

# Modeling Tool

## Report Contents

This report details project-specific results of using a custom environmental assessment model to predict the maximum in-water and sediment concentrations of contaminants downstream of a preserved wood structure proposed for construction in/over an aquatic environment. Included are:

- A description of the model basis;
- The project-specific user inputs entered into the model, with user notes and identifying information about the proposed project;
- The model results, with Charts 1 & 2 and Tables 1 & 2 providing key results (i.e., the maximum predicted in-water and sediment concentrations of the contaminants used as active ingredients in the preservative selected), followed by assorted supplemental result tables;
- And a list of definitions of model input parameters.

## Model Basis

Models provide an opportunity to predict outcomes based on theory, empirical data describing relationships and site and temporal specific inputs. Levels of sophistication can vary from simple to extremely complex. However, complexity does not necessarily mean that models do a better job of predicting outcomes. Weather forecasting is an excellent example of low albeit improving success using very complex models. That is largely due to the complexity of atmospheric dynamics.

This model strives for simplicity by making worst case assumptions for driving the various preservative-specific models that have been integrated. This leads to predictions of environmental levels of contaminants that are generally higher than those actually observed in model verification studies making the models conservative from an environmental risk perspective. It is emphasized that the models are not designed to provide exact predictions of environmental responses on small spatial scales (meters). They are designed to conservatively predict specific sites where pressure treated wood projects have a reasonable probability of creating an unacceptable environmental risk and a range of projects and sites where there is little environmental risk.

The following sources provide additional information regarding this model:

- [Modeling the Environmental Risks Associated With Pressure Treated Wood Used in Sensitive Environments](#) (Dr. Kenneth Brooks, Feb. 2009 - Chapter 9 of aquatic science book titled: *Managing Treated Wood in the Environment*).
- [Screening Level Assessment Process and Worksheets For Endangered Species Act and Essential Fish Habitat Consultation on Proposed Applications of the Treated Wood in Aquatic TEnvironments](#) (Western Wood Preservers Institute, April 1, 2011).

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## Model Input Definitions

### 6. Piling retention

Enter the preservative retention in the piling provided by the producer. If this information is not available, then enter the retention specified in the latest version of the *American Wood Protection Standards*.

### 7. Number of pilings in a row paralleling the currents

Enter the number of piling in rows that most closely parallel the current vector.

### 8. Number of piling bents

Enter the number of rows of pilings.

### 9. Average piling radius

Enter the average radius of the piling used in the project.

*For most projects, the value for this input will be between 2 and 11.8 in.*

### 10. Distance between piling in a row paralleling the currents

Enter the average distance between the centers of pilings driven in rows paralleling the currents.

### 11. Surface area of sawn lumber that is immersed at mean high water (MHW)

This requires access to the project plans. Sum the surface areas of all sawn lumber (all wood excepting piling) that is immersed when the tide is less than or equal to MHW. Tidal heights for small areas are published by the National Oceanographic and Atmospheric Agency (NOAA) and are available on the Internet. For bulkheads that are backed by earth, enter the surface area facing the water plus the two sides of each board. The side in contact with the soil is considered non-leaching with respect to the waterbody.

### 12. Immersed lumber retention

When available, enter the average measured retention provided by the treated wood producer. When that information is not available, enter the retention specified for this use in the latest version of the *American Wood Protection Standards*.

### 13. Surface area of sawn lumber and piling above mean high water (MHW) exposed to rainfall

Enter the surface area (cm<sup>2</sup>) of all piling and lumber in the structure that is above MHW and exposed to rainfall. For piling the surface area is that area located on all perimeters of the structure. For each perimeter piling, this is  $\pi \times r \times \text{height}$  above MHW because only the outer half of the piling is exposed to rain. The inner half is assumed to be under the structure. This is provided only as a guide and special circumstances, such as the use of pin piling will require other approaches.

### 14. Above water lumber retention

This is generally the same as the Immersed Lumber Retention.

### 15. Box width or width of a stream channel under an overhead structure

The box width may be less than the structure's width when the structure is oriented at an angle to the prevailing currents. For structures crossing rivers, streams or estuaries, the box width is the channel width of the stream at the flow used to define the current speed. For bulkheads, the box width is one meter, which assumes that mechanical mixing associated with the bulkhead will initially distribute contaminants to a distance of one meter from the bulkhead. Users may choose higher widths for bulkheads located in energetic environments or slower widths for bulkheads associated in ponds or other quiescent water bodies.

