Assessment of the Risks to Aquatic Life from the Use of Pressure Treated Wood in Water

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Executive Summary

Wood preservatives are chemical pesticides that are applied to wood to protect it from decay brought about by fungi or insect attack. While preservatives can be brushed on, sprayed on, or soaked into wood, the most effective treatment is to force preservative solutions deeply into the wood under high pressure. Creosote, pentachlorophenol, and inorganic arsenicals such as chromated copper arsenate (CCA) are the three most widely used wood preservative compounds. When preserved wood is used for in-water construction such as pilings, break walls, abutments, or other submerged or partially submerged structures, the potential exists for the toxic preservatives to leach from the wood. The purpose of this assessment is to evaluate whether or not preservative compounds leaching from treated wood have the potential to harm aquatic life. Available scientific literature for each of the three types of preservatives was reviewed to attempt to assess the potential risks to aquatic life from the use of pressure treated wood in water. For all three wood preservatives, the greatest amount of leaching occurs when freshly-treated wood is first installed in the water. The rate of leaching drops off significantly after this short initial period of relatively high leaching. In general, any impacts to aquatic life are most likely to occur during that initial period of high leaching. The greater the distance from the treated wood, the more dilute the concentration of leached preservative, and the lower the likelihood of adverse impacts. For each of the three preservatives, fate processes such as volatilization, photolysis, sediment sorption and microbial degradation work to degrade and reduce the concentration of the preservative both in the water and in sediments, even during the initial period of high leaching. For each specific type of wood preservative, recommendations are provided for minimizing the risks to aquatic life. In summary, the use of pressure treated wood in water is unlikely to have significant impacts on aquatic life. However, wood treated with pentachlorophenol should not be used in salt water. Two additional findings of the risk assessment are that creosote and CCA treated wood does not present a hazard to marine organisms when used in salt water, and utility poles in wetlands are also unlikely to cause adverse ecological impacts, particularly after the poles have been in place longer than one to three months.

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1. Purpose

The purpose of this document is to assess the ecological risks from using pressure treated wood in water. This document does not discuss risks associated with terrestrial uses of pressure treated wood. Likewise, it does not discuss safe handling, use, and disposal of treated wood, scrap, or sawdust. It does not discuss human health concerns. The primary focus of the risk assessment is the use of pressure treated wood in fresh water. However, the use of pressure treated wood in other related habitats such as wetlands and marine waters is also discussed. This assessment is only applicable to wood that has been properly pressure treated. Wood that has been soaked, dip-treated, brush or spray treated, or treated with any other wood preservative process other than pressure treatment should never be placed in water or used near natural water bodies.

All wood preservatives have the potential to leach out, to some degree, from pressure treated wood that is submerged in water. While the assessment does attempt to make a quantitative assessment of the potential from such leaching, it is impossible to model every possible scenario. For example, a large number of submerged, treated wood structures in a small water body with a small outlet will pose much greater risk to aquatic life than a small number of similar structures in a large, deep lake or river. The results of the assessment are general, and must be carefully applied to any specific real-world situation.

2. Background

Wood preservatives are compounds that prevent wood from being decayed, degraded, or otherwise attacked by insects or fungi. These compounds act to defeat fungi and insects by being acutely toxic to fungal spores that might land on the wood, or insects that attempt to eat wood or bore into the wood for habitation or to lay eggs. The preservatives can be applied in a number of different ways. They can be brushed or sprayed on; wood can be dipped or soaked in a cold solution of the preservative, or wood can be dipped or soaked in a heated preservative solution. These methods only provide surface protection. Preservatives applied in this manner will wear away, or insects and fungi can penetrate through holes made by nails or screws, or through minute checks and cracks that develop naturally in wood over time.

To provide long term protection of wood, it must be pressure treated. In this process, the wood is placed in a pressure cylinder. The preservative solution is introduced and the internal pressure of the cell is raised to as much as 150 psi for six to eight hours. Under those conditions, the preservative is driven deeply into the wood. After the pressure is vented off, the wood is removed and allowed to dry. Depending on the size and type of wood, the preservative can completely permeate the wood. In more dense wood, the preservative may penetrate as little as

0.4 inches. Under any circumstance, the preservative is driven as deeply into the wood as practicable and the interior of the wood is better protected than with topical applications. However, if the treated layer is breached, such as by a nail- or screw-hole, or natural check or crack in the wood, the untreated interior will be vulnerable to fungi and/or invertebrate attack.

There are three main kinds of preservative pesticides commonly used for pressure treatment of wood: creosote, pentachlorophenol, and inorganic arsenicals. Creosote is a complex mixture of polycyclic aromatic hydrocarbons (PAHs) that are products of the fractional distillation of coal tar. Pentachlorophenol is a manufactured organochlorine pesticide. Inorganic arsenicals are various blends of metallic oxides and arsenic, such as CCA (chromated copper arsenic); or mixtures of metallic oxides, arsenic, and other compounds such as ACZA (Ammoniacal Copper Zinc Arsenate). All three wood preservatives prevent wood decay because they are toxic to insects and to fungi.

The weight of preservative in a given volume of wood in the treated zone is known as ***retention***, and is measured in pounds per cubic foot (pcf). The American Wood-Preservers' Association (AWPA) is a professional/technical society for individuals and organizations interested in wood preservation. In the AWPA Book of Standards, recommendations are provided regarding the preservative retention required for different purposes depending on the type of wood, the specific preservative to be used, and where it will be used. For example, based on the 1989 AWPA Book of Standards (standards can change with time), Eastern (northern) white pine to be used for lumber, timber or ties above ground should be treated to the following retentions: creosote, 8.0 pcf; pentachlorophenol, 0.4 pcf; CCA, 0.25 pcf. A typical white pine 2" X 4" X 8' stud consists of approximately 0.27 cubic feet of wood. If pressure treated, the stud would contain about 2.16 lbs of creosote, 0.11 pounds of pentachlorophenol, or 0.07 lbs of copper, chromium, and arsenic, assuming that the preservative penetrated completely through the wood.

Wood preservatives are pesticides, and as such, they must be registered for use by the U.S. Environmental Protection Agency in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). In October 1978, the EPA issued notices of Rebuttable Presumptions Against Registration (RPAR) on creosote, pentachlorophenol, and inorganic arsenical wood preservatives. The issuance of the RPARs meant that the U.S. EPA had concerns about the potential for adverse human health and environmental effects from the use of these compounds. In July 1984, the U.S. EPA issued "Notices of Intent to Cancel" the FIFRA registrations of creosote, pentachlorophenol, and inorganic arsenical wood preservatives, unless the manufacturers agreed to certain changes in the registrations. The "Notices of Intent to Cancel" the registrations were further amended by the U.S. EPA in January 1986.

In their assessment, the U.S. EPA determined that although wood preservative chemicals are pesticides, treated wood itself was not considered a pesticide, and need not be regulated as such. Changes to registrations of the three wood preservative compounds dealt mostly with the use of the preservatives themselves during the wood treatment process. U. S. EPA's regulatory

changes included such items as making the three types of preservatives restricted use pesticides, requiring protective clothing be worn by wood treatment operators, establishing standards about how the compounds were to be used and disposed of, not allowing the use of creosote or pentachlorophenol treated wood in the interiors of homes or other buildings unless properly sealed, etc. Regarding the use of treated wood itself, the U.S. EPA instituted a voluntary Consumer Awareness Program (CAP) which required that consumer information sheets (CIS) be developed by the manufacturers, approved by the U.S. EPA, and provided to the end-users of treated wood (see Section 10). One of the requirements stipulated by the U.S. EPA was that wood treated with creosote, pentachlorophenol, or inorganic arsenicals should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks and bridges.

There is a growing demand for the use of preserved wood in structures that are to be submerged in water. Docks, for example, are built upon preserved wood pilings. Break walls and other structures are also often built out of heavy timbers that have been pressure treated with preservatives. The U.S. EPA review focused primarily on the potential impacts to human health from the use of wood preservative compounds to treated wood, and the potential impacts of treated wood itself on human health. The U.S. EPA did not examine in detail the potential for adverse ecological impacts from the use of treated wood in water.

3. Summary of Findings and Recommendations

Following are general recommendations pertinent to all three types of wood preservatives, and more specific findings and recommendations for each individual type of wood preservative when used in water. Each of the three types of wood preservatives are then discussed in detail in separate sections.

A. General - applicable to <u>all</u> types of pressure treated wood:

1. **Only wood bearing a stamp, tag, or brand certifying that the treatment was accomplished in accordance with the standards of the American Wood-Preservers' Association (AWPA) should be used for in-water construction.** The accompanying stamp or tag will show the type of preservative, the retention, the recommended use, and the applicable AWPA standard. The standards described in the AWPA Book of Standards specifically for in-water applications should be carefully adhered to.

2. Only wood treated in accordance with Western Wood Preservative Institute Best Management Practices should be used for in-water construction.

3. Contract-writers should specify compliance with AWPA standards and WWPI BMPs when writing contracts for submerged, treated wood structures. Consumers should inquire about compliance with the same standards / BMPs when

purchasing pressure treated wood for use in water.

4. The U.S. EPA states that for all types of pressure treated wood: "Treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks or bridges." The EPA warning statement is vague, because the difference "indirect contact" and "incidental contact" is not defined. The EPA does describe the use of treated wood for docks and bridges as incidental contact and therefore acceptable in public drinking water. This guidance recommends that before using pressure treated wood in New York State waters classified A, AA, A-S, or AA-S for structures other than docks or bridges, consult with the regional office of the New York State Department of Health, or the Pesticide Control Specialist in the regional office of the Department of Environmental Conservation.

4. Wood that has been re-treated because it failed inspection following the first pressure-treatment application of a preservative should not be used for in-water construction.

5. Comprehensive environmental literature reviews and risk assessments for creosote, pentachlorophenol, CCA (Chromated Copper Arsenate), ACZA (Ammoniacal Copper Zinc Arsenate), and ACQ (Ammoniacal Copper Quat) have been produced for the Western Wood Preserver's Institute (Brooks, 1997, 1998, 1997a, 1997b, and 1998a). These reports include comprehensive computer models for estimating preservative losses from submerged structures. In order to predict site-specific risks, these models should be consulted when designing large products with significant volumes of treated wood, or projects using treated wood in small, low flow, or poorly flushed waters. See Section 9.

B. Creosote:

1. Creosote-treated wood used in water does not pose a significant risk to aquatic life. Any actual impacts are likely to be short term and occur when the treated wood is first installed in the water. A thin film or sheen frequently appears on the surface of the water around a creosote-treated wood structure immediately after the structure is put in place. The sheen results from low quantities of volatile PAHs leaching from the wood. The sheen can be controlled by the installation of an absorbent boom around the treated wood structure, but that might serve to concentrate the chemical odor present while the materials evaporate from the water. Aquatic organisms that dwell immediately at the air-water interface could be impacted while the sheen is present. The presence of a sheen, however, is not indicative of the presence of contaminants from creosote treated wood in the water column under the sheen.

2. Creosote treated wood should be aged at least three months in air following treatment, before being installed in water. This will allow some of the volatile, low and medium molecular weight components to evaporate, reducing or eliminating the period of time during which a sheen is visible on the water's surface after the wood is installed in the water. For effective evaporation to occur during the aging, the treated wood needs to be stacked in such a way that air can circulate freely through the pile. The wood should not be stacked at a location where precipitation running off the wood could drain into a natural water body.

C. Pentachlorophenol

1. The use of penta treated wood in water is unlikely to harm aquatic life. Measurable impacts might occur only during the first month after the wood is installed and the potential for leaching is at its highest. For large projects with significant volumes of treated wood, there should be adequate flow to keep the concentration of penta in the water from exceeding the New York State ambient water quality standard for the protection of fish propagation and survival. This flow rate is a site specific value that must be determined during the design stage of a proposed project, by using a model such as Brooks (1998).

2. Penta treated wood should be aged three months after treatment and prior to submersion. This aging period will allow time for some of the carrier oil to evaporate and for the binding of penta with lignin in the middle lamella to begin, thus reducing the potential for higher rates of leaching when the treated wood is first installed in the water. For effective evaporation to occur during the aging, the treated wood needs to be stacked in such a way that air can circulate freely through the pile. The wood should not be stacked at a location where precipitation running off the wood could drain into a natural water body.

3. Wood treated with pentachlorophenol should never be used in water with salinity greater than 8‰. The AWPA has no standard for the use of penta treated wood in saline waters.

