Accessed October 24, 2012.

Brooks, K.M. 2004. Polycyclic Aromatic Hydrocarbon Migration from Creosote-Treated Railway Tie into Ballast and Adjacent Wetlands. Research Paper FPL-RP-617. U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI. 53 p.

Celis, R., M. Real, M.C. Hermosin, and J. Cornejo. 2006. Desorption, Persistence, and Leaching of Dibenzofuran in European Soils. Soil Science Society of America Journal. 70(4):1310-1317. https://www.soils.org/publications/sssaj/abstracts/70/4/1310. Accessed October 24, 2012.

Cramer, Michelle L. (managing editor). 2012. Stream Habitat Restoration Guidelines. Co-published by the Washington Departments of Fish and Wildlife, Natural Resources, Transportation and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service. Olympia, WA.

Davies, H., A. Stone, J. Grice, K. Patora, M. Kadlec, D. Delistraty, D. Norton, J. White. 2012. PAH Chemical Action Plan. Washington State Department of Ecology, Olympia, WA. Publication No. 12-07-048. https://fortress.wa.gov/ecy/publications/SummaryPages/1207048.html.

Ecology. 2006. Persistent Bioaccumulative Toxins, Chapter 173-333 WAC. Washington State Department of Ecology. Olympia, WA. https://fortress.wa.gov/ecy/publications/publications/wac173333.pdf. Accessed August 24, 2012.

Ecology. 2009. Shoreline Master Programs Handbook. Revised 2012. Washington State Department of Ecology. Olympia, WA. https://fortress.wa.gov/ecy/publications/SummaryPages/1106010.html. Accessed January 2013.

Ecology. 2013. Geographic Information Systems Data. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/services/gis/data/data.htm. Accessed January 2013.

Ecology and King County. 2011. Control of Toxic Chemicals in Puget Sound: Assessment of Selected Toxic Chemicals in the Puget Sound Basin, 2007-2011. Washington State Department of Ecology, Olympia, WA, and King County Department of Natural Resources, Seattle, WA. Ecology Publication No. 11-03-055.
https://fortress.wa.gov/ecy/publications/summarypages/1103055.html.

(EPA) United States Environmental Protection Agency. 2012. Integrated Risk Information System. http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showSubstanceList. Accessed January 12, 2013.

Granger, T., T. Hruby, A. McMillan, D. Peters, J. Rubey, D. Sheldon, S. Stanley, E. Stockdale. April 2005. Wetlands in Washington State - Volume 2: Guidance for Protecting and Managing Wetlands. Washington State Department of Ecology, Olympia, WA. Publication No. 05-06-008. https://fortress.wa.gov/ecy/publications/SummaryPages/0506008.html
www.ecy.wa.gov/programs/sea/wetlands/gma/index.html. Accessed January 2013.

IARC, 2010. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 92. Some Non-heterocyclic Polycyclic Aromatic Hydrocarbons and Some Related Exposures. International Agency for Research on Cancer.
http://monographs.iarc.fr/ENG/Monographs/vol92/mono92.pdf. Accessed January 13, 2013.

Lemieux, C.L., J.B. Lambert, S. Lunstedt, M. Tysklind, and P.A. White. 2008. Mutagenic Hazards of Complex Polycyclic Aromatic Hydrocarbon Mixtures in Contaminated Soil. Environmental Toxicology and Chemistry. 27(4):978-990.

Lundstedt, S., P.A. White, C.L. Lemieux, K.D. Lynes, I.B. Lambert, L. Oberg, P. Haglund, and M. Tysklind. 2007. Sources, Fate, and Toxic Hazards of Oxygenated Polycyclic Aromatic Hydrocarbons (PAHs) at PAH-Contaminated Sites. Ambio, Vol. 36, No. 6. Springer on behalf of Royal Swedish Academy of Sciences. www.jstor.org/stable/25547797.

