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Title: Groundwater and Stormwater Treatment at Western Wood Preserving Facilities: An Analysis of Current Treatment Methods.

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The Pacific Northwest is blessed with an abundance of precipitation. This rainfall, however, can have important consequences for industries that must process the resulting stormwater for proper discharge. This is particularly true of wood treatment facilities. Past management practices at wood preserving facilities located in the Western United States create significant hurdles with regard to stormwater treatment or groundwater recovery operations required to achieve regulatory compliance. In many instances, State regulations have more stringent discharge requirements than current Federal regulations. Stringent requirements, combined with the fact that many of these facilities have been in operation for decades, use many different preservatives,

and may be currently involved with remediation activities, can place substantial regulatory burdens on a facility.

Wood preserving facilities tend to experience similar issues and concerns with the treatment of collected stormwater and groundwater, but often do not share this information. Compiling information on how facilities address these issues could help identify potential trends and collectively develop solutions to address the challenges related to water treatment and regulatory compliance.

The goal of the study was to assemble information on stormwater and groundwater handling practices of treatment facilities in the Western United States including: facility age, preservatives used and previously used at the facility, effect on groundwater and stormwater, production information related to preservative type and volume, size of real property subject to water management requirements, volume of water managed, methods of groundwater and stormwater treatment, and regulatory permits and monitoring requirements. This survey was limited to issues related to stormwater and groundwater (as the result of remediation activities) and did not address process related wastewater.

The data suggested that, while many plants dealt with stormwater and groundwater issues, there were no consistent relationships between plant size, age, or production capacity and how these waters were processed. There were also considerable differences in permitting limits among plants in different states, with plants in Oregon or Washington having the most stringent release requirements. However, there were still a number of inconsistencies in how plants dealt with stormwater and groundwater, although it was unclear how or why these differences had developed. The data suggest the need for more standardization of requirements.

Groundwater and Stormwater Treatment at Western Wood Preserving Facilities:
An Analysis of Current Treatment Methods

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APPROVED:

Major Professors, representing Wood Science

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Anita M. Ragan, Author

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LIST OF ACRONYMS &ABBREVIATIONS

ACQ .... Ammoniacal Copper Quaternary
ACZA .... Ammoniacal Copper Zinc Arsenate
BOD .... Biochemical Oxygen Demand
BMP .... Best Management Practice
CCA .... Chromated Copper Arsenate
CuNap .... Copper Naphthenate
CWA .... Clean Water Act
DDT .... dichlorodiphenyltrichloroethane
ED .... electrodialysis
EDR .... electrodialysis reversal
EPA .... Environmental Protection Agency
FIFRA .... Federal Insecticide, Fungicide and Rodenticide Act
GAC .... Granulated Activated Carbon
MCL .... Maximum Contaminant Level
mmbf .... million board feet
NOAA .... National Oceanic and Atmospheric Administration
NPDES .... National Pollution Discharge Elimination System
O&M .... Operating & Maintenance
PAH .... Polycyclic aromatic hydrocarbon
Penta .... Pentachlorophenol
POPC .... Pollutant of Potential Concern
POTW .... Publicly Owned Treatment Works
ppqm .... parts per quadrillion
RCRA .... Resource Conservation and Recovery Act
SDWA .... Safe Drinking Water Act
TPH .... Total Petroleum Hydrocarbons

TRI .... Toxic Release Inventory
TSDF .... Treatment, Storage, and Disposal Facilities
TSS .... Total Suspended Solids
UIC .... Underground Injection Control
WET .... Whole Effluent Toxicity

Chapter 1: Introduction

The wood products industry has historically played a very important role in the economy of the Western United States (US), and continues in this important role to this day. Timber harvesting, sawmills, and pulp and paper mills are common sights in forested areas of the west, and have helped shape the economy and culture of the region. One of the important subsets of the wood products industry is the manufacture of preservative-treated wood products that are designed to extend the life of the product in harsh environments (Preston, 2000). The 2007 census states that the wood preservation industry has a market value of 5.8 billion (U.S. Census, 2007).

The treatment of wood products involves application of pesticides to the wood, either by soaking or pressure treatment. These pesticides are toxic to fungi and other organisms, resulting in an improved resistance to degradation. This reduced decay rate allows for wood use in critical external applications, where a long life cycle is required, for instance is the case with utility poles, piers, decks and bridges. While the preservation of wood products has many beneficial attributes, the treating solutions have varying levels of toxicity, and must be properly managed to protect human health and the environment.

Wood treating facilities deal with a variety of regulatory issues regarding the use of preservative chemicals. In addition to specific methodologies for managing and reporting use of treating chemicals and waste materials, permits are required for air and water discharges. In a perfect system, treating plants would be completely enclosed, but the scale of the operations makes this difficult. Management of stormwater discharge is important, as rainfall can come into contact with and solubilize potentially hazardous substances contained in wood preservative chemicals or the treated products. This is particularly true in the Pacific Northwest, which receives copious quantities of rainfall that must be properly managed.

Past management practices at wood preserving facilities located in the Western US have also created significant hurdles with regard to both groundwater and stormwater management. The presence of treating solutions in surface and subsurface soils resulting from past practices, spills, or other releases often result in a significant mass of treating chemicals in site media (i.e., soil, sediment, and groundwater). These contaminated materials can provide a long-term source for groundwater and surface water contamination (EPA, 1996).

Treatment of both groundwater and stormwater may be required at wood treating facilities, based on the observed concentration of site-related pollutants. Federal rules and regulations set the minimum standards for treatment of stormwater and groundwater; however, State regulations often have more stringent discharge requirements than current Federal regulations (EPA, 1996). These requirements, combined with the fact that many of these facilities have been in operation for decades, and often use many different preservatives can place a regulatory burden on the wood treating facility.

Purpose and Scope

Within the industry, wood treating facilities tend to experience similar issues and concerns with the treatment of stormwater and groundwater, but often do not share this information with each other. Compiling information on how facilities address these issues could be used to help identify potential trends and collectively develop solutions to address the challenges related to water treatment and regulatory compliance.

The scope of work for this study was to compile data on current stormwater and groundwater handling practices at treatment facilities in the Western US. The hypotheses that were tested include:

- There is a significant, positive relationship between facility size and presence of a groundwater or stormwater treatment system.
- There is a significant, positive relationship between types of preservatives

presently or previously used at a facility and presence of a groundwater or stormwater treatment system.

- There is a significant, positive relationship between types average rainfall received at a facility and the presence of a groundwater or stormwater treatment system.
- There is a significant, positive relationship between commodities treated at a facility and the presence of groundwater or stormwater treatment system.
- There is a significant, positive relationship between the age of a facility and the presence of a groundwater or stormwater treatment system.
- Treatment facilities had common strategies for groundwater and stormwater treatment.
- Benchmarks for pollutants of potential concern and water quality parameters are similar regardless of plant location, size, commodities treated or other characteristics.

The following section provides a description of wood treatment and the various types of wood preservation chemicals.

Chapter 2: Description of Wood Treatment

Preservative treatment of wood products has been used since the mid-1800s, and dramatically extends the life of the product (Graham, 1973). Wood treatment became important in the latter half of the 19^{th} century in part due to massive wood usage by railroads that threatened to overwhelm the available supply. Wood treatment increased the service life 10 fold, alleviating the potential shortage and facilitating development of a wood treatment industry in the US (Nicholas, 1973).