D. Chromated Copper Arsenate (CCA) and other Inorganic Arsenicals

1. During the treatment process, copper, chromium, and arsenic form insoluble complexes within the wood. Because of the insoluble nature of the precipitates, the metals are unlikely to leach much, except under very acidic conditions (pH of 3.5 or less). However, a very small fraction of the CCA preservative will leach from the wood. Also, unreacted surface deposits of metal oxides are soluble. When CCA-treated wood is first placed into the water, there will be an initial period of relatively high leaching that drops off sharply with time. The amount of copper and arsenic that will leach from the wood is not likely to be

harmful to aquatic life.

2. CCA-treated wood must pass the Chromotrophic Acid test (AWPA Standard A3-97)) before being used for in-water construction. This test shows that at least 99.6% of the chromium (VI) has been reduced to Chromium (III). When this has been achieved, there is likely to be little loss of any metal from the treated wood.

3. When CCA-treated wood is proposed for in-water construction, the wood should be treated with CCA type C to minimize leaching potential. CCA Type C is the most common formulation of CCA currently being produced.

5. CCA treated wood should be clean and free of obvious surface deposits of preservative. When deposits are present, they should be removed by washing under running water. The wash water must not be allowed to run off into natural water bodies.

E. Construction practices for all types of treated wood.

1. Cutting, shaping, drilling, and other construction activities should not be conducted near the water where sawdust, chips, or other debris might fall into the water.

2. Sawdust, chips, waste wood, and other debris should be collected and disposed of properly.

4. Alternatives

In recent years, a number of products made out of recycled plastic have become available as substitutes for pressure treated wood. These products are designed to replace treated wood for fencing, pilings, and decking, etc. In general, the findings of this assessment are that the use of pressure treated wood in water is unlikely to cause adverse ecological impacts to aquatic ecosystems. However, there is far less uncertainty about the ecological risks from the use of products made from plastics. They are safer because their resistance to decay is not derived from toxicity. Plastic pilings, timber, or decking are simply unsuitable substrate for most fungi or insects to subsist in or on. A discussion of whether or not recycled plastic products have the necessary structural or functional integrity to replace pressure treated lumber, or whether or not they are economically viable replacements for pressure treated lumber is beyond the scope of this risk assessment, however, one useful discussion of this topic can be found in Breslin et al, (1998).

The use of alternative materials for in-water construction should be strongly considered when a large structure is proposed in a small water body, or numerous structures made out of pressure treated wood are already in place in close proximity, or a structure is planned near a sensitive habitat or habitat for a endangered or threatened species, or in areas where the flow adjacent to the proposed structure is very low. More generally, the use of treated wood in water should be limited in water bodies or portions of water bodies where the small concentrations of preservatives that will leach out could not be rapidly diluted, dissipated, or degraded.

5. Aquatic Risk Assessment of Creosote

A. Chemical Description: Creosote is a complex mixture of organic chemical products of the fractional distillation of coal tar (USDA, 1980). It consists principally of liquid and solid aromatic hydrocarbons, and contains appreciable quantities of tar acids and bases (USDA, 1980). Creosote contains substantial amounts of naphthalene and anthracene (Hawley, 1977). Over 200 chemical compounds have been identified in creosote and it has been estimated that several thousand compounds may be present (Ingram et al, 1984). Three separate studies that analyzed the composition of creosote generally found the same 12-15 principal components, however the percentages of each component were quite different. All three studies listed phenanthrene as the most abundant compound, but the percentage of phenanthrene in different creosote mixtures varied from 12% to 23.6%. Table 5-1 lists the three studies reviewed that report on the composition of creosote and provides the breakdown of components. Note that none of the percentages of the composition studies add up to 100%.

Table 5-1: A comparison of the composition of creosote as reported in 3 different studies: Study 1= Lorenz and Gjovik 1972; Study 2= Ingram et al, 1982; and Study 3= Ingram et al, 1984.

Compound or Component	Composition (%) Study 1	Study 2	Study 3
Naphthalene*	3.0	19.60	10.5
1-Methylnaphthalene	2.1	2.55	2.1
2-Methylnaphthalene		5.68	4.0
Dimethylnaphthalenes	2.0		
Biphenyl	0.8	1.74	1.2
Acenaphthene*	9.0	7.65	4.8
Acenaphthylene		1.51	0.29
Dibenzofuran	5.0	5.74	3.2
Fluorene*	10.0	6.38	3.7
Methylfluorenes	3.0		
Phenanthrene*	21.0	23.55	12.0
Anthracene*	2.0	5.10	3.2
Carbazole	2.0	2.32	
Methylphenanthrene	3.0		
Fluoranthene*	10.0	10.44	7.3
Methylanthracene	4.0		
Pyrene*	8.5	6.32	5.2
1,2-Benzanthracene		0.29	1.6
Benzofluorenes	2.0		
Chrysene*	3.0	1.10	1.0
Total	90.4	99.97	60.09

* EPA Priority Pollutants

The American Wood-Preservers' Association (AWPA) Standard for coal tar creosote for land, fresh water, and marine (coastal water) use does not specify the composition of creosote by chemical component, but rather, the composition of creosote is described as the percentage of coal tar distillates that are collected at several specified temperature ranges (AWPA, 1989). Table 5-2 provides an example of this system of documenting the composition of creosote.

Table 5-2: Standard composition for coal tar creosote for land, freshwater, and marine/ coastal water use.

Distillation temperature range	Percent (%) by weight of the total creosote mixture made up of distillates from the corresponding distillation temperature range: Not Less Than	Not More Than
Up to 210°C	-	2.0
Up to 235°C	-	12.0
Up to 270°C	10	40
Up to 315°C	40	65
Up to 355°C	65	77

B. Uses: Creosote was first used to treat railroad ties in 1865 (Webb and Gjovik, 1988). In 1978, cross ties, switch ties, and landscape ties accounted for about 67% of the wood treated with creosote as a preservative. Utility poles accounted for 12%, and lumber and timbers accounted for 7% of the remaining wood treated with creosote (USDA, 1980). Creosote is the wood preservative of choice for marine pilings (Seesman et al, 1977). It has been found that creosote with a greater proportion of naphthalene was required to adequately protect wood pilings from attacks by the marine borer, Limnoria tripunctata (Seesman et al, 1977). Ninety nine percent of all creosote treated wood products are pressure treated products (Webb, 1980).

C. Review of Creosote Literature: Unlike CCA or pentachlorophenol, the literature does not suggest any bonding or fixing of creosote components with or to the wood. Creosote is retained in the wood by being forced deeply into the wood structure during the pressure treatment process, and because it is generally insoluble. Naphthalene is probably the most soluble of the creosote components, with a solubility in water of 33 mg/L. The solubilities of other creosote components in water include acenaphthene, 3.42 mg/L; fluorene, 1.92 mg/L; and phenanthrene, 1.15 mg/L (U.S. EPA, 1979). In a study conducted by Ingram et al, (1982) those four compounds accounted for 60% of the aromatic hydrocarbons that leached out of creosote treated wood into surrounding water. The same four compounds (plus methylated naphthalene) generally comprise between 36 - 65% of the overall composition of creosote. Goyette and Brooks, (1999) found that a significant portion of the naphthalene component contained in raw creosote was lost during the pressure-treatment process.

The majority of the studies reviewed came to the conclusion that only small quantities of aromatic hydrocarbons leach into water from submerged creosote treated wood. This conclusion was derived from the observation that treated wood usually remains in service for a considerable period of time unaffected by decay or attack by marine or aquatic organisms, and that samples taken from treated wood submerged for extensive periods of time still show high preservative retentions. Webb (1980) cites a study by Baechler and Roth (1961) in which pilings that had been in service for 59 years were found to contain creosote retentions of 19 to 20 pounds per cubic foot (pcf). The AWPA standard for creosote treated marine pilings is 20 pcf.

Ingram et al, (1982) conducted a comprehensive study of creosote leaching from treated wood by placing sample pilings in a 300 gallon stainless steel tank and measuring the concentrations of polycyclic aromatic hydrocarbons (PAH's) in the water over time. They compared the differences in leaching between saltwater and freshwater, at different temperatures, and the different rates of leaching between freshly-treated wood with that of a wood piling that had been in service for 12 years. Their results and conclusions were as follows:

1. Leaching of creosote occurs in water. The rate of leaching, based on the concentration of PAH's in the water, could be estimated as being equivalent to an annual loss of 77-147 grams of total PAH's from a piling 10 ft. long and 6 1/4 in. in diameter.

2. PAH's leached from creosote treated wood in fresh water twice as fast as the leaching rate from creosote treated wood in sea water.

3. PAH's leached from creosote treated wood approximately twice as fast at 40°C than at 20°C.

4. Lower concentrations of PAH's leached from aged pilings than freshly treated pilings.

Kelso and Behr (1977) submerged creosote treated southern pine logs in a one acre pond for 5.5 months followed by an exposure in air for 7.5 months. Upon analysis after 13 months, they found that about 20% of the creosote was lost. An analysis of the creosote content in wood showed that most of the loss occurred from the outer ½ inch of the logs. Brooks, (personal communication) suggests that some of the loss of preservative from the outer layer of wood might also be accounted for by migration of the preservative towards the interior of the wood as well as by losses to the surrounding air or water. Kelso and Behr (1977) also cite Hochman (1967) as reporting that when creosote treated wood is placed in sea water, two thirds of the first year's losses occurred during the first month.

Webb (1980) reported that a surface sheen usually appears when creosote treated wood is placed in the water. Freshly treated timbers, piling, and lumber will leach some quantity of low and medium molecular weight PAHs, particularly when the treated wood is first immersed. These

creosote component compounds, such as naphthalene, anthracene, and phenanthrene are somewhat soluble, and are volatile. They will migrate from the wood and concentrate directly at the surface of the water in a very thin layer. This thin layer will refract light, and as a result, a rainbow sheen is visible on the water while the materials are leaching. This sheen is very thin. Because the PAHs are volatile they evaporate from the water quickly and are degraded in the atmosphere. The sheen might last 30 - 90 days, depending on the amount of treated wood that was installed. Then, as the surplus low and medium molecular weight PAHs are depleted, the sheen will disappear. After the first month, leaching slows considerably (Kelso and Behr, 1977), as the excess volume of the more soluble creosote components is depleted The presence of the sheen does not necessarily indicate that toxic conditions exist in the water column below. Brooks, (personal communication) cites Collwell and Seesman, (1976) and Wade et al, (1987) as being unable to detect PAHs in the water under heavy sheening. Goyette and Brooks (1999) used semi-permeable membrane devices (SPMDs) to measure the concentration of dissolved PAHs in the water within 10-15 cm of individual pilings in a six piling dolphin. They detected a maximum value of only 31 ng/L total PAH in the water.

No documented reports of environmental harm from creosote treated wood used in water could be found (USDA, 1980). Dunn and Stich (1975, as reported in USDA, 1980) reported higher concentrations of benzo(a) pyrene in mussels located closer to creosote treated pilings than in mussels further away. However, they were unable to substantiate that the creosote treated piling was in fact the source of the benzo(a) pyrene. This study did not take into consideration the impact of gasoline combustion occurring in boat engines in the immediate vicinity of the piling (Webb, personal communication).

Tagatz et al, (1983) examined the impact of whole creosote mixed into marine sediments on the abundance of organisms and the number of species inhabiting the sediments. They found significantly fewer numbers of annelids, echinoderms, and arthropods in sediments contaminated with 177 ug/g of whole creosote. Mollusks were more resistant, but were significantly affected by concentrations of 844 ug/g of whole creosote in the sediments. Goyette and Brooks (1999) hypothesize that creosote derived PAHs do not readily dissolve in water and that they are transported from treated wood to sediments as small particles. They found a maximum concentration of about 18 ug/g dry sediment at 0.5 meters from treated wood structures. Two meters from the same structures, the total PAH concentration in sediments was less than 5 ug/g dry sediments. At 0.5 meters, the total PAH concentration in sediment peaked about 384 days after the structure was immersed, then declined steadily thereafter.

Creosote treated wood has never been identified as a significant source of PAH's in the water. In a joint impact assessment report by USDA, U.S. EPA, and state land grant universities, creosote treated wood was reported as <u>not</u> posing a significant environmental hazard because only very small quantities of PAH's were released, and those same quantities were rapidly removed from the water column (USDA 1980). The major source of PAH's in water is atmospheric deposition of particulates from combustion sources, including natural sources such as forest fires, and urban runoff (Hites et al, 1980; Hoffman et al, 1984).