### 16. Mean water depth in the box (measured as the depth at mean high water (MHW) in tidal systems)

This is the mean depth of water within the box. In shallow waters, it can be determined using a measured wading staff. In waters of intermediate depth, it can be measured using a weighted tape measure. In deeper waters, the depth is most easily determined using a boat mounted depth sounder. Transects need to be run orthogonal and parallel to the current vector through the center of the project and then averaged. For streams, at least six measurements spaced equally across the channel are recommended. Where depths vary significantly, it may be necessary to partition the box into segments representing different depths. In this case, the partitions must be assessed as individual boxes. However, this is not usually necessary.

#### 17. Maximum tidal current speed or $V_{\text{harmonic}}$

Current speeds can be measured with a number of staff mounted or weighted electromagnetic or mechanical devices. Rough estimates can be obtained by placing a plastic bottle that is 3/4 full of water about two meters upcurrent from a mark on the shore (or the upstream edge of a bridge) and measuring the time required to move past a distance defined by the width of a bridge or a second mark on the shore. The model requires an assessment of the maximum current speed in a tide cycle ( $V_{\text{max}}$ ). Assuming a mixed, semidiurnal tidal regime, at least three measurements should be made three hours before and after slack tide and the six or more data averaged. Measurements should be made on an exchange to mean low water (MLW).

*For most projects, the value for this input will be between 0 and 11.8 in/sec.*

#### 18. Steady state current speed or $V_{\text{ss}}$

The same methods described for Maximum tidal current speed or  $V_{\text{harmonic}}$  are appropriate for determining steady state current speeds. In streams and rivers, a current speed determination should be made at each of the points where water depth is measured, giving six values, which are averaged. In tidally driven systems, triplicate measurements of  $V_{\text{ss}}$  should be made at slack tide. The speed at slack tide should be approximately equal to the difference in  $V_{\text{harmonic}}$  measured three hours before and after slack tide.

*For most projects, the value for this input will be between 0 and 11.8 in/sec.*

#### 19. Average annual water temperature

For purposes of evaluating long-term sediment accumulation of contaminants, an average annual temperature is appropriate. For major river systems, this can be determined from U.S. Geological Survey records. State records are useful for determining average temperatures in many water bodies. In areas where temperatures fluctuate significantly, users may want to evaluate water column concentrations of contaminants at water temperatures appropriate for the time of year when construction is anticipated. This will require two assessments one at the average temperature for sediments and another at the temperature expected during construction.

*For most projects, the value for this input will be between 5 and 27.5 degrees C.*

#### 20. Freshwater pH

This can be measured using any one of the available field or laboratory pH meters. U.S. Geological Survey and state records can also be useful. Where large fluctuations in pH occur as a function of season, users should enter a value appropriate for the time of year when construction is anticipated because in some cases it affects the loss rates of metals from pressure treated wood.

*For most projects, the value for this input will be between 5 and 9 std. pH units.*

#### 21. Water hardness

Water hardness is important for determining the bioavailability and toxicity of metals in freshwaters. It can be measured in the field using selective ion probes or in the laboratory using inductively coupled plasma (ICP) analysis for determination of calcium and magnesium. Hardness is reported in mg  $\text{CaCO}_3/\text{L}$  equivalents and is used by the model to calculate EPA water quality criteria for comparison with model predictions.

*For most projects, the value for this input will be between 0 and 125 mg/L.*

#### 22. Salinity

Salinity can be measured electrometrically using any one of a number of salinity and/or conductivity meters (Standard Method 2520) or by titration in the laboratory (SM 210C). Waters having a salinity < 2.0 ppt are considered freshwaters.

*For most projects, the value for this input will be between 0 and 40 ppt.*

#### 23. Background dissolved copper concentration

Copper is typically evaluated in a laboratory using inductively coupled plasma (ICP) (EPA Method 200.7).

*For most projects, the value for this input will be between 0 and 17  $\mu\text{g Cu/L}$ .*

#### 24. Background dissolved arsenic concentration

Aquatic organisms are less sensitive to arsenic, zinc and chromium than they are to copper. However, these other contaminants may be important, especially when the water is used for humans or livestock. Arsenic is typically measured using inductively coupled plasma (ICP) (EPA Method 200.7).

*For most projects, the value for this input will be between 0 and 360  $\mu\text{g As/L}$ .*

#### 25. Background dissolved chromium concentration

Dissolved chromium is determined using EPA Method 200.7.

*For most projects, the value for this input will be between 0 and 548.7  $\mu\text{g Cr/L}$ .*

#### 26. Background dissolved zinc concentration

Zinc is typically evaluated using inductively coupled plasma (ICP) (EPA Method 200.7).

*For most projects, the value for this input will be between 0 and 114.5  $\mu\text{g Zn/L}$ .*

#### 27. Background dissolved penta concentration

Pentachlorophenol is not typically found outside of industrial areas or in some cases adjacent to railway rights of way. When there is reason to believe that penta may exist in the background, triplicate water samples should be evaluated. This may be accomplished using EPA (8151) by gas chromatography with an electron capture detector (GC/ECD).