Wood treatment introduces pesticides into the structure of the wood, making the wood resistant to attack by decay fungi and insects such as carpenter ants, beetles, and termites. Additionally, some wood preservation chemicals make wood resistant to attack by marine borers (EPA, 1996). The chemicals employed for treatment also pose potential health and environmental risks and these risks must be weighed against the potential benefit of improved service life that reduces forest consumption.

Types of Wood Treatment

Wood treatment preservatives can be applied using pressure and non-pressure treatments. In pressure treatment, wood is placed within a pressure retort and subjected to cycles of vacuum and pressure to force the preservative into the wood structure. Non-pressure treatments include spraying or brushing chemicals onto the surface of the wood or immersing the wood in a preservative solution. The type of preservative utilized and the method by which it is delivered into the wood depend on several factors including the product, wood species, and the anticipated use of the treated product. Wood preservatives are classified as either oil-borne (oil soluble) or water-borne (water soluble) (EPA, 1996).

Oil-borne Preservatives

Oil-borne treatment solutions are carbon-based materials dissolved in a variety of organic solvents. Typical oil-borne treatment solutions include creosote, pentachlorophenol, and copper naphthenate. Creosote is a complex mixture of hydrocarbons derived from the destructive distillation of coal tar. It is used in the treatment of railroad ties, utility poles, and piling; and is one of the oldest preservatives still in use. Pentachlorophenol (penta) is a chlorinated hydrocarbon that is used as a solution in oil or diesel for the treatment of poles, cross-arms, bridge timbers, and laminated timbers. Copper naphthenate contains copper and an organic acid in an oil base. This chemical is seen as a less toxic preservative and is used in similar applications as penta (EPA, 1996).

Water-borne Preservatives

Water-borne treatment solutions include mixtures of metal oxides that may contain some combination of copper, chromium, arsenic, and zinc, combinations of copper and carbon based systems and totally carbon-based formulations (EPA, 1996). Ammoniacal copper zinc arsenate (ACZA) is a preservative developed to treat refractory wood. Species such as Douglas fir contain high percentages of difficult to treat heartwood. ACZA is used primarily on the West Coast of the United States to treat pilings, poles and dimensional lumber. Chromated copper arsenate (CCA) is an acid-based treating solution developed in the 1930's. CCA is unique among the currently used preservatives in its ability to react with and become immobilized within wood (Dahlgren and Hartford, 1972). It is used primarily in the southeastern U.S. for treating piling, poles, and dimensional lumber. In 2003, the producers voluntarily stopped treating wood with CCA for residential applications (Freeman, Shupe, Vlosky & Barnes, 2003). The removal of CCA from residential applications created opportunities for alkaline copper-based systems amended with carbon-based biocides. These include copper systems amended with either quaternary ammonium compounds or triazoles. As a result, more environmentally friendly preservatives have been developed including ammoniacal copper quaternary (ACQ) and copper azole. Both of these preservatives eliminate arsenic or chromium and add an organic component as part of the formulation (American Wood Protection Association, 2010).

Reasons for Remediation at Wood Treating Facilities

Many treating plants have been in operation for decades and their establishment can precede the dates when many environmental laws were enacted. Many common practices occurred before environmental or health concerns arose about wood preservation. More recently, metal-free preservatives containing mixtures of azoles, carbonates and an insecticide have been developed. However, these preservative systems are not suitable for direct soil contact. As our awareness of these chemicals and their toxicity has grown, there has been greater governmental regulation to ensure the health and safety of employees, the public and protection of the environment. For example, it was common practice to dump chemicals and scrap treated wood into pits on the plant site for disposal. Leaks and seepage from treated wood were not addressed with the same sense of urgency as they are today, and many common plant fixtures, such as sealed and covered drip pads, did not exist. Thus, many older plants deal with both current and prior contaminates and these materials produce added water management complications.

Previous Research

The Wood Preservation industry has long been sensitive to potential pollutants generated as part of the wood treatment process. Thompson (1973) reviewed pollution control efforts in the industry and identified the lack of resources for technical information available for addressing pollution specific to the wood preservation industry. He attributed the lack of information to the relative small size of the industry. At the time, there were approximately 400 commercial wood preserving facilities in the U.S. (Thompson, 1973). The United States Economic Census from 2007 states that there were 513 wood preservation facilities in operation (U.S. Census Bureau, 2007). Thompson (1973) stated that stormwater was probably not a significant source of contamination for wood treaters. The intervening decades have witnessed a significant shift with regard to stormwater regulations. The recommendations for preventing potential pollution from the wood treatment process such as recovering preservative during the treatment process, managing waste, addressing leaks in the process areas, reusing wash water in preservative make-up systems, and constructing dikes to prevent stormwater contact with the preservative systems, however, are not new, but all are practices currently utilized to minimize impacts to stormwater and groundwater (Thompson, 1973). Similarly, water treatment technologies, described to abatement pollution, such as biological treatments, chemical oxidation, activated carbon and chemical flocculation were also discussed in the 1970’s, but have become increasingly important for plant operations (Thompson, 1973).

Water Quality Concerns

Water qualitiy concerns are not typically pollutants, but rather measurments associated with water quality that are applied to industrial operations that discharge water. Examples of these are pH (s.u.), boligical oxygen demand (BOD), total suspended solids (TSS) and temperature. Water quality standards are set for all industry based on the health of a reciving body of water or the allowable parameters for the publicly owned treatment works (POTW), for example, pH standards are generally given as an acceptable range, such as 6.5 to 8.5. Oil & Grease and diesel range organics (TPH) are considered pollutants, however, they are generic water quality indicators that are regulated within most industry. Wood preservation operations, like most industrial operations, will have activities that will impact general water quality for example blow-down from boilers may impact the tempature and pH of the recivieing water. The strategies for addressing water quality concerns will likley be consistant with how pollutants of potential concern are addressed within an operating facility.

Pollutants of Potential Concern

Pollutants of potential concern (POPC) are compounds that pose a risk to humans and the environment and therefore are identified as pollutants that must be managed and or minimized. The descriptive term POPCs is used to describe what pollutants have the potential to result from industrial operations for the purposes of managing risk. POPCs for the wood preservation industry vary depending on the operations and preservative types used at a facility. Stormwater and groundwater management at a given wood treating facility is directly related to the POPCs identified. POPCs associated with oil-borne preservatives include pentachlorophenol (penta), polycyclic aromatic hydrocarbons (PAHs) from creosote, the carrier oils used for copper naphthenate or pentachlorophenol, and the copper from copper naphthenate. Additionally, dioxins and furans associated with wastes from pentachlorophenol are considered a POPC (EPA, 1996).

POPCs associated with water-borne preservatives are associated with the metals that are in the respective treating solutions. For example, POPCs associated with ACZA are arsenic, copper and zinc; CCA, copper, chrome and arsenic; and ACQ, copper. The strategies for dealing with the POPCs that result from the treatment process may vary widely, depending on the pollutants of concern. The discussion of regulations in the following chapter put into context the management of POPCs at wood treating facilities in regards to different groundwater and stormwater treating technologies.

Chapter 3: Regulatory Background

All facilities that manufacture products in the US have a wide array of regulatory requirements and compliance standards. Compliance activities at manufacturing facilities typically require dozens of separate plans and reporting requirements for handling and processing of chemicals, finished products, and waste products. In addition, strict regulations apply to discharges of any groundwater, stormwater, vapors, or particulate matter that is generated at the facility or that is exposed to facility-related chemicals. These regulations and strict practices are the result of the following historical events and regulations.