D. Environmental Fate of Leached Creosote Compounds: Once PAH's from creosote enter the water, they are subject to a variety of fate processes. The lower molecular weight, two and three ring PAH's are subject to photolysis, volatilization, biodegradation, and sediment sorption. Four and five ring PAH's are more stable and are much less subject to photolysis and volatilization. The primary route of removal is sediment sorption. Once the PAHs are in the sediment, they are slowly biodegraded by microorganisms (U.S. EPA, 1979). These four and five ring PAH's however, are the creosote components less likely to leach, because of their higher degree of insolubility.

Microbial degradation of PAHs is well-documented. Seesman et al, (1977) found that naphthalene in creosote treated wood suppressed the growth of agar digesting bacteria, but treated wood was colonized by bacteria that were able to utilize naphthalene. Biodegradation is considered the primary route of removal for 2 and 3 ring PAH's in water (U.S. EPA 1979). Phenanthrene has been shown to biodegrade at a rate of 80% over a four week period (Sherrill and Sayler 1980); it is likely that anthracene biodegrades at a similar rate as well.

E. Quantitative Risk Assessment: Using the literature citations discussed above, a simplified, worst-case risk assessment model can be constructed to estimate the concentrations of total PAHs that might occur in the water following the installation of a wooden structure pressure treated with creosote in water. As stated above, Ingram et al, (1982) conducted a comprehensive study of creosote leaching from treated wood by placing sample pilings in a 300 gallon stainless steel tank and measuring the concentrations of polycyclic aromatic hydrocarbons (PAH's) in the water over time. The rate of leaching, based on the concentration of PAH's in the water, could be estimated as being equivalent to an annual loss of 77-147 grams of total PAH's from a piling 10 ft. long and 6 1/4 inches in diameter. Kelso and Behr (1977) cited Hochman (1967) as reporting that when creosote treated wood is placed in sea water, two thirds of the first year's losses occurred during the first month. If ten pilings 10 ft. long and 6 1/4 in. in diameter were installed in a pond six feet deep with a surface acre of one acre, based on the citations above, the worst-case, expected annual total loss of PAHs from the treated wood would be 1,470 grams, 2/3rds of which, or about 980 grams, would be lost during the first month. This corresponds to average daily loss rates of about 33 grams of total PAH during the first month and about 1.5 grams during the subsequent 11 months.

Ingram et al, (1982) reported that 29% of the PAHs leached from creosote-treated wood was naphthalene or methyl-naphthalene, 16% was phenanthrene, and 5% was anthracene. So, of the average of 33 g total PAHs leached each day during the first month, 10 g would be naphthalene or methyl-naphthalene, 5 g would be phenanthrene, and 2 g would be anthracene. The remaining 16 g lost would probably consist of medium to heavier molecular weight PAHs that settle to the sediments as tiny particles in the vicinity of the pilings, as suggested by Brooks.

U.S. EPA (1979) reported that through biodegradation, 50% of the naphthalene in water was converted to CO_2 in one day. U.S. EPA (1979) also reported that phenanthrene and anthracene have a very similar structure and that both are subject to rapid photolysis; with

anthracene possessing a photolytic half-life of five hours during peak summertime conditions and clear water. Assuming average conditions over a month long period, a photolytic half-life of one day was estimated. Using half-lives of 0.5, 1, and 1 day for naphthalene, and phenanthrene and anthracene respectively, the average daily concentration during the first month of these three PAHs in a one acre pond six feet deep can be estimated to be: naphthalene & methyl-naphthalene: 1.4 ug/L; phenanthrene: 1.4 ug/L; and anthracene: 0.54 ug/L.

These concentrations would persist during the first month following the immersion of the creosote-treated wood. During the subsequent 11 months, the average daily PAH loss rates from the creosote treated pilings would only be 1.5 g total PAHs consisting of 0.44 g naphthalene and methylnaphthalene, 0.24 g phenanthrene, and 0.075 g anthracene. Using the same half lives as discussed above, the average daily concentrations of these three PAHs in the one acre pond six feet deep would be 60 ng/L naphthalene & methylnaphthalene; 64 ng/L phenanthrene; and 20 ng/L anthracene. The sum of these three PAHs in the water column is 144 ng/L, which is about 4 times the concentration of total PAHs found by Goyette and Brooks (1999) using SMPDs. Table 5.3 lists the New York State acute and chronic water quality guidance values for the three PAHs. At no time does the concentration of any of the PAHs approach the corresponding water quality guidance value.

Table 5-3. New York State acute and chronic ambient water quality guidance values for some PAHs

	Naphthalene	Anthracene	Phenanthrene
Acute guidance value	110 ug/L	35 ug/L	45 ug/L
Chronic guidance value	13 ug/L	3.8 ug/L	5.0 ug/L

This risk assessment model is not precise because leaching was modeled as a two stage linear process. Actual leaching rates over time have a curved distribution, with a high rate of leaching initially that drops off consistently as time progresses. This model probably overestimates leaching during the first 30 days and the final 30 - 60 days of the first year following immersion of a creosote treated wooden structure. It probably underestimates leaching during the middle, 2-10 month period. However, because the water column concentrations of PAHs do not exceed chronic water quality guidance values, even during the first 30 day, peak leaching period, harmful impacts to aquatic life are unlikely at any time.

F. Summary: Submerged structures constructed of wood that has been properly pressure treated with creosote wood preservative solutions in accordance with American Wood-Preservers' Association Standards and the Western Wood Preservers institute's Best Management Practices are not likely to present a risk of harm to aquatic life. Creosote does not bond to wood, but is retained by being forced deeply into the wood by the pressure treatment process, and because of the low solubility of most of the creosote components. When freshly-treated wood is placed in the water some leaching of primarily low and medium molecular weight PAH's will

occur. The majority of the leaching occurs in the first 30 days after being placed in the water. Most of the leaching appears to come from the outer 0.5 inch of the wood. Leaching occurs at a higher rate at higher temperatures, and leaching occurs faster in freshwater than in saltwater. Leaching occurs much more rapidly from freshly-treated wood than from wood allowed to age after the treatment process, due to the loss of volatile components during aging. The creosote components that are leached have a relatively short life in the water, and are removed by photolysis, volatilization, biodegradation, and sediment sorption. Based on this assessment, creosote treated wood, when treated by pressure methods in accordance with American Wood-Preservers' Association Standards, is unlikely to cause adverse ecological impacts when used for in-water construction.

The risks to aquatic life from PAHs leaching from treated wood during the first month can probably be reduced by not installing the pilings or timbers immediately after they are treated. Allowing at least three months for the lighter creosote components to evaporate into the air before immersing them in water could significantly reduce the quantity of low and medium weight PAHs that would otherwise leach out of the treated wood into the water after they were immersed.

6. Aquatic Risk Assessment of Pentachlorophenol

A. Chemical Description: Pure pentachlorophenol is a white mononclinic crystalline solid with a phenolic odor. Pentachlorophenol is also called penta or PCP (although PCP is also the common abbreviation for phencyclidine, a controlled narcotic often involved in street drug traffic (Hoeting, 1977). The solubility of penta in water is pH dependent, ranging from about 10 mg/L at pH 6 to 20 mg/L at pH 8 (Brooks, 1998). The sodium salt, sodium pentachlorophenate, is readily soluble in water (USDA, 1980). Eisler (1989) reports that the solubility of sodium and potassium pentachlorophenate in water is pH dependent and increases from about 79 mg/L at pH 5.0 to > 4000 mg/L at pH 8.0. Penta is stable and does not decompose when heated at temperatures up to its boiling point for extended periods of time (USDA, 1980). Prior to 1986, technical grade penta typically contained 80-90% pentachlorophenol, 6-12% tetrachlorophenol and other polychlorophenols, and traces to several thousand parts per million of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (Choudhury et al, 1986). After 1986, the U.S. EPA set limits that greatly reduced the concentration of dioxin impurities in technical-grade penta (Federal Register, 1986).

Penta is effective against bacteria, fungi, and insects, and it exerts its toxic effect by uncoupling oxidative phosphorylation in living cells. Since this biochemical process is essentially the same for the aerobic generation of adenosine triphosphate in all biological systems, penta and its salts are highly effective broad-spectrum biocides (USDA, 1980). The toxicity of penta varies with pH, but this is due to variations in the uptake of penta at different pH values rather than changes in water solubility. At a pH 4.0, penta is fully protonated, therefore electrostatically neutral and lipophillic. At a pH of 9.0, penta is almost completely ionized and uptake and accumulation into lipids is minimal (Eisler, 1989).

B. Uses: The first use of penta as a wood preservative occurred in the Panama Canal Zone in 1931 (Hoeting, 1977). Although introduced as a wood preservative in the United States in 1936, commercial production of penta was not reported in the United States until 1950 (Choudhury et al, 1986). In addition to its use as a wood preservative, penta has also been used as an herbicide, defoliant, and mossicide. Its' sodium salt is used for sapstain control, as a general herbicide and mossicide, and as a biocide in mushroom houses (USDA, 1980). As a wood preservative, penta is used primarily to treat utility poles and crossarms (60%), lumber and timber (19%), and fenceposts (10%). Exterior millwork (such as door frames, window sills, moldings, etc.) is also typically treated with penta, and penta has also been used as a slime reducer in paper and pulp mills (USDA, 1980; Choudhury et al, 1986). Between 1970 and 1977, production of penta ranged from a low of 21.5 million pounds in 1977 to a high of 46 million pounds in 1972. About 90% of the penta produced annually is used for pressure treatment of wood. The remaining 10% is used in thermal, groundline, dip, and other treatment processes (USDA, 1980).

Penta is also applied to in-service utility poles by groundline treatment, in which a trench is dug around a standing pole and a thick solution is painted on the pole in the vicinity of where the pole meets the ground. The treated area of the pole is wrapped with plastic to retain the preservative and the trench is filled back in (USDA, 1980).

C. Review of Pentachlorophenol Literature: One of the major concerns about pentachlorophenol prior to 1986 was its association with chlorinated dibenzodioxins and furans. These contaminants were present in technical grade penta as production impurities prior to 1986. They are also formed as degradation products of penta photolysis, both in water and on the surface of treated wood (Arsenault 1976; Choudhury et al, 1986; Johnson et al, 1973; and USDA, 1980). The most highly toxic dioxin compound, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) has never been detected in pentachlorophenol produced in the U.S. (USDA, 1980), nor as a penta degradation product (Arsenault, 1976). Johnson et al, (1973) states that this is not surprising, because the appropriate precursors for formation of 2,3,7,8-TCDD are not present in technical grade penta.

The significance of dioxin contaminants as impurities in technical grade penta diminished significantly when in 1986, the U.S. EPA ruled that in order to be registered as a pesticide, the concentration of HxCDD in penta must be less than 1 ppm, and the concentration of 2,3,7,8-TCDD in penta must be below the limit of analytical detection (Federal Register, 1986).

Pentachlorophenol exposed to sunlight on the surface of treated wood can form octachlorodibenzo-dioxin (OCDD) via a photolytic condensation reaction. After exposing small pieces of penta-treated wood for 20 days to natural and artificial light, Lamparski and Stehl (1980) measured OCDD concentrations of about 70 ppm (ng OCDD/mg PCP). The OCDD in turn degraded to HpCDD and HxCDD (hepta- and hexa-chlorodibenzodioxin). The final concentration of HxCDD was approximately 15 - 20 ppm. When P-9 oil was used as the solvent for penta, concentration of OCDD formed from penta ranged from 2 - 4 ppm. Of the three contaminants identified above, the most toxic is the hexachlorodibenzo-p-dioxin (HxCDD). The toxicity of HxCDD is approximately the same as that of pentachlorophenol. The acute LD_{50} for the HxCDD is about 100 mg/kg in male rats. For penta, the acute LD_{50} for rats ranges from 27 - 80 mg/kg depending upon the solvent used (Arsenault, 1976). Octachlorodibenzo-p-dioxin (OCDD) is the least toxic polychlorinated dioxin compound. Doses of 1 g/kg and 4 g/kg of OCDD to female rats and male mice, respectively, failed to cause any lethality (Johnson et al, 1973). The most toxic chlorinated dioxin, 2,3,7,8-TCDD, has acute LD_{50}s ranging from 0.6 ug/kg for male guinea pigs to 115 ug/kg for rabbits of both sexes. Based on the toxicity equivalency factors, Heptachlorodibenzo-p-dioxin (HpCDD) is about three orders of magnitude less toxic (1000X) than 2,3,7,8-TCDD (U.S. EPA, 1987). The photolytic formation of OCDD, HpCDD, and HxCDD were all reduced when the concentrations of the three polychlorinated dioxins present in the original formulation were also reduced (Lamparski and Stehl, 1980), so the EPA-mandated reduction in polychlorinated dioxin contaminants should also serve to reduce the concentration of dioxin contaminants produced by photolytic processes.