NOAA Fisheries. 2009. The Use of Treated Wood Products in Aquatic Environments: Guidelines to West Coast NOAA Fisheries Staff for Endangered Species Act and Essential Fish Habitat Consultations in the Alaska, Northwest and Southwest Regions. National Oceanic Atmospheric Administration. Southwest Region.
http://swr.nmfs.noaa.gov/pdf/Treated%20Wood%20Guidelines-FINALClean_2010.pdf. Accessed January 2013.

Poston, T., Battelle. 2001. Treated Wood Issues Associated with Overwater Structures in Marine and Freshwater Environments. Submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Department of Transportation. http://wdfw.wa.gov/publications/00053/. Accessed March 2013.

RTA. 2013. Internet Home Page, Railway Tie Association**.** www.rta.org/. Accessed April 2013.

Shemer, J. and K.G. Linden. 2007. Photolysis, Oxidation and Subsequent Toxicity of a Mixture of Polycyclic Aromatic Hydrocarbons in Natural Waters. Journal of Photochemistry and Photobiology A: Chemistry. 187:186-195.

Stratus. 2006. Creosote-Treated Wood in Aquatic Environments: Technical Review and Use Recommendations. Prepared for National Marine Fisheries Service, Southwest Region, Habitat Conservation Division by Stratus Consulting, Inc., Boulder, CO. December 31, 2006. http://swr.nmfs.noaa.gov/wood/Creosote_Report-final.pdf. Accessed January 2013.

(WDFW) Washington Department of Fish and Wildlife. 2008. Priority Habitat and Species List. Olympia, Washington. 177 pp. http://wdfw.wa.gov/publications/00165/wdfw00165.pdf. Accessed January 2013.

(WDFW) Washington Department of Fish and Wildlife. 2009. Protection of Marine Riparian Functions in Puget Sound, Washington. Olympia, Washington. Prepared by Washington Sea Grant. http://wdfw.wa.gov/publications/00693/wdfw00693.pdf. Accessed January 2013.

(WDFW) Washington Department of Fish and Wildlife. 2010. Protecting Nearshore Habitat and Functions in Puget Sound. EnviroVision, Herrera Environmental and Aquatics Habitat Guidelines Program. http://wdfw.wa.gov/publications/00047/wdfw00047.pdf. Accessed January 2013.

WHO, 2004. Coal Tar Creosote. World Health Organization. Concise International Chemical Assessment Document 62, 149 pages.

Appendices

Appendix A. Model Schematic for GIS Analyses

Figure A-1. Sensitive Habitat Areas near Railroad Lines Model.