Prior to promulgation of the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) in the 1970s, the only environmental regulation applicable to contamination of water was the Federal Water Pollution Control Act of 1948 (EPA, 2011). This act provided the federal government with only limited authority to regulate water pollution and enforce compliance. However, increasing environmental awareness in the 1960s and early 1970s resulted in sweeping changes to environmental regulations and the establishment of the Environmental Protection Agency (EPA). The following discussion summarizes the events that led up to the 1972 amendments to the CWA and SDWA, which still guide the regulations today, and the tools that are currently utilized to reduce environmental impacts (EPA, 2011).

Increasing Environmental Awareness

Several key events occurred in the 1960s that helped increase public awareness about the effects of humans on the environment. Some of the key events leading to the modern environmental movement included Rachel Carson's book *Silent Spring* (1962), the Cuyahoga River fire (1969), and the establishment of Earth Day (1970).

Rachel Carson, a well-known author and marine biologist with the U.S. Department of Fish and Wildlife, published *Silent Spring* in 1962. The book was on the New York Times Best Seller List, and discussed the lasting environmental effects of the commonly used pesticide dichlorodiphenyltrichloroethane (DDT). This book described how DDT accumulated in the fatty tissues of animals and humans, potentially causing cancer and genetic damage. Carson noted that a single application of DDT on a crop would kill not only the target insect, but would persist in the environment for an extremely long time (National Resources Defense Council, 1997). She called for changes in the way people viewed the natural world and focused public attention on the problem of chemical pollution in water and the environment (Cafaro, 2011). Many historians have credited her with initiating the environmental movement of this period.

Another event that significantly changed public perception about environmental issues was the fire on the Cuyahoga River in 1969. This river runs through Cleveland, Ohio, a heavily industrialized city, and flows into Lake Erie. The industries bordering the Cuyahoga River dumped a wide array of materials into the river, including a number of flammables. This was not the first time that this river had a major fire nor would it be the last. In 1969, oil and debris floating on the top of the Cuyahoga River caught fire and the resulting fire gained national media attention (Fister, 2005). This helped to galvanize public opinion about the need for more stringent environmental legislation (NOAA, 2008).

These two key events led to the first Earth Day in 1970. Gaylord Nelson, a Wisconsin senator who is often referred to as the father of the Clean Water Act (CWA), initially proposed Earth Day. Senator Nelson wanted to focus public attention on environmental issues through a grassroots movement that empowered individuals and groups to organize Earth Day activities. This vision resulted in one in ten Americans participating in the first Earth Day activities and led to an increased public perception of environmental problems. This awareness led to bold environmental legislation such as the CWA (Board of Regents of the University of Wisconsin System Nelson Institute for Environmental Studies, 2010).

Clean Water Act

In the 1972 and 1977, Congress amended the Federal Water Pollution Control Act of 1948 to address the growing concerns regarding water pollution. This legislation is commonly known as the Clean Water Act. Amendments made to the CWA in 1972 and 1977 gave the EPA authority to implement pollution control programs such as setting wastewater standards for cities and industries. It also established a basic structure for regulating pollutants discharged into waters of the United States. Additionally, it made it unlawful for any person(s) to discharge any pollutant from a point source into navigable water, unless a permit was obtained under the CWA provisions. These regulatory changes, as well as other changes made to the CWA, directly affected the wood treatment industry and the way that stormwater and groundwater were managed at wood preserving facilities (EPA, 2011).

Safe Drinking Water Act – Maximum Contamination Level

The 1972 and 1977 amendments made to the Federal Water Pollution Control Act of 1948 also addressed pollution associated with drinking water. The Safe Drinking Water Act authorized the EPA to develop national standards to protect human health from pollutants present in drinking water. Wood preserving facilities that had groundwater contaminated because of past practices were subject to monitoring and clean up to meet maximum contaminant level (MCLs) requirements. MCLs are established by the Federal government (EPA), and are typically used to establish clean-up goals for affected groundwater at wood treating facilities (EPA, 1996).

Regulatory tools authorized by the CWA and SDWA that are utilized by the EPA and state agencies to control water pollution from cities and industries include the National Pollution Discharge Elimination System (NPDES), Pretreatment Program, and Underground Injection Control (UIC) program (EPA, 1996).

National Pollution Discharge Elimination System (NPDES)

Under the NPDES, cities and industries are subject to point source (e.g., pipe) discharge permits if they have stormwater or other discharges to water of the United States (i.e., most surface water bodies including streams, ponds lakes, and rivers). The permitting process requires the entity to self-identify pollutants of potential concern that may be contained in a facility's stormwater and discharged to waters of the United States (EPA, 1996). The regulating agency sets the limits for pollutants based on the receiving body of water. Discharge limits are determined by volume of water discharged, volume of water in the receiving body of water, the levels of pollutants in the receiving body of water, and the total level of potential pollutants other industries may contribute to the receiving body of water (EPA, 1996).

Pretreatment Standards

Facilities that do not discharge to waters of the United States, but instead discharge to a Publicly Owned Treatment Works (POTW) are regulated under Pretreatment Standards. This regulation assures that the POTW receives discharges that are within the acceptable limits for a variety of water quality standards and that discharges from an industrial facility do no overwhelm the capacity of the POTW (EPA, 1996).

Underground Injection Control Program

Discharges into a subsurface aquifer (i.e., via a well or infiltration gallery) are subject to the Underground Injection Control Program (UIC). Discharge limits under this program are often state and aquifer specific. Maximum Contamination Levels determined under the UIC for underground sources of drinking water are aimed at protecting the drinking water resource. These are also important because groundwater contamination can be extremely costly to mitigate (EPA, 1996).

Pesticide Regulations – Federal Insecticide, Fungicide and Rodenticide Act

The EPA regulates all wood preservation chemicals under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Under FIFRA, wood preservation chemicals are classified as either general-use pesticides or restricted-use pesticides. General-use pesticides are deemed safe to be handled and used by the public. Wood products treated with general-use pesticides may be used in any application. Restricted-use pesticides are more toxic and can only be handled by licensed pesticide applicators. Use of some wood products treated with restricted-use pesticides may be limited to industrial and commercial applications. As a result of the use of restricted-use pesticides by wood treaters, EPA requires that wood treaters have zero discharge for process water. Therefore, process water is managed separately at wood treating facilities from groundwater and stormwater (EPA, 1996).

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA), was established in 1976 and most significantly amended in 1984. It was originally an amendment to the SWDA designed to guarantee the safe disposal of the huge volumes of solid waste created nationwide. Although RCRA provides regulations that minimize the potential for contaminates from industrial operations, the 1984 amendments provided more rigorous standards, which now affected sites, contaminated prior to that date. These older wood preservation operations may have existing contaminated soil and groundwater that affect current groundwater and stormwater management at wood treating facilities (EPA, 1996).

Wood treaters are subject to additional regulations under RCRA Subpart W, which allows treaters to operate utilizing potentially hazardous listed chemicals, restricted use pesticides such as pentachlorophenol, creosote and arsenical based treating solutions without becoming Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF). Subpart W contains specific criteria on handling the treated material after it is removed from the retorts or dip tanks. These criteria include methodologies to contain drippage after treatment, as well as any contamination of the surrounding area. Because many of the chemicals used for treatment are considered a hazardous waste after they are used, residuals (including drippage) must be properly managed in accordance with RCRA regulations. Subpart W does anticipate that some level of incidental drippage from treated materials may occur outside of the treatment area (i.e., storage yards); however, this infrequent and incidental drippage is considered "de minimis," as long as the Subpart W regulations are strictly adhered to (Aspen Law & Business, 2001, p.521-528).