Penta is retained in the wood initially because it is driven deeply into the wood under high pressure. Some of the compound may bleed out, vaporize along with the carrier oil, or be washed away. With time, the biological activity decreases and extractable penta declines although physical analysis shows that the penta concentration in the wood remains constant. Several methods of analysis all show that the penta eventually becomes bound to the cell walls, primarily

in the middle lamella (Crosby, 1981; Arsenault, 1973). The middle lamella is the intercellular space between the primary walls of wood cells. In wood cells, the middle lamella is commonly lignified (Esau, 1967). Lignin has a strong affinity for phenolic substances by hydrogen bonding (Arsenault, 1973). The adsorption of penta to the lignin in the middle lamella and cell walls is a time-dependent process. Arsenault (1973) reported that heartwood aged three years after penta treatment released only 50-60% of the penta upon benzene extraction, but newly treated wood released 97%.

Loss of penta to the air, probably through evaporation, occurs mostly from the outer 0.5 in of treated poles. The amount of penta lost is influenced by the characteristics of the carrier oil used (Walters and Arsenault, 1971).

Few studies could be found that investigated the loss of penta via leaching from treated wood submerged in water. Arsenault (1976) reported on the leaching of penta from pressure treated thin slats used to line cooling towers. Connor (1994) (cited in Brooks, 1998) studied the leaching of penta from treated piling sections to support the EPA re-registration of penta as a pesticide. Brooks (1998) used Connor's work to develop an aquatic risk assessment model for penta treated wood in water. Like creosote, penta and the carrier oil that is used to transport the penta into the wood during the treatment process are fairly insoluble, so the likelihood that much penta would leach out into water is small. Penta is also apparently not the preservative of choice for marine pilings or other submerged structures. No standard for penta-treated marine pilings is published in the American Wood-Preservers' Association book of standards (AWPA 1989, National Timber Piling Council, 1995).

Penta is highly toxic to aquatic life. Adverse effects on growth, survival, and reproduction have been documented at penta concentrations of 2.5 to 100 ug/L for aquatic and marine invertebrates, especially mollusks, and <1.0 to 68 ug/L for fish, especially salmonids (Eisler, 1989). Although penta is usually described as insoluble, the solubility of penta in water at 20°C is 14 ug/L. The acute LC_{50} for the common carp is 4.355 ug/L, which is more than three times lower than the solubility of penta in water (U.S. EPA, 1986). The toxicity of penta is pH dependent, and increasing the pH of the water column decreases the risk to aquatic biota (Eisler, 1989).

D. Environmental Fate: Microbial degradation is an important, perhaps dominant removal mechanism for pentachlorophenol in soil. In a moist garden, the half-life of penta in non-sterile soil was about 12 days, with only a 30% decomposition rate over the same time period in sterile soil. In other soil types, however, microbial degradation required as much as 72 days. Penta is strongly adsorbed and is relatively immobile in acidic soils, but is more mobile and less tightly bound in neutral or alkaline soils. Penta will also undergo photolysis in the soil, with octachlorodibenzo-p-dioxin as a degradation product. Penta decomposes more readily in soils of high organic content than in soils of low organic content, and more rapidly when moisture content is high and temperatures are conducive for microbial activity. The typical soil half-life of pentachlorophenol in soil is about 2-4 weeks (Choudhury et al, 1986).

In water, the concentration of penta is degraded by photolysis, sediment sorption, and microbial degradation. Pignatello et al, (1983) found that in an artificial stream, photolysis was rapid near the water's surface and accounted for 5 - 28% of the initial decline of penta in the water. Sediment sorption and uptake by biota accounted for <15% of the decline. After about three weeks, microbial degradation became significant and accounted for 26 - 46% of the initial decline of penta in the water.

The rate of photolysis decreases with depth and light penetration. Pignatello et al, (1983) determined that the photolytic half-life of penta in water during daylight hours varied from 0.7 - 9.63 hours as the depth varied from 0.5 - 13.8 cm, and the photolytic half-life over a 24 hour period varied from 3.02 - 43.9 hours over the same depth range.

Pierce et al, (1977) noted that following a spill into a 30 acre lake in Mississippi, penta had a short residence time in the water column, but remained present in sediments and leaf litter. DeLaune et al, (1983) found that the rate of microbial degradation of penta in sediments was related to pH and redox potential. Less than 1% of radiolabelled penta was degraded to $^{14}CO_2$ at pH 5, while maximum penta degradation occurred at pH 8 +500 mV, where 68% of the radiolabelled penta was degraded to $^{14}CO_2$ after about 40 days.

Microbial degradation of penta in water can occur in waters that have been exposed to domestic and industrial effluents. A lag period of about two weeks is necessary for microbial populations to adapt to metabolizing penta. In relatively unpolluted waters, microbial degradation occurs very slowly or not at all. Penta will sorb to sediments, but the degree of sorption varies depending on the pH, whether the sediments are oxidized or reduced, and the chemical form of penta (Choudhury et al, 1986). Eisler (1989) reported that overall, the half-life of penta in water ranged from 0.15 - 15 days, being fastest when ambient conditions included high incident radiation, high dissolved oxygen, and elevated pH.

It appears that in the air, the non-disassociated form of penta undergoes photolysis at an environmentally significant rate. It is possible that direct photolysis is an important environmental sink for penta present in the atmosphere (Choudhury et al, 1986).

E. Quantitative Risk Assessment: In order to assess the potential for toxic concentrations of penta to leach from treated wood, the rate of loss of penta from treated wood must be estimated, and the resulting concentration compared to in-water toxicity thresholds. Arsenault (1976) reported that in cooling tower leach tests with thin (3/8") wooden specimens, the loss of penta was 38% after 1 ½ years, 47% after 5 years, and 66% after 10 years. This equates to monthly loss rates due to leaching of 2.1%; 0.78%, and 0.55% respectively.

Assume that a dock was built in a one-acre pond with a mean depth of six feet. The dock is supported by 10 timber pilings treated with pentachlorophenol. The pilings are 1 foot in diameter and the average length of the submerged portion is three feet. The volume of submerged, treated wood in the scenario described above is 23.56 ft^3. Walters & Arsenault

(1971) reported that after studying the loss of penta from treated wood to air over a 97 month period, most of the losses occurred from the outer 0.5 inch zone of wood. Most of the penta lost from submerged pilings via leaching also probably comes from the outer 0.5 inch zone. The total volume of wood in the outer 0.5 inch of the submerged portion of the ten pilings is 3.76 ft^3. The AWPA (1989) Book of Standards recommends that for use in fresh water, pilings should be treated to a retention of 0.6 - 0.85 pcf, depending on the type of wood used in the piling. Assuming that the 0.85 pcf retention level was used, the volume of penta contained in the outer 0.5 inch of the 10 wooden pilings submerged an average of three feet in water is about 3.2 pounds. At a monthly loss rate of 2.1%, it could be expected that a total of 0.0672 lbs of penta, approximately 31 grams, would leach out of the ten timber pilings each month, or about 1 gram per day.

The total volume of water in a one acre pond with a mean depth of six feet would be 7,400,931 liters. Eisler (1989) describes the half-life of penta in water as 0.15 - 15 days. The geometric mean of that range is 1.5 days. However, such a rapid rate of dissipation is only realistic in very clear, very shallow (less than six inches) water, where the rate of photolysis is the most rapid. Penta treated wood is more likely to be used in deeper, more turbid waters where rapid photolysis would not be anticipated. For that reason, the arithmetic half-life, 7.6 days, is probably a better estimate of the average half-life of penta in water. Thus, if about 1 gram of penta were released from the treated wood into a six foot deep, one acre pond each day, and the half-life of penta in the water ranged from 7.6 - 15 days, the steady-state concentration of penta in the pond water would be 2.13 - 4.2 ug/L.

The New York State water quality standard varies with the pH of the ambient water. At a pH of 6.5, the chronic water quality standard for the protection of aquatic life propagation and survival would be 4.1 ug/L. At a pH of 7.0, the water quality standard would rise to 6.7 ug/L. At the slowest degradation rate, $T_{1/2}$ = 15 days, the concentration of penta resulting from leaching from 10 pilings into a six foot deep pond one acre pond with a low pH would just equal the chronic water quality standard. At higher pH values, the water quality standard is not likely to be exceeded. A pH of 6.5 is the lower bound of the range of pH values (6.5 - 9.0) needed to provide adequate protection for fish and benthic invertebrates (U.S. EPA, 1986a). Although lower pH values would result in a lower water quality standard for penta, below a pH of 6.5, aquatic life would begin to be impaired by the low pH value itself regardless of the concentration of penta or other contaminants.

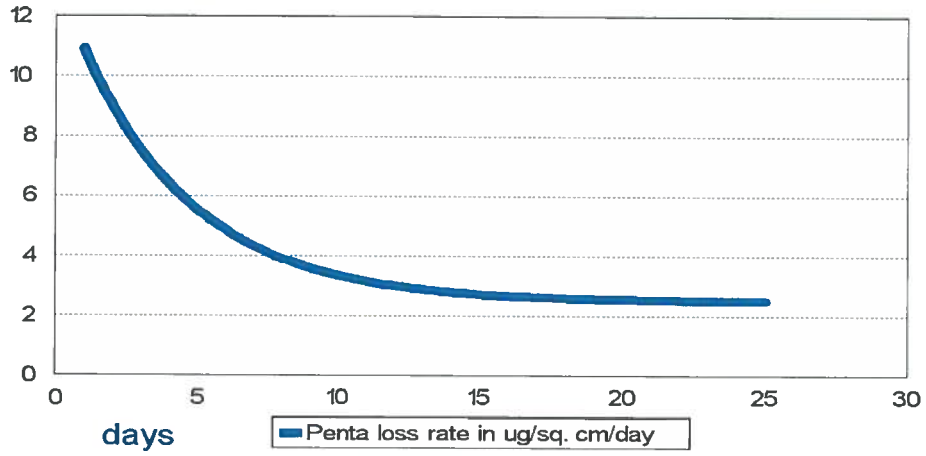
In a larger water body with greater dilution of leached penta, the likelihood of exceeding the water quality standard would greatly diminish. The Arsenault (1976) data clearly shows that the rate of loss of penta from submerged wood decreases over time. The monthly loss rate after five years was approximately 1/3rd of the loss rate after 1½ years, or about 0.78% per month instead of 2.1% as modeled above. The difference is because, like creosote, there is a short initial period of relatively high leaching when the treated wood is initially installed, which biases the estimated monthly loss rates.

Brooks, (1998) used data from Connor, (1994) to develop an algorithm to describe the penta loss rates from submerged pole sections:

$$\text{Penta loss} = 10.9 * \exp^{-0.255 * \text{Day} + 0.355 * \text{pH} + 0.01 * \text{salinity}} \text{ ug/cm}^2 \text{ - day}$$

This equation can be used to calculate the daily loss rates of penta from a treated pole submerged in water. By plotting the daily loss rates from day 1 to 25 for penta leaching at a pH of 7.0 and a salinity of 0, it can be seen in Figure 6-1 that the high initial leaching rate drops off rapidly and stabilizes around day 10. The difference between the 18 month and 60 month average penta losses reported by Arsenault (1976) is probably due to the influence of this initial period of high leaching, and the continued steady albeit slow decline in the loss rate with time. See Figure 6.1

Figure 6.1. Daily loss rates of pentachlorophenol from submerged pole sections. From Brooks (1998)



Brook's (1998) model can also be used to estimate the water column concentration of penta in the same scenario as described above. The total submerged surface area of the ten pilings, each one foot in diameter three feet in submerged length, would be about 87,560 cm^2. The daily loss rate on day 10 in a water body with a pH of 7 and salinity 0% would be 3.34 ug/cm^2 for a total daily loss of 292,3000 ug penta from the submerged pilings. Using a half-life in water of 7.6 days, and assuming the day 10 loss rate was constant, the average concentration of penta in the pond would be 0.061 ug/L, or 61 ng/L.