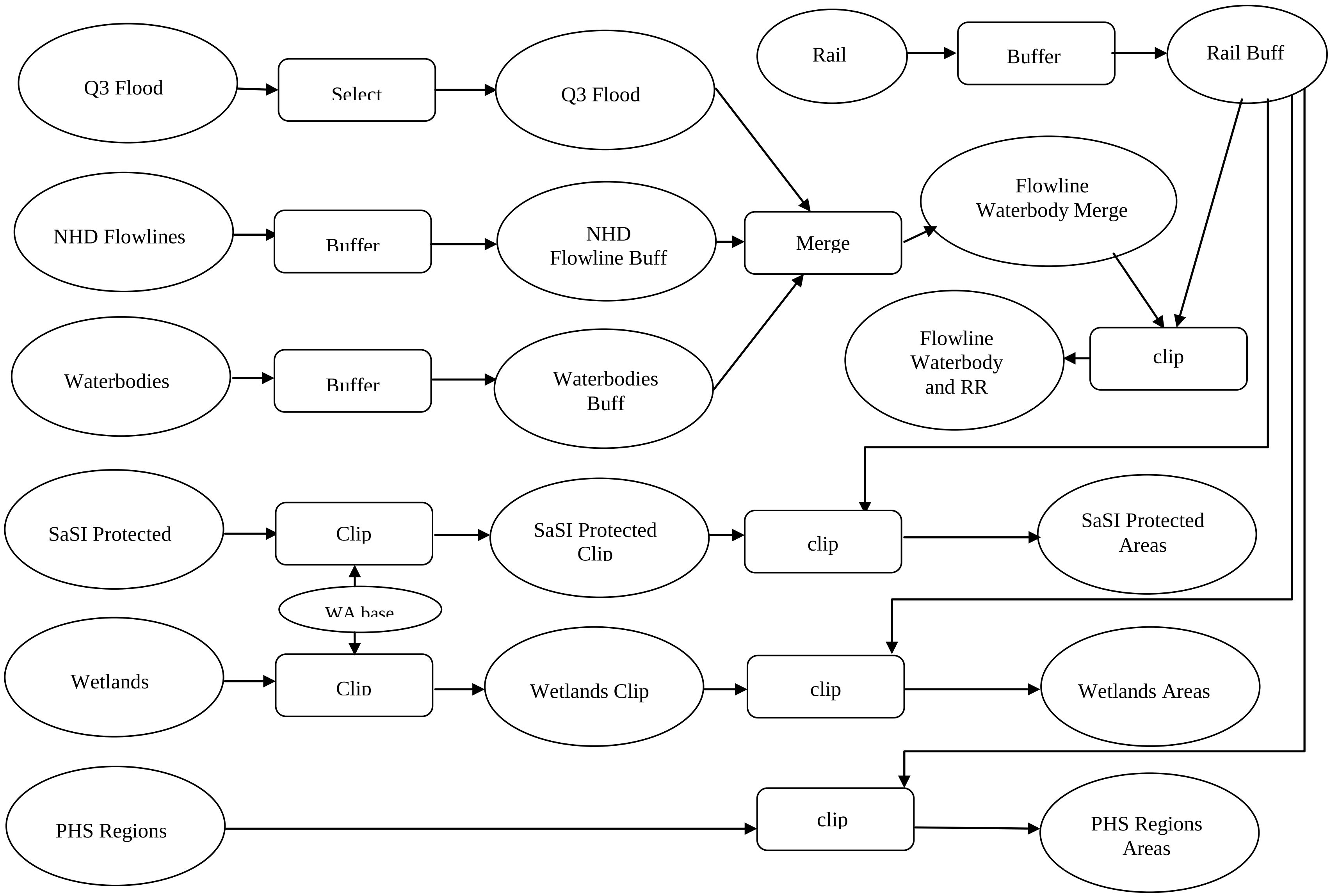


Figure A-2. Railroad Line Miles near Sensitive Habitat Model.