The regulations discussed in the preceding sections affect wood treating operations and groundwater/stormwater treatments at wood treating facilities.

Chapter 4: Best Management Practices at Wood Preserving Facilities

One of the most influential ways to reduce costs involved with groundwater and stormwater treatment is to minimize the impact of pollutants of potential concern (POPCs) on groundwater and stormwater. One method to accomplish this is by implementing Best Management Practices (BMPs) in wood treating operations. The methods discussed in the following sections may help a facility attain desired discharge concentrations for water quality and POPCs, thereby minimizing the need for groundwater and stormwater treatment.

Treating plants may be required to collect and monitor rainwater that falls on their site for preservative chemical pollutants. Preservative chemicals present on process equipment, tankage or treated wood have the potential to contaminate rainwater it comes in contact with. Preservative chemicals can escape through drippage onto the ground from treated wood, by being washed off wood and equipment surfaces by rainwater and/or through spillage during opening and closing of retorts or delivery of chemicals. The old adage “An ounce of prevention is worth a pound of cure” applies in this case, as preventing chemical contamination of water is far cheaper than remedial treatment. Preventative measures include; construction of drip pads and roofs for processing areas near retorts where treated wood is off-loaded, storage of treated wood under cover to avoid exposure to rainwater, modifying treating cycles to prevent drippage from treated wood, covering tank farms, and reducing the time that retorts are open. The cost of treating stormwater to remove these pollutants makes it financially beneficial to reduce contamination. Modification of treating operations is just one method for reducing the amount of water treatment required. This often involves altering the process to recover excess preservative from the wood, reduce internal pressure at the end of the process to minimize bleeding, and post treatment steaming to clean the wood surface and immobilize chemicals.

Modifying Wood Treatment Methods

Increasing chemical cost has forced treating plants to look for ways to minimize chemical usage while maintaining treatment standards. When less chemical is used for treatment there is less likelihood of drippage from treated wood on the drip pad and during storage on the plant site.

A number of treating processes can reduce excess chemical after treatment. For example, treatment processes utilizing consistent initial air as well as extended final vacuum periods and final steaming produces products that are less likely to bleed excess chemicals and a product that has a cleaner surface. Similarly, drying wood properly prior to treatment produces more uniform preservative penetration, reducing the need for retreatment (Hunt & Garratt, 1938).

Drip Pads

The treating process begins when untreated wood is loaded onto trams that resemble small railroad cars. The cars sit on railroad tracks and are pushed into the retorts. After treatment, the trams are removed from the retort and excess chemical is allowed to drip from the wood onto the drip pad surface (EPA, 1996).

All wood treating facilities have been required to install drip pads, most often constructed with cement or steel. The drip pad captures drippage and funnels it into a sump where it can be recycled into the treating process. Other fundamental drip pad standards that must be observed consist of: a sloped construction to avoid puddles of drippage and liquids on the drip pad surface, construction of a curb or berm surrounding the drip pad to prevent liquid from leaving the surface, and a surface with sufficient strength to handle normal daily operations and the use by heavy machinery that is part of the wood treating industry. Drip pads are usually covered by a roof to limit treated wood exposure to rainwater (EPA, 1996).

Covered Storage Pads for Finished Products

All of the chemicals used to protect wood have some degree of water solubility. Storing freshly treated wood outdoors can allow rainwater to solubilize chemical, while exposure to sunlight can heat the wood, which causes the air in the wood to expand forcing chemical to the surface. Internal pressure can be relieved using heat and/or vacuums at the end of the treatment process.

Processing Leaks

Chemicals can leak in the plant from tanks, pipes, pumps, retorts and delivery vehicles. These leaks must be managed in accordance with EPA regulations to minimize contaminant contribution to both stormwater and groundwater (EPA, 1996).

Managing Drippage – de minimis

Before a completed charge is placed in the storage yard, the facility personnel must document that drippage from the treated material has ceased. Drippage of excess chemical occurring in the storage yard is known as incidental drippage, and must be cleaned up within 24 hours from the time it was originally noticed or 72 hours should the detection occur on a weekend or holiday. In order for incidental drippage to be noticed, it is an expectation that storage yards are regularly inspected. Additionally, any detected and cleaned incidental drippage must be documented and managed per facility and EPA standards (EPA, 1996). Effective management of incidental drippage minimizes the contribution of pollutants of potential concern to stormwater and groundwater.

Water treatment technologies discussed in the following chapter may be utilized in the event that Best Management Practices, described in the preceding sections, do not sufficiently address water quality issues and pollutants of potential concern for groundwater and stormwater.

Chapter 5: Current Water Treatment Technologies

The type of water treatment methodologies used at a particular facility will vary depending on site-specific characteristics including average annual rainfall, soil permeability and sediment particulate size. Additionally, the type of water treatment system will depend largely on the targeted pollutants of concern. The technologies discussed below may be used separately or in combination to achieve the desired discharge concentration for water quality and pollutants of concern. Additional technologies that are presented in this chapter that may be in use in applications other than water treatment systems at wood treatment facilities which may be considered as more stringent regulations for pollutants of concerns become more common.

Water Treatment Technologies

pH Adjustment

pH is a measurement of the hydrogen-ion activity in a media such as water. Water molecules naturally dissociate into hydrogen ions and hydroxyl ions. When these two ions are equal, the pH is 7, also known as neutral (Kresic, 2009). The pH of the water can be adjusted using an acid, which lowers pH or a base, which raises pH. An example of chemicals used for pH adjustment in industrial water treatment would be sodium hydroxide and sulfuric acid. The reason that pH adjustment is very important in the treatment of water is because it can have an effect on the mobility and solubility of many substances. For example, metals are dissolved at low or acidic pH and will precipitate to a solid phase with an increase in pH, making removal feasible (Kresic, 2009). The degree of pH adjustment depends on the particular dissolved metal(s) encountered and it can become difficult to precipitate one targeted metal over another. For example, arsenic precipitates more readily at a different pH than copper. Additionally, some pollutants of potential concern (POPC) are more bio-available to aquatic organisms at different pH. An example is pentachlorophenol, which is more bio-available at 6.5 pH than it is at 8.5 pH (California Environmental Protection Agency, 1998). Because acceptable discharge ranges vary for pH, it may be more cost effective to withhold additional chemical if the pH after treatment is within acceptable discharge ranges. Therefore, each plant may set a pH range for water discharged depending on permit requirements.

Flocculation

Flocculation is a process that uses chemicals to precipitate particulates from water, allowing for settling of suspended materials that acts to clarify the water. Flocculants used in water treatment include aluminum sulfate, ferric chloride and cationic and anionic polymers. When flocculants are added to water to be treated, the negative charge of the particles is counteracted, thus allowing the particles to bond together when the water is stirred or moved. Larger clumps of these particles or “flocs” form and can be more easily removed (Kresic, 2009). The types of coagulant and/or flocculants chosen for use in a water treatment system are based on factors such as water quality and treatment objectives. The effectiveness of this clarification process is also dependent on a variety of factors including the physical design of the facility, concentrations and types of particulate to be removed, type and dosage of the coagulant, pH, ionic strength and temperature (Kresic, 2009). The resulting clarified water is typically subjected to additional treatment processes, and the sludge that is generated by of this process must be managed and disposed of properly. Throughput of water must be balanced to allow enough time for flocculation/settling, yet allow for adequate water treatment volume (National Academy of Sciences, 2008).