Repeating the first analysis described above with the 5 year average leaching rate from Arsenault (1976), that is, 47% over 5 years, or 0.78% /month instead of 2.1%/month shows that only 0.025 lbs, or about 11.3 grams of penta would be lost each month, or 0.38 g lost each day. The steady-state concentration of penta in the water would be about 0.077 ug/L (77 ng/L) using the half-life of 7.6 days. This concentration is practically the same as the concentration predicted by the Brooks, (1998) model. Pierce et al, (1977) reported that the "background" concentration of penta in a control pond was 0.5 ug/L. The quantitative risk assessment shows that penta

leaching from treated wood submerged in water is unlikely to result in ambient water concentrations that are harmful to aquatic life.

F. Summary: Pentachlorophenol appears to leach from treated wood at very slow rates, ranging from 2.1% month over a 1 ½ year period to 0.55% per month over a 10 year period. Over time, penta binds increasingly to lignin in the middle lamella of the treated wood, and the rate of leaching decreases. Penta is degraded relatively quickly in water, and has the potential to degrade rapidly in sediments, depending upon the sediment pH and redox potential. At the highest leaching rate and slowest half-life modeled, the penta concentration estimates in the risk assessment model only marginally exceeded the New York State water quality standard for chronic aquatic life toxicity. The AWPA does not have a standard for the use of penta treated wood in marine waters. According to the Brooks, (1998) model, penta will leach at a higher rate in salt water. However, because of the lack of an AWPA standard, penta treated wood should not be used in salt, brackish, or estuarine waters. For purposes of determining whether not penta treated wood should be used, salt, brackish, or estuarine waters can be defined as waters where the salinity does not exceed 8 ‰ at any time. The use of penta treated wood in water is unlikely to present any long lasting impacts to the aquatic ecosystem, particularly after the treated wood has been in place for more than one to three months.

7. Aquatic Risk Assessment of CCA and other Inorganic Arsenicals

A. Chemical Description: Inorganic arsenicals are wood preservatives that use solutions of soluble metallic oxides as toxic agents to prevent wood decay. The concept of using toxic metallic oxides (metallic salts were used originally) is not new. In 1730 wood was treated by immersion in arsenic solutions to protect against insect attack (Henry and Jeroski, 1967). This method was not suitable for treating wood that would be submerged in water because the soluble arsenic salts would immediately leach out. In 1931, Falk and Kamesam conducted a series of experiments in which they attempted to "fix" the arsenic in wood by precipitating insoluble complexes. They developed a leach-resistant formula of arsenic pentoxide and sodium dichromate, and were granted a French patent in 1933. Copper sulfate was another soluble metallic salt that was known to be effective as a fungicide, so with the addition of copper sulfate to Falk and Kamesam's original formulation, the wood preservative CCA (Chromated Copper Arsenate) was produced (Henry and Jeroski 1967).

CCA is just one of a number of water-soluble wood preservatives that use metallic ions as toxic agents. Others include Ammoniacal Copper Zinc Arsenate (ACZA) and Ammoniacal Copper Quat (ACQ).

B. Uses: As of 1977, CCA comprised 91% of all of the water-soluble wood preservatives in use. In 1978, 79% of all CCA treated wood products were lumber and timber, and an additional 12% were plywood and fence posts (USDA 1980). For most of the wood treated with CCA, application is made by pressure treatment (USDA, 1980). CCA is used in low quantities. A typical white pine 2" X 4" X 8' stud consists of approximately 0.27 cubic feet of wood. If pressure treated to a retention of 1.0 pcf, the stud would contain 0.27 lbs ($\approx$123 g) of copper, chromium, and arsenic. Using the ratio of metallic oxides found in CCA type C, the stud would contain 58.4 g chromic oxide; 22.8 g of copper oxide; and 41.8 g of arsenic pentoxide. This is equivalent to 30.4 g ionic chromium, 18.2 g ionic copper, and 31.8 g ionic arsenic.

C. Review of CCA Literature: During pressure treatment, the copper, chromium, and arsenic compounds are driven deeply into the wood in a water solution. Once in the wood, a series of fixing reactions occur involving the reduction of hexavalent chromium to trivalent chromium and formation of a complex mixture of insoluble chromates (Arsenault, 1975). These reactions occur in the treated wood during the treating process under conditions of low pH. The chromium has little or no biocidal properties in itself. Its primary function is to fix the arsenic and copper by forming insoluble complexes with the arsenic, copper and wood carbohydrate structures (Hartford, 1986).

CCA permanence is dependent on a number of factors, such as the ratio of reactants (copper, chromium, and arsenic), the pH, and the time and temperature allowed for the fixing reactions to occur. Each of these factors is discussed below:

Ratio of Reactants: Henry and Jeroski (1967) experimented with ten formulations of CCA to find which combination of components provided the most leach-resistant formula. They found when the arsenic pentoxide (As_2O_5) content was more than two-thirds of the chromic oxide (CrO_3) content, the excess arsenic pentoxide was wasted through leaching. They also found that if the chromic oxide content was more than twice the arsenic pentoxide content, the excess chromic oxide did not contribute additional permanence.

In a similar series of experiments, Häger (1969) found that copper from a simple soluble salt (copper sulfate) could be fixed in sawdust even without a fixing agent. Häger (1969) also found that the addition of chromium does improve the fixation of copper. Irvine and Dahlgren (1976) noted the formation of copper-arsenic compounds that represented minima points on a curve of copper leaching rates from CCA treated wood with changes in pH.

Henry and Jeroski (1967) reported the most leach resistant formulation of CCA to be a mixture of chromic oxide 50%, copper oxide 17%, and arsenic pentoxide 33%. In a similar experiment, Fahlstrom et al, (1987) found the most leach resistant formula from their series to be a ratio of chromic oxide 49.1%, copper oxide 17.2%, and arsenic pentoxide 33.7%.

The American Wood-Preservers' Association currently recognizes three standard formulations of CCA (AWPA, 1989). These standard formulations are described in table 7-1.

Table 7-1. AWPA-recognized standard formulations of chromated copper arsenate (CCA).

Type	Percentage of Chromium as CrO_3	Copper as CuO	Arsenic as As_2O_5
A	65.5	18.1	16.4
B	35.3	19.6	45.1
C	47.5	18.5	34.0

The formulation of CCA Type C most closely matches the experimental results of Henry and Jeroski (1967) and Fahlstrom et al, (1967), suggesting that CCA type C is the most leach resistant. The preponderance of CCA treatments are now based on the CCA-C formulation. CCA-A and CCA-B are not commonly used anymore (Brooks, personal communication).

pH: During the pressure treatment process, the pH of the working solution must

be below 2.5-3.0 to allow the hexavalent chromium to be reduced to trivalent chromium. The trivalent chromium reacts with copper, arsenic, and wood carbohydrates to precipitate insoluble complexes in the wood. As this reaction proceeds, the pH in the wood increases to about 5.5, the normal pH of wood (Hartford, 1986). However, the precipitation of insoluble complexes is reversible. Cook (1957) reported that significant leaching of fixed copper chromium arsenic preservatives can occur when the pH of moving water in contact with the treated timber drops to a value below 3.0. Evans (1987) reported that silage, described as "very acid", leached considerable quantities of copper, chromium, and arsenic from silo panels constructed from CCA treated wood.

Reaction Time and Temperature: The formation of insoluble precipitates in treated wood depends on the presence of water as a substrate in which the soluble ions react. The fixing of copper, chromium, and arsenic in the wood is not completed during the pressure treatment process. Pressure treatment forces the compounds deeply into the wood where the reactions then take place over time. The presence of water over the time period when reactions are occurring is important for maximum fixation. Oven drying of CCA pressure- treated wood can drive off critical moisture and hasten the reactions to a different end point, rather than the desired insoluble precipitates (Arsenault, 1975). Drying the wood too quickly may not allow the wood to equilibrate at a higher pH, thus increasing the rate of leaching (Arsenault, 1975).

The factors discussed above demonstrate how the potential for leaching can be increased or decreased by the processes used to treat the wood. The end user of the treated wood has no control over there factors. **To insure that treated wood has been preserved properly for the greatest resistance to leaching of copper, chromium and arsenic, the consumer should examine the wood for a stamp, tag, or brand indicating that the wood has been treated in accordance with the standards and methods developed by the American Wood-Preservers' Association.** The quality of the preservative treatment of treated wood not bearing that stamp or brand is suspect. Furthermore, when treated wood will be placed in water, the end user should insure that the wood was treated in accordance with the Best Management Procedures for CCA, ACZA, or ACQ developed by the Western Wood Preservers Institute. These practices will insure that the treatment process will result in the most leach resistant product possible.

It has been shown that the rate of leaching decreases markedly with increase in the size of the piece of treated wood, and when the proportion of the end grain exposed per unit of surface area leached is reduced (Arsenault, 1975; Fahlstrom et al, 1967). The significance of this fact must be taken into consideration when evaluating earlier (pre-1995) laboratory studies of CCA leaching. Most older leaching studies use sawdust, thin wood shavings, or small pieces of wood, all of which have very high surface area to volume ratios. The leaching from timbers, logs, and pilings, all with much less surface area per unit of volume, will occur at a lower rate. More recent studies account for this variable by coating the ends of wood samples with paraffin to reduce or eliminate the proportion of end grain exposed , or by simply using larger pieces of wood.

The environmental impacts of leaching from CCA have been the object of considerable research. Most of the research, however, has examined treated wood such as timbers, poles, pilings, and water cooling tower slats that have been in service for varying periods of time (Arsenault, 1975). The preservative retentions after the wood has been in service were compared to original retentions before the wood was placed in service. Arsenault (1975) reported CCA treated pilings that had been in service for 18 years showed no significant changes in CCA retentions, and cooling tower slats treated with CCA type A and exposed to leaching for 10 years retained 75-82% of the original CCA applied. (Note that CCA type A is not the most leach resistant formulation). Baechler et al, (1970) submerged wooden coupons treated with CCA in sea water, and after 60 months the coupons actually showed an increase in CCA retention. They suspected that there must have been some loss of wood without a balanced loss of preservative. The increase however, implies that overall preservative loss was slight. Webb and Gjovik, (1988) reported that leachability studies from arsenically treated wood resulted in arsenic concentrations in the environment that would be considered normal background residual levels for arsenic compounds.

Despite numerous studies that show very high preservative retentions remaining in CCA treated wood after considerable periods of time, CCA components will leach from wood. Some leaching of copper, chromium, and arsenic ions must occur if toxicity to destructive organisms is to occur (Hartford, 1986).

Evans (1987) collected rainwater that washed off CCA treated wooden roofing boards. After two years of exposure to a combined total of 1800 mm of precipitation, the following concentrations of leached metallic ions were measured in the collected rainwater: copper 0.76 mg/L, chromium 0.094 mg/L; arsenic 1.21 mg/L. In a simultaneous experiment, CCA treated roofing boards were washed with a brush and water to remove any particles of preservative on the surfaces of the wood. This treatment reduced the concentration of copper in the collected rainwater by 62%; chromium by 19%; and arsenic 8%. The pH of the rainwater ranged from 4.0 to 6.5.

Cserjesi (1976) also examined the leaching of CCA components from roofing panels. He found that leaching did occur, but after 8 months of exposure, adequate CCA remained to prevent biological deterioration. Analysis of the rainwater collected showed that leaching leveled off to a relatively low level after 6-8 months of exposure and remained at this level for at least an additional year, when the experiment was concluded. Less leaching of copper, chromium, and arsenic occurred from roofing panels treated with CCA-C than from those treated with CCA-B.

Arsenault (1975) documented reductions in CCA retentions from preserved wood in service, although these reductions were slight.

Spodaryk (1977) also documented that copper and arsenic would leach from treated wood. He examined the rate of leaching of CCA type B from short sections of a treated wooden post. It was his conclusion that the copper and arsenic leaching would not present a hazard in

terms of acute toxicity to fish. He also found that chromium leaching was insignificant.

D. Environmental Fate: The water column concentrations of copper and arsenic resulting from CCA treated wood leaching are influenced by their fate in the environment. At pH's of 6-7, copper ions are readily complexed by carbonates, hydroxide, or organic molecules (U.S. EPA, 1979). Many of the copper complexes are insoluble and precipitate out into the water and sediments (Elder and Horne, 1978). Copper itself, as well as many copper complexes adsorb to the sediments and are thus removed from the water column (U.S. EPA, 1979). Wagemann and Barica (1979) found that dissolved copper from copper sulfate treatments for algae control in six lakes had a half-life of 1-2 days while in one other lake, the half-life of copper in the water was seven days. The most toxic form of copper is the CU^{++} ion, and the various complexes and precipitates of copper are significantly less toxic (Andrew et al, 1976).