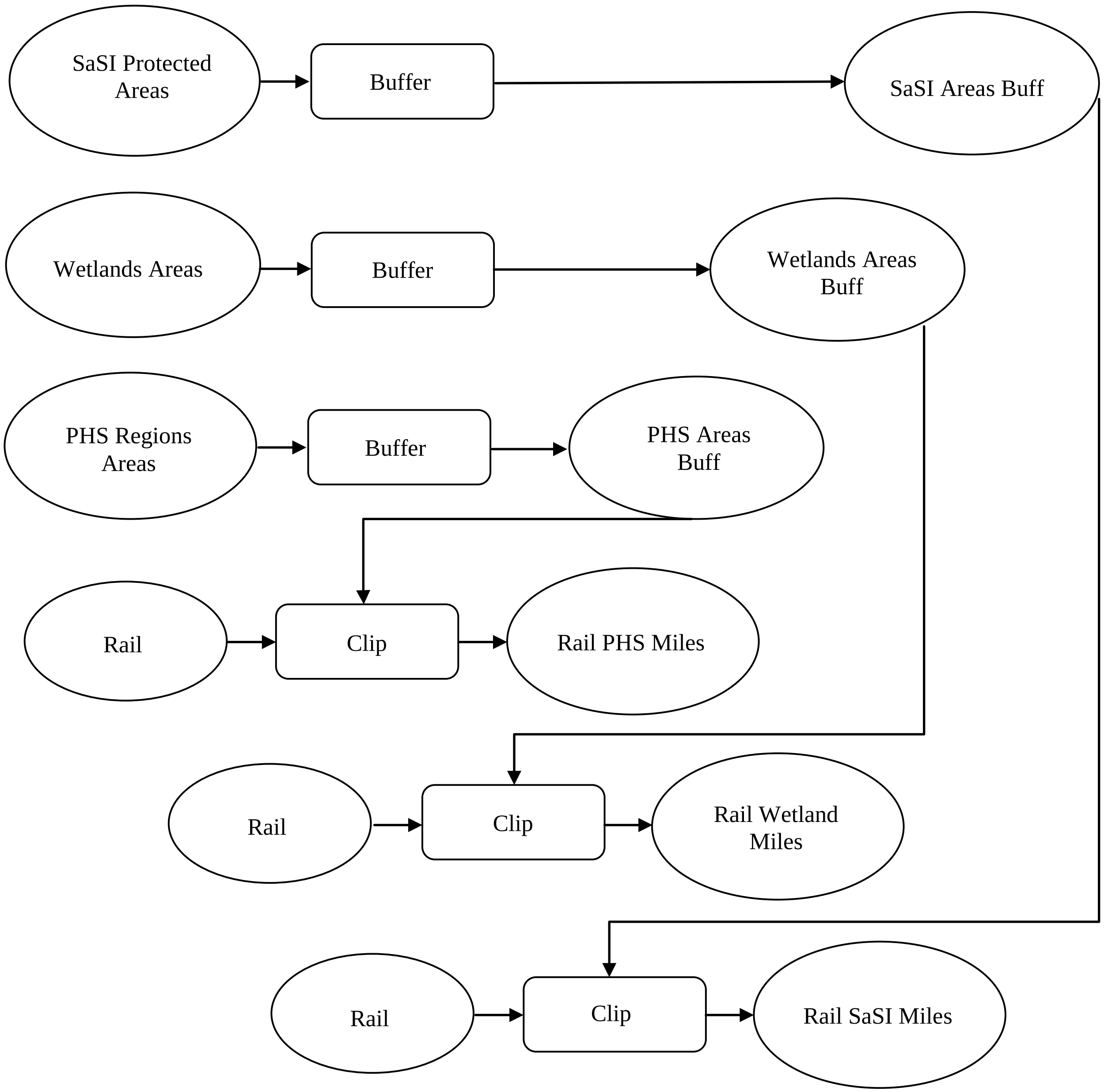