Filtration

Filtration typically follows the clarification process to remove remaining particulates in water treatment systems. This process usually consists of passing the water through a bed of granular material such as sand, anthracite, or other filtering media (Kresic, 2009). There are a variety of different styles of filtering systems including; rapid sand filters, slow sand filters, pressure filters, precoat filters, bag and cartridge filters and ceramic filters (Kresic, 2009). Precoat filter, bag and cartridge filters and ceramic filters are not suitable for water with high-suspended solids and therefore would only be options in water treatment systems that have low turbidity. Common types of filters currently utilized in industrial water treatment are rapid sand filter, slow sand filters and pressure filters (Kresic, 2009). Rapid sand filters are granular filters that have one or more layers of porous media such as anthracite, carbon and sand. These units are typically composed of surface wash units, filter media, gravel bed and an open drainage system in the bottom that allows the filtered water to flow from the tank (Kresic, 2009). The mode of force for water flowing through this type of filter is gravity. Once these filtering rates slow due to compaction and sediment loading, a backwashing cycle (reverse flow through the beds) is conducted and the solids are captured and managed (Kresic, 2009). Pressure filters are, in essence, the same type of filtering system as rapid sand filters; however, the main difference is that pressure forces water flow rather than gravity as in a rapid sand filter (Kresic, 2009). Slow sand filters are similar to rapid sand filters in that the force for water flow is gravity. However, slow sand filters function by having a bed of relatively uniform sized filter media that allows a layer of solids and microbes to build up on top, also known as the "schmutzdecke" (Kresic, 2009). The top layer is manually removed and managed for disposal; therefore, no backwashing is used with this type of filtering system (Kresic, 2009).

Membrane Filtration

Membrane filtration uses a new generation of water filters that are becoming more common in drinking water treatment (Kresic, 2009). Membrane filtration also may become a viable alternative for treating POPCs in groundwater and stormwater at industrial sites as capital and O&M costs have considerably declined in recent years. Additionally, as technology develops, microfiltration, ultrafiltration, reverse osmosis and nanofiltration may emerge as viable alternatives for applications where sediment loading is minimal (Kresic, 2009). These membrane filtrations systems are driven by either pressure or vacuum and force water through a semipermeable membrane that retains the impurities in the feed water. Ultrafiltration and microfiltration are designed primarily to remove total suspended solids by the formation of a cake layer on the surface of the membrane, which must be removed via backwashing and then managed for disposal (Kresic, 2009). Reverse osmosis and nanofiltration are not designed to treat water that contains suspended solids; however, these systems are specifically designed for the removal of total dissolved solids. Because these systems cannot be backwashed, fouling caused by particulate matter is irreversible and leads to sharply reduced membrane life. Reverse osmosis and nanofiltration systems must be chemically cleaned on a periodic basis and the residuals must be managed for disposal (Kresic, 2009).

Inorganic Adsorption Treatment

Ion exchange is a process that is effective for the treatment of constituents such as calcium (hardness), nitrates, fluoride and arsenic in drinking water treatment. It is a reversible chemical process where a charged molecule is removed from the solution by exchange with a similarly charged ion attached to a solid matrix (Kresic, 2009). Synthetic or natural, polymeric or inorganic resin materials have high porosity providing a large surface area to weight ratio and providing a solid matrix for this type of treatment. This type of system is best suited for a water treatment system that has a relatively low sediment and organic load, such as groundwater (Kresic, 2009). Activated alumina is used for ion removal by adsorption, in a way similar to the name by which ion-exchange resins remove metals such as arsenic. These media have an adsorptive capacity and once this is reached, the media must be regenerated or replaced (Kresic, 2009).

Biological Treatments

The principal behind biological treatment is that bacteria consume the organic material present in water and through their metabolism, transform the material into cellular mass (Cushman, 2006). These bacteria can convert or biodegrade unwanted constituents such as biodegradable organic matter, synthetic organic chemicals, iron, manganese and arsenic (Kresic, 2009). There are two types of biological treatment systems, mechanical or a passive (such as constructed wetlands). The disadvantages of a wetlands type system is that it occupies a large area, has reduced performance in regions where the ground freezes and must be managed to limit exposure to receptors such as people. An advantage of a passive system is that it requires little or no energy to operate (Cushman, 2006).

Some examples of mechanical biological systems include; activated sludge, trickling filter and biological contactor (Cushman, 2006). An activated sludge system consists of two tanks or basins that are aligned in series. The first tank aerates from the bottom, which provides oxygen to the microbes and creates a turbulent system that increases contact with microbes, promoting biodegradation of undesired constituents (Cushman, 2006). The second tank or basin is a settling tank that allows the remaining unwanted constituents and microbes to settle to the bottom where anaerobic degradation occurs (Cushman, 2006). A trickling filter system consists of a bed of media, such as rocks, that creates a structure for biological slime to develop. The water continuously sprayed over the top of this media bed and trickles down through, which allows time for the undesired constituent to be consumed by the microbes (Cushman, 2006). Periodically, the bacteria film slides off the media, is collected at the bottom of this system, must then be removed and managed (Cushman, 2006). A biological contactor system is a variation on the trickling filter. In the contactor system, the media is in rotating disks, which are rotated through the water rather than the water being sprayed onto the media (Cushman, 2006). All of these types of treatment systems are designed for above ground treatment, which would likely be more relevant for stormwater treatment, or for systems, which groundwater is pumped from the ground for treatment.

In some cases, biological treatment may also be used for in-situ treatment (treatment in place) of contaminated groundwater. Pump and treat systems for treating contaminated groundwater are limited with respect to restoring groundwater to a contaminate level required to meet health-based standards over a 5 to 10 year period (Kresic, 2009). The major reason for this is the slow processes of desorption and back-diffusion of contaminates trapped in stagnant groundwater zones and rock matrices (Kresic, 2009). Because of these limitations, in-situ treatments including those with a bioremediation component are becoming a more acceptable treatment technology (Kresic, 2009). Similar to pump and treat systems, one of the goals for an in-situ treatment system might be hydraulic containment, which acts to control the movement of contaminated groundwater beyond the contaminated zone (Kresic, 2009). An example of an in-situ treatment system is a facility with groundwater that is contaminated with penta and PAHs that is being pumped up gradient, relative to the flow of groundwater, within the contaminated zone, and re-injected through a media (J.S. Barnett, personal communication, 7-Jan-2011). This achieves hydraulic containment and increases oxygenation, which accelerates the rate of biodegradation (Kresic, 2009). An additional example of biological treatments is included in the following carbon filtration section.

Carbon Filtration

Granulated activated carbon (GAC) filtration is used to remove organic molecules like polyaromatic hydrocarbons and pentachlorophenol from wastewater. The carbon can originate from a variety of materials including bituminous coal, coconut shell, petroleum coke, wood, or peat. This material is ground, roasted and activated with high-temperature steam (Kresic, 2009). The resulting carbon has a high internal surface area that adsorbs organics readily (Kresic, 2009). Carbon filtration works by a surface adsorption mechanism where the large surface area of the carbon can attract and hold substantial amounts of organics (Matilainen, Tuhkanen & Vieno, 2005). Once the GAC reaches its adsorptive capacity, the media must be removed, managed for disposal, and replaced. The replacement interval is affected by the concentration of the pollutant(s) of concern as well as any pretreatments that remove suspended solids (Kresic, 2009).