Arsenic in CCA is in the pentavalent state, which is much less toxic than arsenic in the trivalent state (U.S. EPA, 1979). Arsenic is sorbed rapidly to sediments. When 1000 ppb of arsenic was added to water only 17% remained after 11 days (USDA, 1980). Once in the sediments, arsenic can be metabolized by microorganisms, and released back into the water as organic complexes. The organic metabolites are less toxic than inorganic arsenic compounds (Sax, 1979). Because of the cyclical behavior of arsenic in the water and it's resulting mobility, the ultimate sink of arsenic is considered to be the oceans (U.S. EPA, 1979).

E. Quantitative Risk Assessment:

In recent years, several careful studies have been conducted into the leaching of copper, chromium, and arsenic from CCA treated wood. Lebow, et al, (1999) examined the loss of metals from CCA treated lumber and pilings in freshwater and saltwater of different degrees of salinity over a 10-15 month period. They found that there is a initial period of relatively high leaching for copper and arsenic when the treated wood is first placed in water, that drops off rapidly over time. From their study, Lebow, et al. determined the average rate of metal loss per unit of surface area for the first six months following immersion (short term loss rate), and the average monthly rate of loss per unit of surface area for the subsequent months of the study (long term rate). They compared their results with three other CCA leaching studies, and found that all four studies had approximately the same results. From the Lebow et al, (1999) study, a model can be constructed to estimate the potential impacts from the installation of CCA treated wood in a small pond.

Assume that a dock was built in a one-acre pond with a mean depth of six feet. The dock is supported by 10 timber pilings treated with CCA Type C. The pilings are one foot in diameter and the submerged portion is three feet in length. The surface area of wood exposed to the water is 94.24 ft^2, about or 87560 cm^2.

Lebow et al, (1999) examined leaching rates from both lumber and pilings treated at a high retention (2.5 pcf) and a low retention (1.25 pcf) in fresh (deionized) water and salt water with

salinities of 23‰ and 34‰. They found that pilings leached more than lumber; wood treated at the higher retention leached more than wood treated at the lower retention; treated wood submerged in salt water leached more than treated wood in freshwater, and wood submerged in salt water with a salinity of 23‰ leached more than wood submerged in salt water with a salinity of 34‰.

From Lebow et al, (1999), the highest freshwater, saltwater, short term, and long term leaching rates for copper and arsenic were used to estimate the worst case potential for impacts to aquatic life in the model scenario described above. Their short term leaching rate was the average leaching rate for the first six months. Their long term leaching rate was the monthly average leaching rate for the subsequent 4-9 months. From those average rates, daily short term and long term leaching rates can be estimated. See Table 7-2.

Table 7-2: Estimates of daily short term and long term leaching rates for copper and arsenic from CCA treated wood in fresh and salt water. Six month and monthly average leaching rates are from Lebow, et al, (1999). Daily averages were determined by dividing by 180 and 30 days respectively.

Metal	water type	6 month average loss rate in ug/cm^2 (from lebow et al, (1999) short tem loss rate	Daily short term loss rate in ug/cm^2/day	Monthly average loss rate in ug/cm^2 from Lebow et al, (1999) (long term loss rate)	Daily short term loss rate in ug/cm^2/day
copper	fresh	73	0.41	0.9	0.03
copper	salt	258	1.43	24.4	0.81
arsenic	fresh	78	0.43	4.1	0.14
arsenic	salt	48	0.27	2.4	0.08

From the daily loss rates determined in table 7-2, the total amount of metal lost each day from the 10 pilings in the model pond can be estimated by multiplying by 87561.12 cm^2. See table 7-3.

When released into the water, the resulting metals concentrations are degraded by a variety of environmental fate processes. Wagemann & Barica (1979) reported that the water column half-life of copper in six lakes was one to two days, and seven days in one other lake. Taking the geometric mean, the half-life of dissolved copper in water can be estimated to be 2.4 days. The USDA (1980) reported that when 1000 ug/L of arsenic was added to water, only 17% remained after 11 days. By linear interpolation, the half-life of ionic arsenic in water can be estimated as 6.6 days. The metal is bound up by organic complexes, suspended sediment, and other particulate matter in the water. Ultimately, the fate of the leached copper and arsenic is to be deposited in the bottom sediments. Higher concentrations of metals would be expected to occur in the sediments immediately surrounding the submerged CCA treated structure.

Table 7-3. Estimates of daily total metal losses from 10 CCA treated pilings three feet long submerged in a one acre pond with a mean depth of six feet, in ug/day. Total metals lost estimated by multiplying daily loss rate in ug/cm^2/day by 87561.12 cm^2.

		short term		long term	
metal	water	daily loss rate in ug/cm^2/day	total metals lost in ug/day	daily loss rate in ug/cm^2/day	total metals lost in ug/day
copper	fresh	0.41	35900	0.03	2627
copper	salt	1.43	125212	0.81	70925
arsenic	fresh	0.43	37651	0.14	12259
arsenic	salt	0.27	23542	0.08	7005

Even though metals are being continuously released into the water column from the CCA treated wood, fate processes are working to remove the metals from the water. Using a computer program, the steady- state concentration of metals in the water resulting from a combination of leaching and environmental fate processes can be estimated. See table 7-4.

Table 7-4: Estimate of the steady state equilibrium concentration of metals in the water column taking into account the continuous release of metals from the CCA treated wood and the fate processes at work removing metals from the water column.

metal	water	total metals lost in ug/day	estimate of the steady state amount of metal available in the water column in ug	Concentration of metals in the water column of a one acre pond with a mean depth of six feet, in ug/L
Short term (first six months after wood is installed)				
copper	fresh	35900	172320	0.023
copper	salt	125212	601018	0.081
arsenic	fresh	37651	496993	0.067
arsenic	salt	23642	312074	0.042
Long term				
copper	fresh	2627	12598	0.002
copper	salt	70925	340132	0.046
arsenic	fresh	12259	146592	0.020
arsenic	salt	7005	83765	0.011

To estimate the potential for adverse impacts to aquatic life, the copper and arsenic concentrations in the last column of table 7-4 can be compared to the corresponding New York State water quality standards for the protection of survival and propagation of aquatic life. The copper water quality standard is dependent upon the hardness of the water. New York's water quality standards for copper and arsenic are summarized in table 7-5.

Table 7-5: New York State ambient water quality standards for copper and arsenic for the protection of aquatic life propagation and survival, in ug/L. Hardness concentrations are in parts per million as $CaCO_3$

		Hardness (ppm)		
Metal	Water	50	100	200
copper	fresh	5	9	26
copper	salt	3.4		
arsenic	fresh	150		
arsenic	salt	63		

A comparison of the concentrations of copper and arsenic that would occur in the water column when ten pilings three feet long are installed in a one acre pond with a mean depth of six feet to the New York State water quality standards shows that the copper and arsenic leaching from the treated wood are not likely to impact aquatic life.

Chromium was not addressed in this quantitative evaluation because chromium is of low toxicity compared to copper and arsenic, and leaching rates for chromium are consistently lower than those of copper and arsenic (Lebow et al, 1999).

F. Summary: A thorough consideration of the factors described above indicates that the use of CCA-treated wood is not likely to result in a significant environmental impact when used for in-water construction. Although copper and arsenic will leach into the water, they are not likely to leach enough to be harmful to aquatic life. Dissolved copper and arsenic are removed from the water column fairly quickly by sediment sorption or complexation. The concentration of copper and arsenic in the sediments near CCA-treated pilings would probably be higher than background, although the metals in the sediments are most likely to be adsorbed and in a biologically unavailable state. Brooks, (1997a) investigated the accumulation of copper in sediments in the vicinity of CCA treated pilings. He found copper concentrations in the sediments in the vicinity of the pilings to be approximately only 0.35 ppm. Because the data show that CCA-treated wood retains most of the metallic oxides, the volume that could build up in the sediments as a result of leaching is apparently small. This risk assessment generally shows that metals leaching from CCA treated wood are unlikely to build up to concentrations in the sediment or water column that would be harmful to aquatic life.

8. Other Aquatic Habitats

A. Marine:

1. Creosote. Creosote-treated timbers are commonly used as pilings in both fresh water and salt water. As stated above, Ingram et al, (1982) reported that PAH's leached from creosote treated wood in fresh water twice as fast as the leaching rate from creosote treated wood in sea water. Since leaching occurs more slowly in salt water than in freshwater, the risk of adverse impacts to marine life are correspondingly lower than the risks to freshwater aquatic life.

2. Pentachlorophenol. According to the Brooks, (1998) model, penta leaches at a higher rate in salt water than in fresh water. For example, on day 10 following submersion, a penta treated piling would leach 3.34 ug/cm^2 in freshwater, salinity 0. In water with a salinity with 35‰, the piling would leach 3.69 ug/cm^2. More importantly, The America Wood Preservers Association has not developed a standard for the use of penta treated wood in salt water. The lack of an AWPA standard suggests that either penta is not effective in controlling marine organisms that attack submerged wood, or that the penta will leach out of the wood. In either case, because the AWPA has not developed a standard, penta treated wood should not be used in salt water. This risk assessment recommends against the use of penta-treated wood in water with a salinity greater than 8‰. At that salinity concentration, sensitive freshwater organisms (zebra mussels) begin to have significant mortality due to salinity effects, suggesting that 8‰ is an appropriate salinity for differentiating fresh water habitat from marine/estuarine habitat (Mackie and Kilgour, 1992).

3. CCA. The leaching of CCA in salt water was examined in the CCA Quantitative Risk Assessment Section (Section 7E) of this report. Copper tended to leach more in salt water, and arsenic leached more in fresh water. In the model scenario analyzed, neither copper nor arsenic leaching caused an exceedance of state water quality standards in fresh or salt water. Brooks, (1997a) developed a model that integrates salinity as a factor for estimating leaching rates.

B. Wetlands: Two typical applications of pressure treated wood in wetlands are occasionally observed in New York State. The first is the construction of trails or walkways through wetlands visited by the public, and the second is the installation of utility poles through wetland areas. Utility poles are most frequently treated with pentachlorophenol; however, walkways, boardwalks, or bridges can be constructed out of timbers treated with any of the three common wood preservatives. Wetlands can either have permanent standing water over the saturated soils, or have only seasonal, temporary pools of standing water.

This risk assessment has already found that the use of pressure treated wood in freshwater habitats is unlikely to be harmful to aquatic life. Preservatives leached only in small quantities, and at the highest rates when freshly-treated wood has been newly installed. The leached preservative compounds have a short half-life in the environment in their most toxic form. It is

similarly unlikely that creosote or CCA treated timbers would have adverse impacts on wetlands, particularly those without permanent standing water. Soluble (ionic) copper, chromium, arsenic would be rapidly complexed into forms with little or no biological availability by humic substances in the wetland soil. PAHs from creosote would adsorb strongly to organic carbon in wetland soil and be degraded by microbes.

Pentachlorophenol treated wood used in the decking for boardwalks in wetlands is also likely to have little or no measurable adverse ecological impact. The primary source of water to leach penta would be precipitation. Penta washed off the decking would adsorb to the typically acidic soils found in wetlands and be degraded either by photolysis or microbial degradation.

Pentachlorophenol is currently the most widely-used wood preservative for utility poles (USDA, 1980). Concerns have been frequently raised about the potential for adverse environmental impacts from utility poles being placed into wetlands. Utility poles could be placed in two types of wetland situations: 1) saturated soil but no standing water over the soil; and 2) saturated soil and 1-6 feet of standing water over the saturated soil. In the first case, the concern would be the impact of penta leaching into soil. In the second case, the concern would be for penta leaching into soil and into the surface water in the wetland.

In either case, groundwater contamination should not be a concern. Penta leaching out of the wood into the soil would be bound up and degraded in the soil, and not likely to move more than a foot or so away from the pole, particularly in acidic soils. Also, wetlands in general tend to be impervious areas where surface water is unable to penetrate to groundwater, although there are some wetlands with the specific function of groundwater recharge.

In wetlands with little or no standing water over the saturated soils, the moisture in the soil could provide a medium for penta to leach out of the pole into the surrounding soil. Penta tends to more strongly adsorb to soils with lower pH and higher organic matter content (ESEERCO, 1992). High organic matter and low pH tend in general to be characteristics of wetland soils. Leached penta would adsorb to the soil where it would be decomposed by microbial degradation. Because of the relatively low volumes of penta that can be leached, detectable concentrations of penta are unlikely to be found more than a foot or so away from the pole.