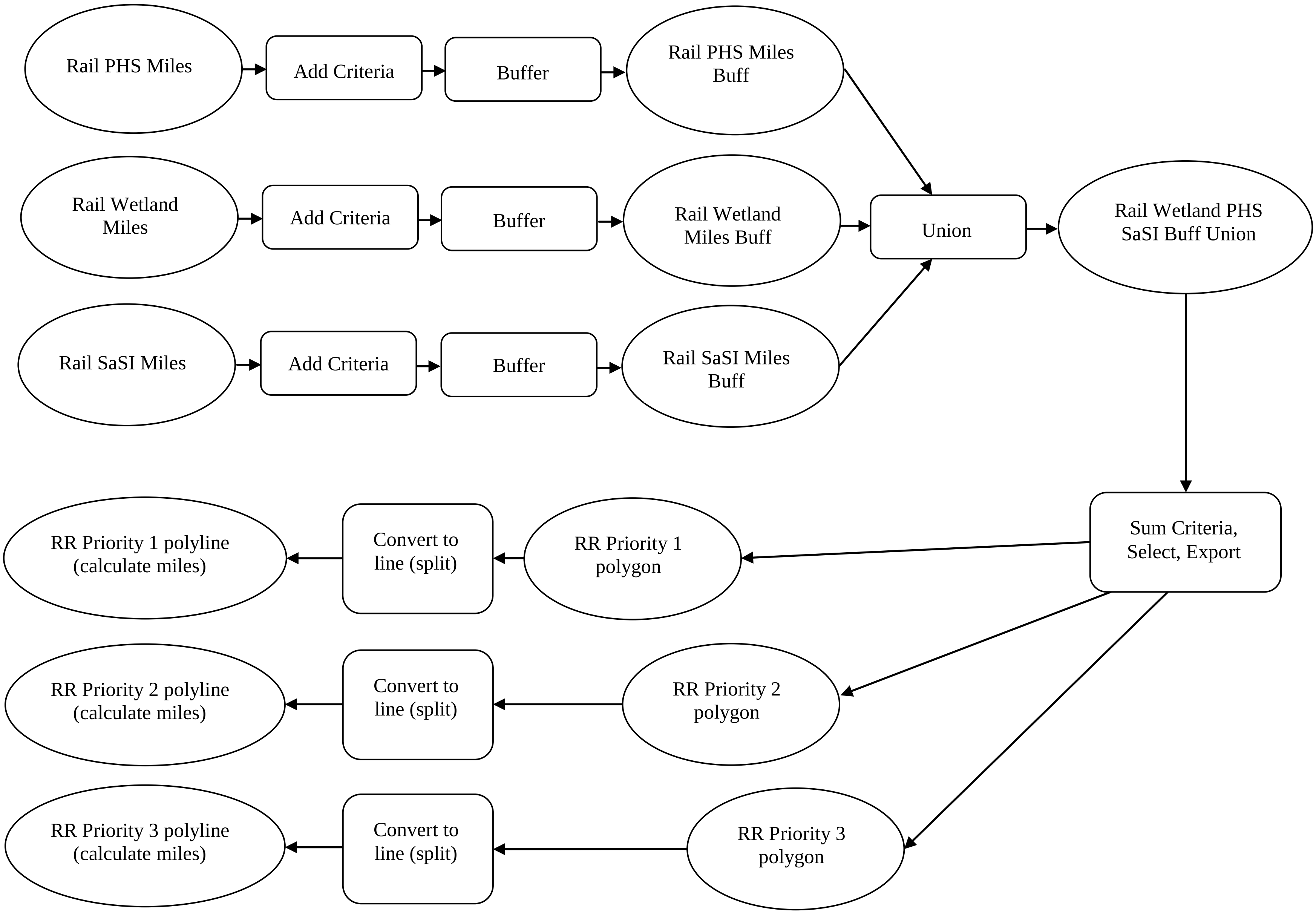