*For most projects, the value for this input will be between 0 and 13  $\mu\text{g penta/L}$ .*

#### 28. Annual rainfall

Rainfall data is available from the U.S. Natural Resources Conservation Service (NRCS) in soil surveys or from National Oceanographic and Atmospheric Agency (NOAA). In the United States, this is usually given in inches/year.

*For most projects, the value for this input will be between 0 and 98.4 in/year.*

#### 29. Storm event

Trials runs with the model suggest that contaminated rainwater runoff from pressure treated wood structures during storm events has little effect on the predicted concentration of contaminants in water—unless unrealistic amounts of rainwater runoff are introduced to a small body of water whose flow does not respond to the storm. The model allows users to evaluate the effects of increased rainfall during storm events. This input defines the rate of rainfall.

*For most projects, the value for this input will be between 0 and 2 in/hour.*

#### 30. Duration of the storm event

The length of the storm event is entered here. Because water body flows are not programmed (in the model) to increase during storm events, this input has little effect on predicted concentrations. In reality, high rainfall events lasting more than a few hours will increase stream flows as the unit hydrograph responds to increased rainfall in the watershed.

*For most projects, the value for this input will be between 0 and 36 hours.*

### 31. Sediment total organic carbon (TOC)

TOC should be measured in sediments whenever either creosote or pentachlorophenol treated wood is proposed and a site specific assessment is required. Non-polar organic contaminants like pentachlorophenol and polycyclic aromatic hydrocarbon (PAH), bind to organic carbon-reducing their bioavailability and toxicity. Few governmental jurisdictions have published marine sediment quality criteria (SQC). Washington State is an exception and their SQC have been adopted for this risk assessment. Sedimented PAH in the SQC are based on sediment TOC. At one percent TOC, the SQC for HPAH is 9.6 mg HPAH/kg dry sediment. At two percent TOC the SQC for HPAH is 19.2. The model uses this input to determine SQC for both PAH and pentachlorophenol. TOC is determined in a laboratory using available elemental analyzers.

*For most projects, the value for this input will be between 0 and 5 percent.*

### 32. Sediment density

The recommended value of 2.6 g/cm<sup>3</sup> should not be changed unless site specific information indicates otherwise.

*For most projects, the value for this input will be between 2 and 4.3 g/cm<sup>3</sup>.*

### 32a. Sediment redox potential for penta

This endpoint should be determined for all projects involving either creosote or pentachlorophenol treated wood. The redox potential discontinuity (RPD) is easy to measure in the field. For full risk assessments, redox potential can be measured using probes. These measurements are typically made in the field. The depth of the RPD is determined by measuring the depth in the sediments where the matrix's chroma and value decline sharply and become dull or black due to the accumulation of iron sulfide in anaerobic layers.

*For most projects, the value for this input will be between -250 and 500 mV.*

### 32b. Depth of the redox potential discontinuity (RPD) for creosote

This endpoint should be determined for all projects involving either creosote or pentachlorophenol treated wood. The redox potential discontinuity (RPD) is easy to measure in the field. For full risk assessments, redox potential can be measured using probes. These measurements are typically made in the field. The depth of the RPD is determined by measuring the depth in the sediments where the matrix's chroma and value decline sharply and become dull or black due to the accumulation of iron sulfide in anaerobic layers.

*For most projects, the value for this input will be between 0.5 and 4 cm.*

### 33. Background sediment copper concentration

When required, triplicate samples should be analyzed in the laboratory using inductively coupled plasma (ICP) and EPA Method 6010 following a strong acid digestion. Reported as mg Cu/kg dry sediment.

*For most projects, the value for this input will be between 0 and 390 mg/kg.*

### 34. Background sediment arsenic concentration

When required, triplicate samples should be analyzed in the laboratory using inductively coupled plasma (ICP) and EPA method 6010 following a strong acid digestion.

*For most projects, the value for this input will be between 0 and 57 mg/kg.*

### 35. Background sediment chromium concentration

When required, triplicate samples should be analyzed in the laboratory using inductively coupled plasma (ICP) and EPA Method 6010 following a strong acid digestion.

*For most projects, the value for this input will be between 0 and 260 mg/kg.*

### 36. Background sediment zinc concentration

When required, triplicate samples should be analyzed in the laboratory using inductively coupled plasma (ICP) and EPA Method 6010 following a strong acid digestion.