Granulated active carbon can be utilized as a substructure for biological water treatment systems for drinking water (Kresic, 2009). These biological treatment systems are used in small and large municipality water treatment plants in Europe and this technology is under increasing consideration in North America (Kresic, 2009). Conditions are optimized to promote a permanent active biofilm the will biodegrade or convert unwanted constituents such as biodegradable organic matter, iron, manganese, and arsenic (Kresic, 2009). GAC with a biofilm is most effective when preceded by ozonation and the biological growth must be controlled to address the operational issues such as sloughing-off of microbial films from the filter (Kresic, 2009). Additionally, research on new biocarriers on varying matrixes support the dense colonization of microorganisms and improve the productivity of bioreactors in bench scale test (Durham et al, 1994). Biological treatment systems can be affected by temperature extremes and rapid variations in pollutant loading that can disrupt the efficacy of the microbes, therefore consideration must be given to the characteristics of the pollutant loads as well as other external factors when considering these systems in an industrial application. Bench scale research has been conducted that showed that in water with high sediment load, contaminated with PCB that a GAC inoculated with a biofilm was more effective when compared to GAC alone (Ghosh et al, 1999). Biological /GAC systems may best be suited for contaminated groundwater treatment systems with a consistent temperature and minimal changes in concentrations of the pollutants of concern.

Electrolysis Based Treatment

Electrodialysis (ED) and electrodialysis reversal (EDR) are processes by which contaminant ionic species are transported selectively across permeable membranes driven by an electric potential (Kresic, 2009). EDR is different from ED in that the polarity of the electrodes is periodically reversed to alter the direction of the ion movement, which allows for reduced scaling (Kresic, 2009). This technology is currently utilized for the removal of nitrate in drinking water, is effective for arsenic, and has comparable efficiency to reverse osmosis for this contaminant. However, these systems are generally more expensive, have low recovery rates and are not currently cost effective relative to other technologies (Kresic, 2009).

Treatment Technologies Discussion

Wood treaters face a variety of water treatment issues based upon the characteristics of their facilities. Factors that affect treatment include whether a site is paved or unpaved, the types of preservatives, the natural geology of the site, and average annual rainfall. Treatment effectiveness depends largely on how a site operates and where it is located. A simple water treatment process at a paved facility with moderate rainfall using organic preservatives might consist of carbon (GAC) for removal of any residual organics. A similar site using a single metal-based preservative might be able to manage treated product such that the amount of metals in the untreated stormwater were negligible. A complex site might include large unpaved areas, moderate to high annual rainfall, and the use of both metal-based preservatives and organic based preservatives.

The remaining chapters will present data gathered from Western US wood treaters, illustrating how some of these practices and treatment technologies are currently utilized. As the cost of water treatment increases (due to chemicals, media, and energy) and compliance requirements become more stringent, industry will benefit from considering a variety of water treatment technologies that may not have previously been cost effective.

Chapter 6: Treatment Technology Survey Methods

Survey Objectives

A questionnaire was designed with a goal of developing data on groundwater and stormwater treatment practices at wood treatment facilities in the Western United States and how it might be related to the operations at wood preserving facilities. Additionally, information was collected with regards to limits and benchmarks set for water quality and pollutants of potential concern. The following sections describe the questionnaire and the results of the survey regarding the stated objectives.

Survey Development

Section One – Real Property Information

The first section requested general facility information, including location, size and age of the facility. Facility age was requested providing ranges of years. These general questions about the real property was requested to access any relationship between this data and the management of groundwater and stormwater management.

Section Two – Production Information

The second section requested various production data, such as production volume, preservatives used (both currently and historically) and commodities treated. Common commodities and preservatives were given in a table format so that the respondent could simply mark the correct fields. There was also an “other” field so that the respondents could specify any other commodities and/or preservatives that were not already provided in the questionnaire. The production data requested was also broken down into a table, requesting five-year averages for each preservative type with the objective of learning what preservatives were most commonly used at the specific facilities. An “other” field was present in this section so the respondents could clarify any other information. This general information, with regards to production, was requested in order to facilitate comparisons between this data and stormwater and groundwater management at a facility.

Section Three – Permits Related to Water Management

The third section addressed the regulatory permits held by a facility related to groundwater and stormwater under which a given plant operated.

Section Four – Water Treatment Strategies / Limits and Benchmarks

The fourth section examined the water treatment strategies used at each plant. The tables requesting data for both sections 3 and 4 were formatted in a manner similar to the format used for SARA 313, Toxic Release Inventory (TRI) and NPDES reporting to make it easier for facilities to respond. Instead of having to generate a large quantity of data for the purposes of this study, they would just have needed to copy the data from the TRI forms and NPDES permits and place it in the appropriate sections on the questionnaire.

Section Five – Sources for Technical Information

A final section requested subjective information regarding the importance of different sources of technical information. Respondents were asked to rank seven different pre-selected technical sources from most to least important. This information was requested to identify any common sources for interpreting how and why the facilities may have the practices that they do. The data collected in this was unclear, likely due to the wording of the questions, so the data was eliminated from the results.

Questionnaire Pretesting

The questionnaire was pretested by three wood treating industry professionals, in addition to three industry environmental consultants and two wood products academics. Changes were made according to the feedback received. Feedback received suggested formatting all questions in a consistent format, both within the questionnaire document and with a format similar to that of TRI reporting. It was hoped that by creating a consistent format for presenting questions it would increase responses from the facilities survey.

Survey Sampling

The Western Wood Preservers Institute (WWPI) members were contacted and agreed to participate in this research. The WWPI trade organization recognizes the importance of a healthy environment and good stewardship and to that end the cooperation of the WWPI members was a critical component of the success of this survey. The study was limited to issues related to stormwater and groundwater (as the result of remediation activities) and did not address process related wastewater.

The questionnaire was sent to 27 wood treating companies, some with multiple operations, all were members of the Western Wood Preservers Institute. Questionnaires were disturbed via mail and email and were received completed via fax, mail and email. In some cases, phone interviews were conducted to clarify respondent’s data. Survey information is presented for thirty-two (32) out of the thirty-nine (39) individual facilities, 82% of the targeted group. One company reported on a facility outside of the study area and the results from this facility were deleted from the study. In addition to the information gathered from the questionnaires, an internet search was performed from public records to obtain relevant information for seven wood treatment facilities. After reviewing the questionnaires submitted by the responding facilities, additional public records were reviewed to supplement the questionnaire responses for several facilities. Twenty-five questionnaires were returned for varying facilities and public record information was sought for another seven facilities. Public records for the facilities who did not respond to the questionnaire were obtained from company websites and NPDES permits and evaluation reports. A copy of the questionnaire sent to the pre-selected survey group is Located in the appendix.

Statistical Analysis

A binary logistic regression was conducted on data presented for size of the real property, number of preservatives, production volume, and average annual rainfall when compared to the presence or absence of a groundwater or stormwater treatment system.