Figure A-3. Priority Areas of Concern Model.



Appendix B. Data Quality

The data used in this study were obtained through Ecology's GIS database. Most metadata for the files used in this study claim to have the best-known data available. Although the metadata reports that professional researches were employed for the collection and documentation of these data, no claim is made as to the completeness of the data. Environmental data is dynamic, and users must recognize the data reflects a snapshot in time rather than absolute condition. Gaps in the data are inevitable. Overall, this was not a problem since this study was a broad approach to find areas with sensitive biota adjacent to railroad lines—a mapping exercise.

Ecology continually upgrades their GIS database. Spatial attributes are updated when available. Most of the data used for this study were recently updated; exceptions include the FEMA Q3 flood data. New Digital Flood Insurance Rate Maps (DFIRM) are becoming available for most counties in Washington, but not yet statewide, leaving data gaps. The DFIRM will replace the older (1999) FEMA Q3 flood data.

The PHS is the most comprehensive and current list available for identifying sensitive habitat and species for Washington State, but because fish and wildlife are mobile and habitats change, project reviews should not rest solely on mapped information (WDFW, 2008). The PHS data show presence of species or habitat but do not show that a species or type of habitat is not present.

Model Quality Assurance

Sensitive Habitat

A subset of data was tested to compare the impact from two different ways (models) for finding areas within the buffer zone of 300 ft. One model intersected the railroad lines with buffered waterbodies (hence referred to as waterbodies buffered or WbBuff), while the other model intersected buffered railroad lines with waterbodies having no buffer (hence referred to as waterbodies with no buffers or RailBuff).

RailBuff showed a higher percent of selected areas than WbBuff (14.4% and 12.6% respectively). The difference came from the inability of the RailBuff model to merge the polygon files (e.g., lakes, reservoirs, and flood zones) to the linear files (e.g., rivers and streams). In the WbBuff model, the linear files were buffered, which created polygon files compatible for merging. Therefore, the RailBuff model tended to overestimate areas of possible impact because there were more polygons (more areas) selected within the individual files. This percentage difference would likely be increased when using the whole dataset.

The WbBuff model may also overestimate impacted areas but to a lesser degree than the RailBuff model. These overestimations would be caused from the model's recognition of individual features as digitized within the dataset. For example, river segments are described spatially in a variety of lengths or sections. These sections may begin or end inside or outside of the area of interest for this study. If part of the section is outside the area being analyzed then an overestimation error will occur because the model will only select the section as a whole rather than divide it.

To reduce the bias of overestimation of sensitive habitat, a combination of the two models was used. WbBuff areas were clipped by railroad lines with a buffer distance of 300 ft from the tracks. The buffer distance around the railroad lines represents a conservative estimate of the mobility of the creosote-treated wood contamination.

Railroad Lines

When estimating miles of railroad lines near sensitive habitat, the models found a potential for underestimating miles. This was caused by some railroad lines not being included during selection. Some line features within 300 feet, but not intersecting sensitive habitat areas, were missed. Using the buffered railroad line feature as the selecting layer produced the same results as the buffered habitats. Both produced underestimation bias.

To compensate, sensitive habitats previously identified within 300 feet of the railroad lines were buffered 300 feet in order to recapture the railroad lines when selected. As might be expected, this produced an overestimation bias.

Using the subset of data described above, bias was evaluated. One bias underestimated miles of railroad lines near sensitive habitat by about 37% while the other bias overestimated miles of railroad line by about 12%. This study applied a method that favored capturing more railroad lines rather than missing sections that may be located near sensitive habitat. The overall impact of using this method appears to be less than 5% when estimating the difference of the results statewide using the percent error found in the subset test. In light of the uncertainties, results from this study should be considered estimates.

Appendix C. Glossary, Acronyms, and Abbreviations

Glossary

Anthropogenic: Human-caused.

Benchmark: A concentration of a contaminant that produces a biological response in association with some element of environmental exposure. They are advisory rather than regulatory and help assess environmental impacts where standards are under review or do not exist.

Best Management Practices (BMPs): Conservation practices or systems of practices and management measures that:

(a) Control soil loss and reduce water quality degradation caused by high concentrations of nutrients, animal waste, toxics, or sediment;

(b) Minimize adverse impacts to surface water and ground water flow and circulation patterns and to the chemical, physical, and biological characteristics of wetlands;

(c) Protect trees, vegetation and soils designated to be retained during and following site construction and use native plant species appropriate to the site for re-vegetation of disturbed areas; and

(d) Provide standards for proper use of chemical herbicides within critical areas.

Buffer or Buffer Zone: The area contiguous with a critical area that maintains the functions and/or structural stability of the critical area.

Critical Areas: Critical areas include any of the following areas or ecosystems: critical aquifer recharge areas, fish and wildlife habitat conservation areas, geologically hazardous areas, frequently flooded areas, and wetlands, as defined in RCW 36.70A and this Chapter.

Floodplain: Synonymous with one hundred-year flood plain and means that land area susceptible to inundation with a one percent chance of being equaled or exceeded in any given year.