If a wetland has standing water over the saturated soils, penta could leach out of the poles into the ambient water in the same manner as described earlier for pilings. A worst-case scenario would be a one acre wetland that was 45 feet wide by 1000 feet long covered by six feet of standing water. Traversing the wetland's length would require about 12 poles separated by 70-80 feet. If each pole was one foot in diameter, treated to a retention of 0.8 pcf, and submerged in six feet of water, the possible concentration of penta leaching from the 12 poles into the surrounding surface water could be estimated.

The surface area of the 12 submerged utility poles, assuming they are submerged to a

depth of six feet in standing water is 226.2 ft^2, or 210,142 cm^2. In the Pentachlorophenol Quantitative Risk Assessment section (Section 6E), the daily leaching rate for penta on day 10 after submersion in water with a salinity of 0 ‰ and a pH of 7.0, was found to be 3.34 ug/cm^2 using the leaching model from Brooks, (1998). From this leaching rate, the steady state concentration of penta in the water from the 12 poles would be 2.8 ug/L if the half-life of penta in water was 15 days, or 1.4 ug/L if the half-life of penta in water was 7.6 days. Neither value exceeds the NY State ambient water quality standard for pentachlorophenol for the protection of fish propagation and survival.

9. Sources of Additional Information

Further information about wood preservatives can be obtained from Internet Web sites. The American Wood-Preserver's Association maintains a site at: http://www.awpa.com. The American Wood Preserver's Institute maintains an website at http://www.awpi.org. Also, the Western Wood Preserver's Institute maintains a website at http://wwpinstitute.org The Western Wood Preserver's Institute website contains the series of Best Management Practices for minimizing environmental impacts when pressure treated wood is used in water. The risk assessment documents and computer modeling software referred to through this report for creosote (Brooks, 1997); pentachlorophenol (Brooks, 1998), CCA (Brooks, 1997a); ACZA (Brooks, 1997b); and ACQ (Brooks, 1998a) can also be obtained from that website.

10. Consumer Information Sheets

As a condition of registration, the U.S. EPA required the wood preservative industry to develop and distribute Consumer Information Sheets for each type of treated wood. The sheets provide information on the safe use, handling, and disposal of treated wood. Copies of the U.S. EPA-approved consumer information sheets for CCA (Inorganic Arsenical), pentachlorophenol, and creosote treated wood follow:

Consumer Information Sheet

INORGANIC ARSENICAL PRESSURE TREATED WOOD

(Including CCA, ACA, and ACZA)

CONSUMER INFORMATION

This wood has been preserved by pressure treatment with an EPA-registered pesticide containing inorganic arsenic to protect it from insect attack and decay. Wood treated with inorganic arsenic should be used only where such protection is important.

Inorganic arsenic penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to inorganic arsenic may present certain hazards. Therefore, the following precautions should be taken both when handling the treated wood and in determining where to use or dispose of the treated wood.

USE SITE PRECAUTIONS

Wood pressure-treated with waterborne arsenical preservatives may be used inside residences as long as all sawdust and construction debris are cleaned up and disposed of after construction.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such sites would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops. Only treated wood that is visibly clean and free of surface residue should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come in contact with the honey.

Treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks and bridges.

HANDLING PRECAUTIONS

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces, or residential boilers because toxic chemicals may be produced as part of the smoke and ashes. Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalation of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible, these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking, and use of tobacco products, wash exposed areas thoroughly.

If preservatives or sawdust accumulate on clothes, launder before reuse. Wash work clothes separately from other household clothing.

Consumer Information Sheet

PENTACHLOROPHENOL PRESSURE TREATED WOOD

CONSUMER INFORMATION

This wood has been preserved by pressure-treatment with an EPA-registered pesticide containing pentachlorophenol to protect it from insect attack and decay. Wood treated with pentachlorophenol should be used only where such protection is important.

Pentachlorophenol penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to pentachlorophenol may present certain hazards. Therefore, the following precautions should be taken both when handling the treated wood and in determining where to use and dispose of the treated wood.

USE SITE PRECAUTIONS

Logs treated with pentachlorophenol should not be used for log homes.

Wood treated with pentachlorophenol should not be used where it will be in frequent or prolonged contact with bare skin (for example, chairs and other outdoor furniture), unless an effective sealer has been applied.

Pentachlorophenol-treated wood should not be used in residential, industrial, or commercial interiors except for laminated beams or for building components which are in ground contact and are subject to decay or insect infestation and where two coats of an appropriate sealer is applied. Sealers may be applied at the installation site.

Wood treated with pentachlorophenol should not be used in the interiors of farm buildings where there may be direct contact with domestic animals or livestock which may crib (bite) or lick the wood.

In interiors of farm buildings where domestic animals or livestock are unlikely to crib (bite) or lick the wood, pentachlorophenol-treated wood may be used for building components which are in ground contact and are subject to decay or insect infestation and where two coats of an appropriate sealer are applied. Sealers may be applied at the installation site.

Do not use pentachlorophenol-treated wood for farrowing or brooding facilities.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such sites would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops.

Only treated wood that is visibly clean and free of surface residue should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come in contact with the honey.

Pentachlorophenol-treated wood should not be used where it may come in direct or indirect contact with public drinking water, except for uses involving incidental contact such as docks and bridges.

Do not use pentachlorophenol-treated wood where it may come into direct or indirect contact with drinking water for domestic animals or livestock, except for uses involving incidental contact such as docks and bridges.

HANDLING PRECAUTIONS

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces, or residential boilers because toxic chemicals may be produced as part of the smoke and ashes. Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers rated at 20 million BTU/hour or greater heat input or its equivalent in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalation of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible, these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

Avoid frequent or prolonged skin contact with pentachlorophenol-treated wood; when handling the treated wood, wear long-sleeved shirts and long pants and use gloves impervious to the chemicals (for example, gloves that are vinyl coated). When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking, and use of tobacco products, wash exposed areas thoroughly.

If oily preservatives or sawdust accumulate on clothes, launder before reuse. Wash work clothes separately from other household clothing. Urethane, shellac, latex epoxy enamel and varnish are acceptable sealers for pentachlorophenol-treated wood.

Consumer Information Sheet

CREOSOTE
PRESSURE TREATED WOOD

CONSUMER INFORMATION

This wood has been preserved by pressure-treatment with an EPA-registered pesticide containing creosote to protect it from insect attack and decay. Wood treated with creosote should be used only where such protection is important.

Creosote penetrates deeply into and remains in the pressure-treated wood for a long time. Exposure to creosote may present certain hazards. Therefore, the following precautions should be taken both with handling the treated wood and in determining where to use the treated wood.

USE SITE PRECAUTIONS

Wood treated with creosote should not be used where it will be in frequent contact with bare skin (for example, chairs and other outdoor furniture) unless an effective sealer has been applied.

Creosote-treated wood should not be used in residential interiors. Creosote-treated wood in interiors of industrial building should be used only for industrial building components which are in ground contact and are subject to decay or insect infestation and wood block flooring. For such uses, two coats of an appropriate sealer must be applied. Sealers may be applied at the installation site.

Wood treated with creosote should not be used in the interiors of farm buildings where there may be direct contact with domestic animals or livestock which may crib (bite) or lick the wood.

In interiors of farm buildings where domestic animals or livestock are unlikely to crib (bite) or lick the wood, creosote-treated wood may be used for building components which are in ground contact and are subject to decay or insect infestation if two coats of an effective sealer are applied. Sealers may be applied at the installation site.

Do not use creosote-treated wood for farrowing or brooding facilities.

Do not use treated wood under circumstances where the preservative may become a component of food or animal feed. Examples of such use would be structures or containers for storing silage or food.

Do not use treated wood for cutting-boards or countertops.

Only treated wood that is visibly clean and free of surface residue should be used for patios, decks and walkways.

Do not use treated wood for construction of those portions of beehives which may come in contact with the honey.

Creosote-treated wood should not be used where it may come into direct or indirect contact with public drinking water, except for the uses involving incidental contact such as docks or bridges.

Do not use creosote-treated wood where it may come into direct or indirect contact with drinking water for domestic animals or livestock, except for uses involving incidental contact such as docks and bridges.

HANDLING PRECAUTIONS

Dispose of treated wood by ordinary trash collection or burial. Treated wood should not be burned in open fires or in stoves, fireplaces, or residential boilers because toxic chemicals may be produced as part of the smoke and ashes. Treated wood from commercial or industrial use (e.g., construction sites) may be burned only in commercial or industrial incinerators or boilers in accordance with state and Federal regulations.

Avoid frequent or prolonged inhalation of sawdust from treated wood. When sawing and machining treated wood, wear a dust mask. Whenever possible, these operations should be performed outdoors to avoid indoor accumulations of airborne sawdust from treated wood.

Avoid frequent or prolonged skin contact with creosote-treated wood; when handling the treated wood, wear long sleeved shirts and long pants and use gloves impervious to the chemicals (for example, gloves that are vinyl coated).

When power-sawing and machining, wear goggles to protect eyes from flying particles.

After working with the wood, and before eating, drinking, and the use of tobacco products, wash exposed areas thoroughly.

If oily preservatives or sawdust accumulate on clothes, launder before reuse. Wash work clothes separately from other household clothing.

Coal tar pitch and coal tar pitch emulsion are effective sealers for creosote-treated wood-block flooring.

Urethane, epoxy, and shellac are acceptable sealers for all creosote-treated wood.

11. LITERATURE CITED

Andrew, R.K., Biesinger, K.E., and G.E. Glass, 1977. Effects of Inorganic Complexing on the Toxicity of Copper to Daphnia magna. Water Research, 11:309-315

Arsenault, R.D., 1973. Chapter 2. Factors Influencing the Effectiveness of Preservative Systems. in Wood Deterioration and Its Prevention by Preservative Treatments, Volume II, Preservatives and Preservative Systems. Darrel D. Nicholas, Editor. Syracuse University Press, 1973, Syracuse, New York.

Arsenault, R.D., 1975. CCA-Treated Wood Foundations: A study of Permanence, Effectiveness, Durability, and Environmental Considerations. Proc. American Wood-Preserver's Association, V.71:126-147

Arsenault, R.D., 1976. Pentachlorophenol and Contained Chlorinated Dibenzodioxins in the Environment. Journal of the American Wood-Preservers Association, 1976.

AWPA, 1989. American Wood Preservers' Association Book of Standards, 1989. American Wood Preservers Association, Stevensville, Maryland.

AWPA, 1989. American Wood Preservers' Association Book of Standards, 1989.

Baechler, R.H. and H.G. Roth, 1961. Further Data on the Extraction of Creosote from Marine Piles. Proc. AWPA 57:120-132.

Baechler, R.H., Richards, B.R., Richards, AP., and H.G. Roth, 1970. Effectiveness and Permanence of Several Preservatives in Wood Coupons Exposed to Sea Water. Proc. American Wood-Preserver's Association, Vol.66:1-16

Breslin, V.T., Senturk, U., and C.C. Berndt, 1998. Long-term engineering properties of recycled plastic lumber used in pier construction. Resources, Conservation and Recycling 23(1998) 243-358. Elsevier Science B.V.

Brooks, K.M., 1997. Literature Review, Computer Model and Assessment of the Potential Environmental Risks Associated With Creosote Treated Wood Products Used in Aquatic Environments. April 25, 1995, Revised June 1, 1997. Aquatic Environmental Sciences, 644 Old Eaglemount Road, Port Townsend, Washington 98368. Prepared for Western Wood Preservers Institute, 601 Main Street, Suite 401, Vancouver, Washington, 98660.

Brooks, K.M., 1997a. Literature Review and Assessment of the Environmental Risks Associated With the Use of CCA Treated Wood Products in Aquatic Environments, August 1, 1997. Aquatic Environmental Sciences, 644 Old Eaglemount Road, Port Townsend, Washington 98368. Prepared for Western Wood Preservers Institute, 7017 NE Highway 99, Suite 108, Vancouver, Washington, 98665.

Brooks, K.M., 1997a. Literature Review and Assessment of the Environmental Risks Associated With the Use of ACZA Treated Wood Products in Aquatic Environments, August 1, 1997. Aquatic Environmental Sciences, 644 Old Eaglemount Road, Port Townsend, Washington 98368. Prepared for Western Wood Preservers Institute, 7017 NE Highway 99, Suite 108, Vancouver, Washington, 98665.

Brooks, K.M., 1998. Literature Review, Computer Model and Assessment of the Potential Environmental Risks Associated With Pentachlorophenol Treated Wood Products Used in Aquatic Environments, February 9, 1998. Aquatic Environmental Sciences, 644 Old Eaglemount Road, Port Townsend, Washington 98368. Prepared for Western Wood Preservers Institute,7017 NE Highway 99, Suite 108, Vancouver, Washington, 98665.