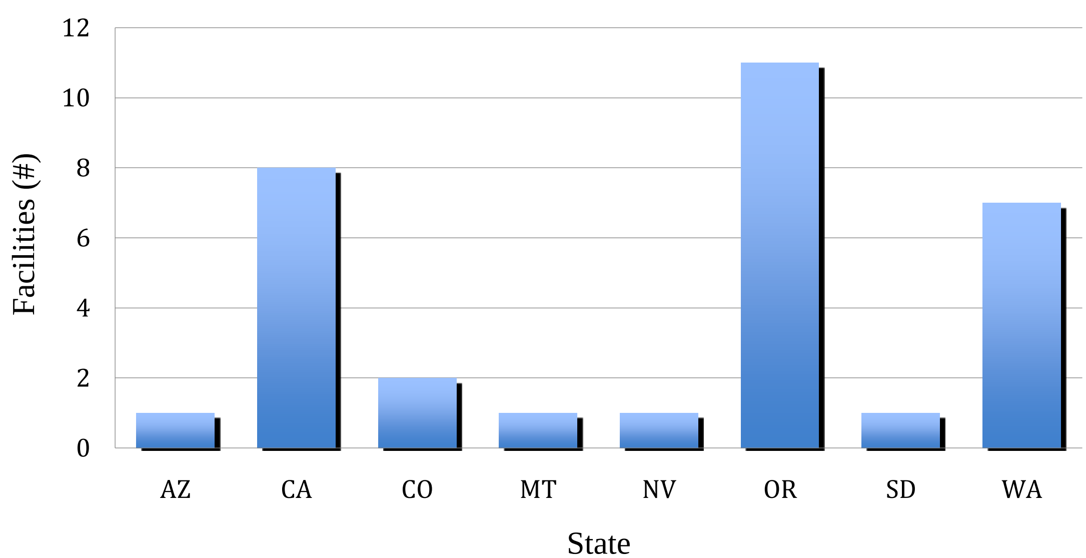
Chapter 7: Results & Discussion

The survey responses were summarized and then categorized so that individual responses could not be used to identify a specific facility.

<u>Facility Location, Size, and Production Capabilities</u>

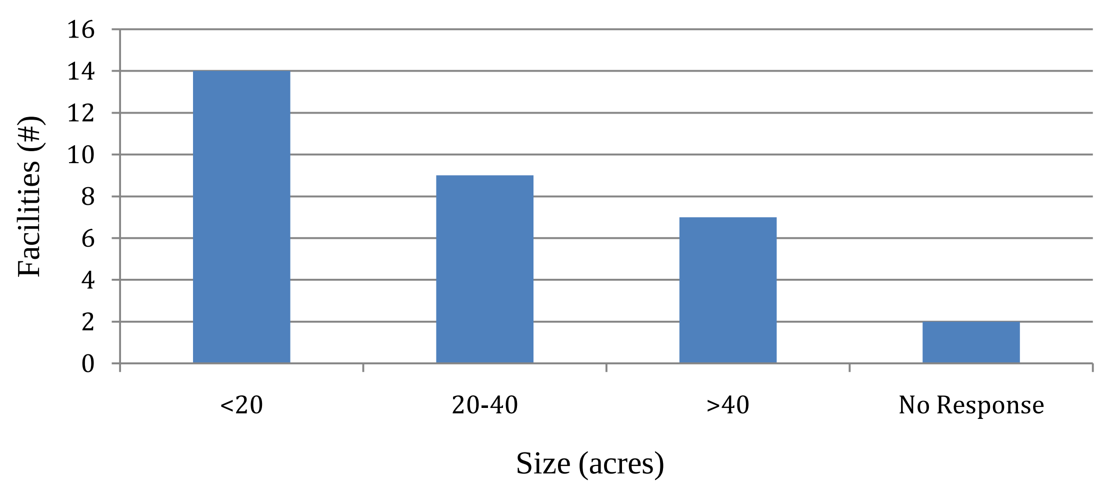
The majority of responding facilities were located in Oregon, California or Washington (Figure 1). This likely reflected the close proximity to timber resources in the cases of Oregon or Washington facilities and the proximity to markets for the California facilities. Although facility location could produce important business advantages in terms of access to resources or reduced transportation costs, it could also produce varying regulatory environments.

Figure 1. Location of survey respondents by State

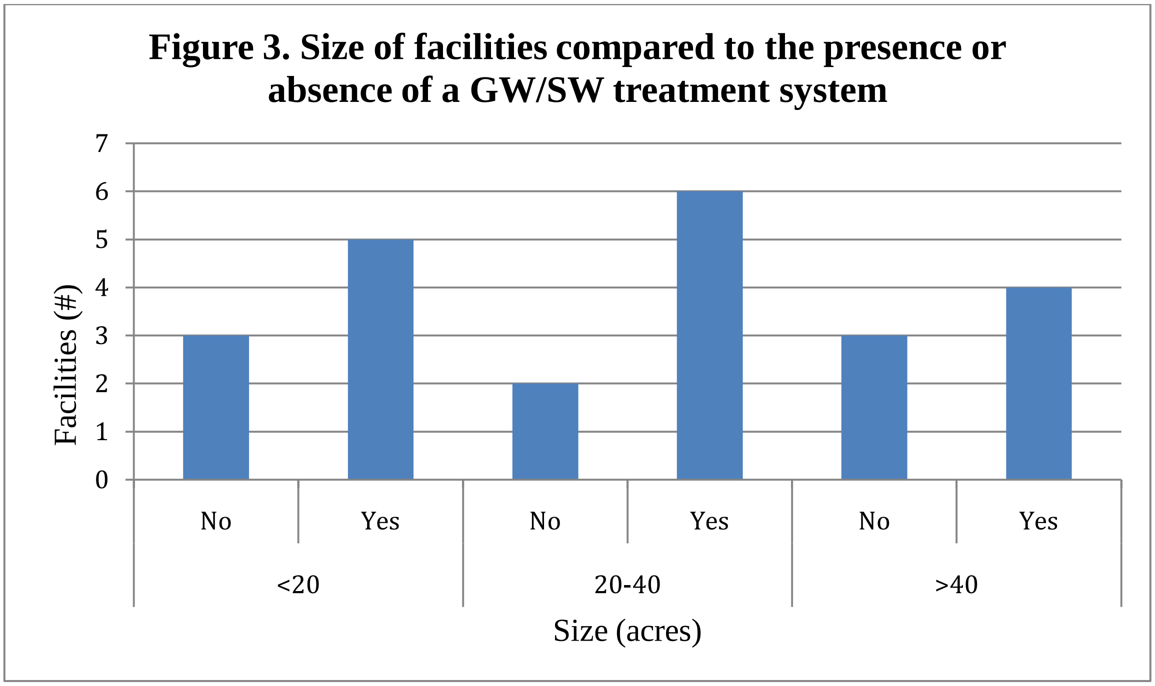


Plant size varied widely among the respondents (Figure 2). None of the eight facilities located in California exceeded forty acres; however, there did not appear to be any trend related to size among the facilities located in Oregon or Washington. Plant size could have important implications on stormwater management, particularly in older plants with potentially more surface contamination from prior practices.