Floodway: The area, as identified in a GMA or SMA, that either: (i) Has been established in Federal Emergency Management Agency (FEMA) flood insurance rate maps or floodway maps; or (ii) consists of those portions of a river valley lying stream ward from the outer limits of a watercourse upon which flood waters are carried during periods of flooding that occur with reasonable regularity, although not necessarily annually, said floodway being identified, under normal condition, by changes in surface soil conditions or changes in types or quality of vegetative ground cover condition, topography, or other indicators of flooding that occurs with reasonable regularity, although not necessarily annually.

Growth Management Act (GMA) (RCW 36.70A.060) and 36.70B, as amended: The GMA was adopted by the legislature in 1990 and amended in 1995 to require counties and cities to include the best available science in developing policies and development regulations to protect the functions and values of critical areas.

Ordinary High Water Mark (OHWM): That mark which is found by examining the bed and banks of waterbodies and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, that the soil has a character distinct from that of the abutting upland in respect to vegetation.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Q3 Flood Data: A digital FIRM product developed and distributed by FEMA. Q3 Flood Data are developed by scanning and vectorizing the existing hardcopy FIRM to create a raster product suitable for viewing or printing, as well as a thematic vector overlay of flood risks. Q3 Flood Data capture all FIRM data in the raster file, but vectorize only certain features.

Riparian Habitat: Areas adjacent to aquatic systems with flowing water that contain elements of both aquatic and terrestrial ecosystems that mutually influence each other.

Salmonid: Fish that belong to the family *Salmonidae*. Species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm.

Shorelands: Shorelands include those lands extending landward 200 feet in all directions as measured on a horizontal plane from the ordinary high water mark (OHWM).

Shorelines of the State: The total of all "shorelines," as defined in RCW 90.58.030(2)(d), and "shorelines of statewide significance" within the state, as defined in RCW 90.58.030(2)(c).

Shoreline Management Act (SMA) (RCW 90.58): The SMA was passed by the Legislature in 1971 and adopted by the public in a 1972 referendum. The goal of the SMA is "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines." The Act governs the use and development of Washington's shorelines and creates a unique partnership between local and state government.

Species: Any group of animals or plants classified as a species or subspecies as commonly accepted by the scientific community.

Species, Endangered: Any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state (WAC 232-12-297, Section 2.4).

Species, Priority: Any fish or wildlife species requiring protective measures and/or management guidelines to ensure its persistence at genetically viable population levels as classified by the Washington Department of Fish and Wildlife, including endangered, threatened, sensitive, candidate, and monitor species, and those of recreational, commercial, or tribal importance.

Species, Threatened: Any wildlife species native to the state of Washington that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state without cooperative management or removal of threats (WAC 232-12-297, Section 2.5).

Species, Sensitive: Any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened throughout a significant portion of its range within the state without cooperative management or removal of threats (WAC 232-12-297, Section 2.6).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Washington Administration Code (WAC): Administrative guidelines implementing the Growth Management Act, WAC 365-190 and WAC 365-195, as amended.

Wetlands: Areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

Acronyms and Abbreviations

ACZA	Ammoniacal copper zinc arsenate
BMP	Best management practice
DOM	Dissolved oxygen matter
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System software
GMA	Growth Management Act
NHD	National Hydrography Dataset
NOAA	National Oceanic Atmospheric Administration
NRCS	Natural Resources Conservation Services
OHWM	Ordinary High Water Mark
OPAH	Oxygen-containing PAHs
PAH	Polycyclic aromatic hydrocarbons
PBT	Persistent, bioaccumulative, toxic chemical
PHS	Priority habitat and species areas
PSTLA	Puget Sound Toxics Loading Analysis
SaSI	Salmonid Stock Inventory
SMA	Shoreline Management Act
SOM	Soil organic matter
SSURGO	Soil Survey Geographic
USDA	United States Department of Agriculture
USFW	United States Fish and Wildlife
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

Units of Measurement

cm	centimeters
ft	feet
m	meter
ug/L	micrograms per liter (parts per billion)