Brooks, K.M., 1998a. Literature Review and Assessment of the Environmental Risks Associated With the Use of ACQ Treated Wood Products in Aquatic Environments, January 21, 1998. Aquatic Environmental Sciences, 644 Old Eaglemount Road, Port Townsend, Washington 98368. Prepared for Western Wood Preservers Institute, 7017 NE Highway 99, Suite 108, Vancouver, Washington, 98665.

Brooks, K.M., Personal Communication. Letter, from Dr. Kenneth M. Brooks, Aquatic Environmental Sciences, 644 Old Eaglemount Road, Port Townsend, Washington 98368. to Timothy J. Sinnott, NYSDEC, dated November 16, 1999.

Choudhury, H., Coleman, J., De Rosa, C.T., and J.F. Stara, 1986. Pentachlorophenol: Health and Environmental Effects Profile. Toxicology and Industrial Health 2(4):483-571, 1986.

Collwell, R.R., and R.A. Seesman, 1976. Progress Report on Roosevelt Roads Pilings Project, Preliminary Work. Report to Koppers Company: Koppers; 1976. 7 pp. AWPI.

Connor, S.R., 1994. Pentachlorophenol - Leaching from utility poles exposed to the aquatic environment. Springborn Laboratories Report Number 94-3-5201. Environmental Sciences Division, 790 Main Street, Wareham, Massachusetts 02571-1075.

Cook, C.D., 1957. The Permanence of Water Borne Preservatives in Timber. Chemistry and Industry, 25 May 1957, p. 663.

Crosby, D.G., 1981. Environmental Chemistry of Pentachlorophenol. Pure and Applied Chem., Vol. 53, pp 1051-1080 Pergammon Press, Ltd., 1981.

Cserjesi, A.J., 1975. Permanence of Preservatives in Treated Experimental Shake Roofs. Forest Products Journal 26(12):34-39

DeLaune, R.D., Gambrell, R.P., and K.S. Reddy, 1983. Fate of Pentachlorophenol in Estuarine Sediment. Environmental Pollution (Series B) 6 (1983) 297-308.

Dunn, B.P. and H.G. Stich, 1975. The Use of Mussels in Estimating Benzo(A) pyrene Contamination of the Marine Environment. Proc. Soc. Exp. Biol. Med. 150:49-51.

Elder, J.F., and A.J. Horne, 1978. Copper Cycles and $CuSO_4$ algicidal Capacity in Two California Lakes. Environmental Management 2(1):17-30, 1978.

Eisler, R., 1989. Pentachlorophenol hazards to Fish, Wildlife, and Invertebrates: A synoptic Review. Biological Report 85(1.17) April 1989, Contaminant Hazard Reviews Report No. 17, U.S. Fish & Wildlife Service.

Esau, K., 1967. Plant Anatomy. John Wiley & Sons, Inc., 3rd Printing.

ESEERCO, 1992. Pentachlorophenol in Wood Utility Poles: Environmental Fate and Toxicology, Literature Review. Empire State Electrical Energy Research Cooperation, Electric Energy Research Institute, February, 1992. Prepared by O'Brien and Gere Engineers, Inc. Syracuse, N.Y. 13221

Evans, F.G., 1987. Leaching from CCA-impregnated Wood to Food, Drinking-Water, and Silage. International Research Group on Wood Preservation, Eighteenth Annual Meeting, 17-22 May 1987. Document No:IRG/WP/3433

Fahlstrom, G.B., Gumming, P.E., and J.A. Carlson, 1967. Copper-Chrome-Arsenate Wood Preservatives: A Study of the Influence of Composition on Leachability. Forest Products Journal 17(7):17-22.

Federal Register, 1986. Creosote, Pentachlorophenol, and Inorganic Arsenicals: Amendment of Notice of Intent to Cancel Registrations. U.S. Environmental Protection Agency. Federal Register 51(7):1334-1348. Friday, January 10, 1986.

Goyette, D., and K.M. Brooks, 1999. Creosote Evaluation: Phase II. Sooke Basin Study - Baseline to 535 Days Post Construction 1995 - 1996. Published by Environment Canada. 224 West Esplanade, North Vancouver, British Columbia, Canada V7M 3H7. 568 pp.

Häger, B., 1969. Leaching Tests on Copper-Chromium-Arsenic Preservatives. Forest Products Journal 19(10):21-26

Hartford, W.H., 1986. The Practical Chemistry of CCA in Service. Proc. American Wood-Preserver's Association 82:28-45

Hawley, G.G., 1977. The Condensed Chemical Dictionary, 9th ed. Van Nostrand Reinhold Company, New York, New York.

Henry, W.T. and E.B. Jeroski,1967. Relationship of Arsenic Concentration to the Leachability of Chromated Copper Arsenate Formulations. Proc. American Wood-Preserver's Association 63:1-6.

Hites, R.A., LaFlamme, R.E. and J.G. Windsor, Jr., 1980. Polycyclic Aromatic Hydrocarbons in Marine/Aquatic Sediments: Their Ubiquity. Advances in Chemistry Series, No. 185, Petroleum in the Marine Environment. American Chemical Society.

Hochman, H., 1967. Creosoted Wood in the Marine Environment - A Summary Report. Proc. AWPA 63,138-150.

Hoeting, A.L., 1979. Penta - Another Environmental Contaminant. Reprinted manuscript from A talk presented at the Spring Meeting of the Central States Association of Food and Drug Officials, Mason, Ohio, May 4-5, 1977.

Hoffman, E.J., Mills, G.L., Latimer, J.S., and J. G. Quinn, 1984. Urban Runoff as A Source of Polycyclic Aromatic Hydrocarbons to Coastal Waters. Environmental Science and Technology 18(8):580-587.

Ingham, G.L. Jr., McGinnis, G.D., Gjovik, L.R., and G. Roberson, 1982. Migration of Creosote and its Components from Treated Piling Sections in A Marine Environment. Proc. AWPA 78:120-128.

Ingham, G.L. Jr., McGinnis, G.D. Prince, S.E., Gjovik, L.R., and D.A. Webb, 1984. The Effects of Temperature, Flow Rates, and Coating Systems on the Vaporization of Creosote Components from Treated Wood. Proc. AWPA 80:97-104.

Irvine, J. and S.E. Dahlgren, 1976. Mechanism of Leaching of Copper-Chrome-Arsenic Preservatives in Saline Waters. Holzforschung. 30(2):45-60

Johnson, R.L., Gehring, P.J., Kociba, R.J., and B.A. Schwetz, 1973. Chlorinated Dibenzodioxins and Pentachlorophenol. Environmental Health Perspectives, September, 1973 pp. 171-175

Kelso, W.C. Jr. and E.A. Behr, 1977. Depletion of Preservatives from Round Southern Pine in Fresh Water. Proc. AWPA 73:135-139.

Lamparski, G.L., and R.H. Stehl, 1980. Photolysis of Pentachlorophenol-Treated Wood. Chlorinated Dibenzo-p-dioxin Formation. Environmental Science & Technology, Vol. 14, pp. 196-200, February 1980.

Lorenz, L.G., and L.R. Gjovik, 1972. Analyzing Creosote by Gas Chromatography: Relationship to Creosote Specification. Proc. AWPA. 68:32-41.

Mackie, G.L., and B.W. Kilgour, 1992. Effects of Salinity on Growth and Survival of Zebra Mussels. Mackie and Associates Water Systems Analysts, 381 Elmira Road, Guelph, Ontario, Canada N1K 1H3. Prepared for Empire State Electric Energy Research Corporation, 1155 Avenue of the Americas, New York, New York 10036, April, 1992

National Timber Piling Council, 1995. Technical Guidelines for Construction with Treated Round Timber Piling. National Timber Piling Council, Inc., 446 Park Ave, Rye, New York 10580

Pierce, R.H., Brent, C.R., Williams, H.P., and S.G. Reeves, 1977. Pentachlorophenol Distribution in A Fresh Water Ecosystem. Bull. Environ. Contam. Toxicol. 15(2):251-258.

Pignatello, J.J., Martinson, M.M.,Steiert, J.G., Carlson, R.E., and R.L. Crawford, 1983. Biodegradation and Photolysis of Pentachlorophenol in Artificial Freshwater Streams. Applied and Environmental Microbiology 46(5):1024-1031, November 1983.

Sax, N.I., (1979). Dangerous Properties of Industrial Materials, 5th Edition. Van Nostrand Reinhold Company, New York.

Seesman, P.A., Colwell, R.R. and A. Zachary, 1977. Biodegradation of Creosote/Naphthalene-Treated Wood in the Marine Environment. Proc. AWPA 73:54-60.

Sherrill, T.W. and G.S. Sayler, 1980. Phenanthrene Biodegradation in Freshwater Environments. Applied and Environmental Microbiology 39(1):172-178.

Spodaryk, J.G., 1977. Status Report: The Use of Osmose K-33 (CCA-B) as A Wood Preservative. New York State Department of Environmental Conservation, Bureau of Environmental Protection, 50 Wolf Road, Albany, NY 12233-4756

Tagatz, M.E., Plaia, G.R. Deans, C.H., and E.M. Tores, 1983. Toxicity of Creosote-Contaminated Sediment to Field and Laboratory-Colonized Estuarine Benthic Communities. Environmental Toxicology and Chemistry, 2:441-450.

USDA, 1980. The Biologic and Economic Assessment of Pentachlorophenol, Inorganic Arsenicals, and Creosote, Vol. 1: Wood Preservatives. U.S. Department of Agriculture, Technical Bulletin number 165 8-1.

U.S. EPA, 1979. Water-Related Environmental Fate of 129 Priority Pollutants, Volume II. U.S. Environmental Protection Agency, Office of Water Planning and Standards, PB 80-204381, EPA-440/4-79-029b.

U.S. EPA, 1986. Ambient Water Quality Criteria for Pentachlorophenol. U.S. Environmental Protection Agency, Office of Water, EPA 440/5-86-009 September, 1986.

U.S. EPA, 1986a. Quality Criteria for Water, 1986. U. S. Environmental Protection Agency, Office of Water, EPA 440/5-86-001, May 1, 1986.

U.S. EPA, 1987. Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-*p*-Dioxins and -Dibenzofurans (CDDs and CDFs). U.S. Environmental Protection Agency, EPA/625/3-87/012, March 1987.

Wade, M.J., Connor, M.S., Jop, K.M., Hillman, R.E., and H.J. Costa, 1987. Final Report to the U.S. Department of the Interior, National Park Service, North Atlantic Region. Prepared by Battelle Ocean Sciences, 397 Washington Street, Duxberry, Massachusetts 02332.

Wagemann, R. and J. Barica, 1979. Speciation and Rate of Loss of Copper from Lakewater with Implications to Toxicity. Water Research 13:515-523.

Walters, C.S. and R.D. Arsenault, 1971. The Concentration and Distribution of Pentachlorophenol in Pressure treated Pine Pole-Stubs After Exposure. Journal of the American Wood-Preservers' Association, 1971, pp. 149-169.

Webb, D.A., 1980. Creosote its Biodegradation and Environmental Effects. Proc. AWPA 76:65-68.

Webb, D.A. and L.R. Gjovik, 1988. Treated Wood Products, Their Effect on the Environment. Proc. American Wood-Preserver's Association 84:254-259

12. WWPI Best Management Practices

As stated several times throughout this report, the Western Wood Preservers Institute (WWPI) has developed a series of best management practices (BMPs). These BMPs were developed for the wood preserving industry. They identify practices and procedures for producing treated wood in a manner that will minimize the potential for leaching when the treated wood is placed in water. Preserved wood should be treated in accordance with these BMPs whenever it will be placed in water.

These BMPs are in a state of evolution, just as AWPA standards can change with advances in the science of wood preservation. With the permission of the WWPI, the BMPs as of March, 2000 are included in this report. In future years, the WWPI website should be checked to see if BMPs have been changed or updated.

The WWPI is trying to implement a nation-wide program wherein wood treated in accordance with the BMPs will be marked with a specific stamp or brand. In the future, it will be possible to confirm that wood has been treated in accordance with the WWPI BMPs simply by looking for the appropriate marking. In the meantime, contract-writers should stipulate that treated wood intended for in-water applications must be processed in accordance with the WWPI BMPs.

NOTE: Western Wood Preservative Institute BMP's are not included in the on-line version of the risk assessment. The BMPs can be downloaded at http://wwpinstitute.org

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