*For most projects, the value for this input will be between 0 and 410 mg/kg.*

### 37. Background sediment penta concentration

When required, sediment concentrations of pentachlorophenol can be determined using EPA Method 8151 by gas chromatography with an electron capture detector (GC/ECD) to evaluate triplicate sediment samples. It is recommended that background concentrations of this compound be determined only if there is reasonable cause to suspect some previous or ongoing contamination.

*For most projects, the value for this input will be between 0 and 0.4 mg/kg.*

### 38. Background sediment polycyclic aromatic hydrocarbon (PAH) concentration

Sediment concentrations of PAH can be determined using either high performance liquid chromatography (HPLC) with EPA Method 8310 or gas chromatography/mass spectrometry (GC/MS) analyses using EPA Method 8270.

*For most projects, the value for this input will be between 0 and 37.6 mg/kg.*

### 39. Days since construction for determining contaminant concentrations in water

Preservative loss rates from pressure treated wood decline with time with the highest losses occurring immediately after construction. Washington State acute water quality criterion (WQC) are one hour concentrations and a user entry of 0.5 days is recommended for comparison of predictions with acute criteria (this may be different in your region). Chronic criteria are generally a four day average and a user entry of 2.0 days is recommended for comparison with these criteria. This user entry has no effect on predicted sediment accumulation of contaminants. However, preservative loss rates and water column concentrations can be evaluated for any day during the life of the project by manipulating this entry.

### 40. Anticipated lifespan of the project

Default is 35 years with a minimum of 10 years. If a project is expected to remain in place for longer than 35 years, enter the larger expected lifespan here. If the project is temporary or it is expected that periodic storm events will refresh sediments through erosion or accretion, you may enter the period at which you expect these events to occur. However, entries of < 10 years will result in errors because of the way in which the model assesses the accumulation of metals.

*For normal use, an expected lifespan of 35 years is recommended.*

### 41. Channel width

Width of receiving channel of water. For projects crossing streams or those located in narrow channels, dilution zones are constrained by the boundary conditions imposed at the shoreline. The width of dilution zones will not exceed the channel width entered here.

## Default Model Input Values

### Site-Specific Conditions

The site specific conditions include the physical setting of the project such as the type of water body (freshwater or marine), the velocity of the current in the water body, water depth, rainfall, sediment characteristics, pH, water temperature, and other background water quality characteristics. These factors are key inputs for assessment of treated wood applications and are used as inputs in this model. In the event any of these parameters are unknown for your project, the default values listed below for these model inputs were chosen to produce conservative results (i.e., higher contaminant concentrations).

### Project Design

The exposure of treated wood to the aquatic environment can be from submerged wood structures such as piling or timbers, from overhead structures such as decking or from both. The proposed number of piling is a key factor. The below list of assumptions regarding the project design are factored into the default model input values.

All projects should be undertaken in conformance with the guidance provided in the *Best Management Practices for the Use of Treated Wood in Aquatic and Other Sensitive Environments (BMPs)* (Western Wood Preservers Institute, 2006). This includes BMPs for product production, quality assurance, installation and management. BMPs are available online at [www.wwpinstitute.org](http://www.wwpinstitute.org).

## Default Values

The following simplified assumptions were factored into as default model input values to allow the user to arrive at a conservative finding in determining if the project would qualify for a "[no effect](#)" determination. These assumptions are summarized below:

- Piling are spaced 3.0 m apart (~10 ft), and it is recommended the user conservatively assume each piling will support an overhead deck structure covering an area of 3.0 m x 3.0 m = 9 m<sup>2</sup> or approximately 100 ft<sup>2</sup> of decking including associated railing.
- The assessment conservatively assumes that all treated wood components are placed on Day 0.5.
- The anticipated lifespan of the project is 35 years.
- In freshwater, current speeds are an average of those found at mid depth within the project's footprint.
- In tidally driven marine environments, the current speed is the Maximum tidal current speed. Based on this maximum speed, the model computes average speeds for determining sediment concentrations and the mean speed within half an hour either side of slack tide for determining maximum water column concentrations of the chemicals of concern.
- Water depths within the footprint of the project are not critical but are assumed to be spatially similar and equal to 2.0 m depths.
- Freshwater environments: pH = 6.5; Temperature = 15 degrees C, background copper = 1.5 µg Cu/L, Hardness = 50 mg CaCO<sub>3</sub>/L.
- Sediment environment: Density = 2.6 g/cm<sup>3</sup>; Sediment Total Organic Carbon = 1.0 %; Background Sediment Copper = 15 mg Cu/kg; Background concentrations of PAH (Creosote) and Pentachlorophenol = 0.0.
- Annual rainfall = 100 cm/year (40 in/year); Rainwater pH = 6.5. No significant storms occur during or immediately after construction.
- Pentachlorophenol assessments were conducted assuming a conservatively low sediment redox potential of 50 mV.