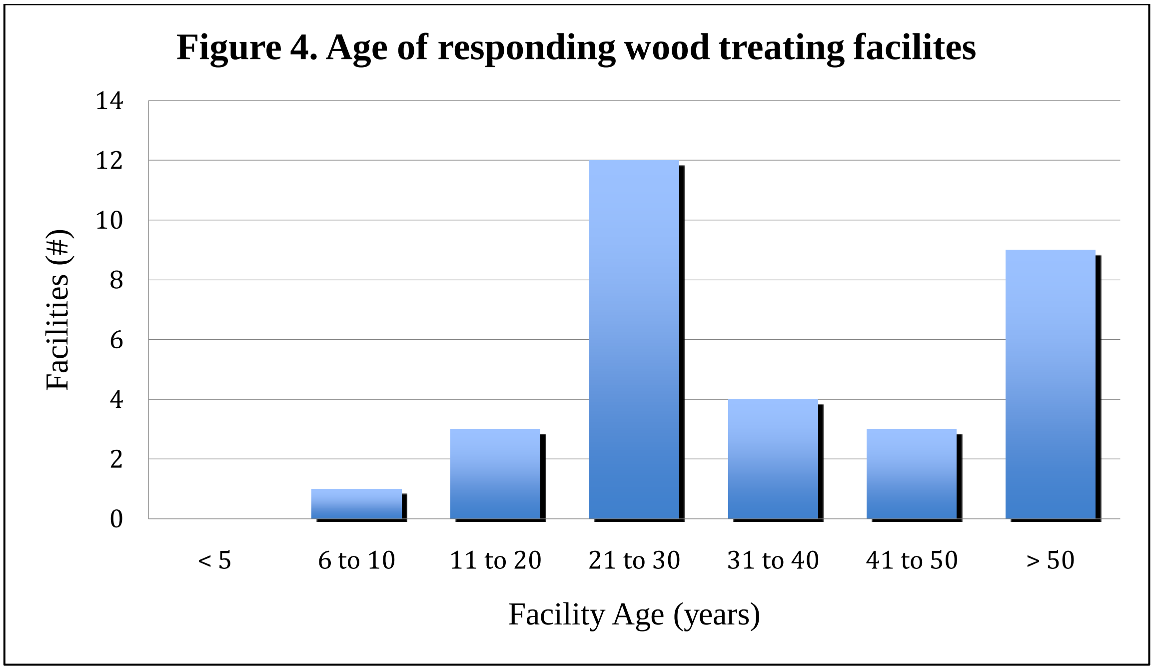
Figure 2. Size of responding wood treating facilities



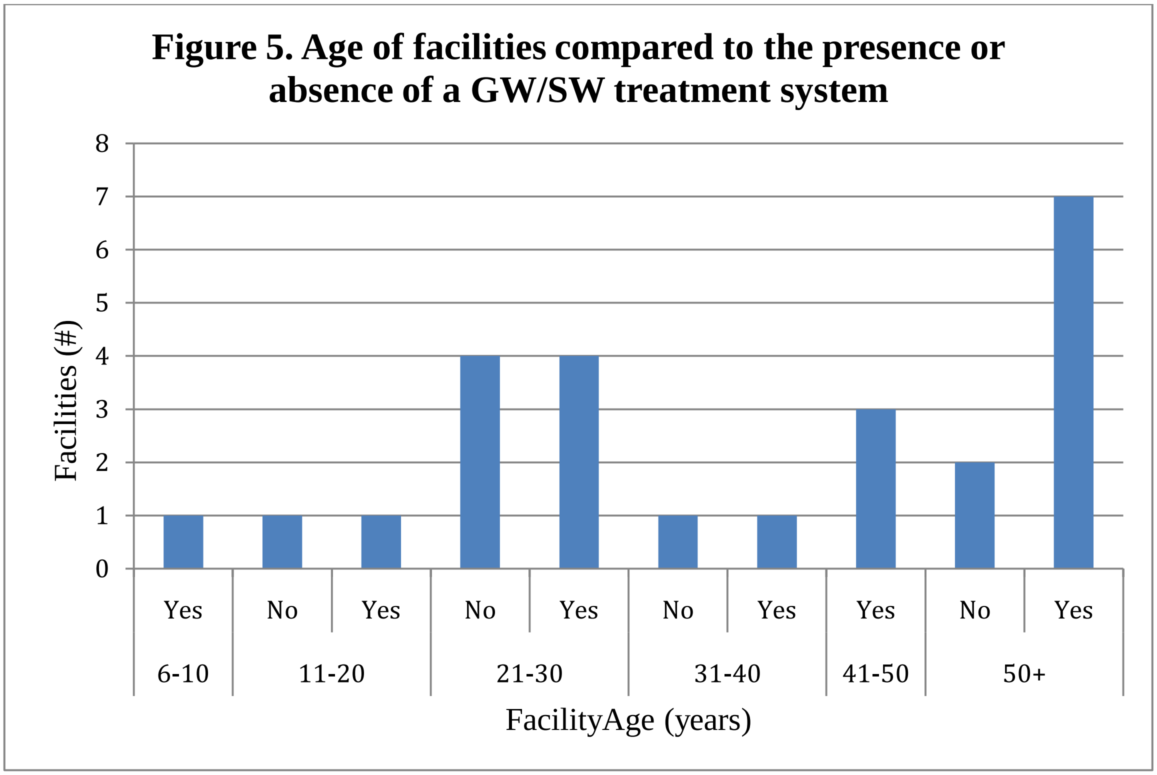
The size of a facility could also impact whether a facility may have to treat groundwater or stormwater, however survey results did not indicated a connection (figure 3, P-Value = 0.366).



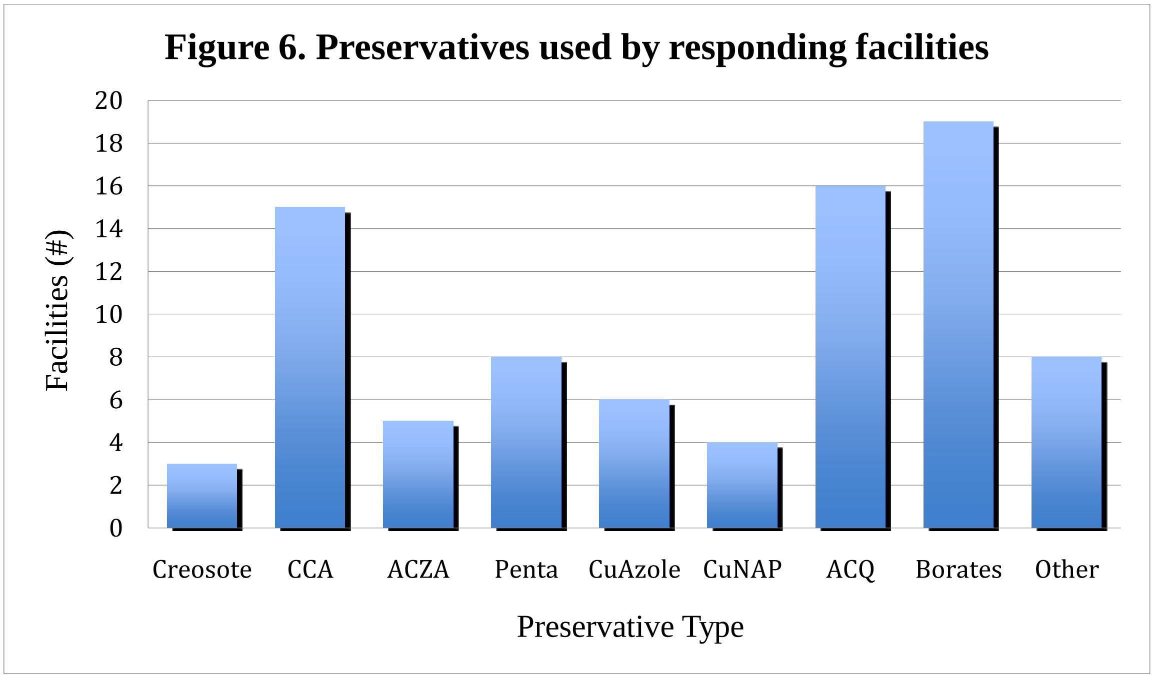
Only four of the thirty-two responding facilities were less than twenty years of age, eighty-eight percent were greater than twenty years of age and twenty-eight percent were greater than fifty years old (Figure 4). This may suggest a few potential issues with the existing treating industry. The lack of new facilities suggested that the market for treated wood may not be growing or the sizes of facilities may make it easier to expand at an existing site rather than to start new operating sites. It may also suggest that most plants were older and therefore had a higher potential for having environmental issues related to past practices.



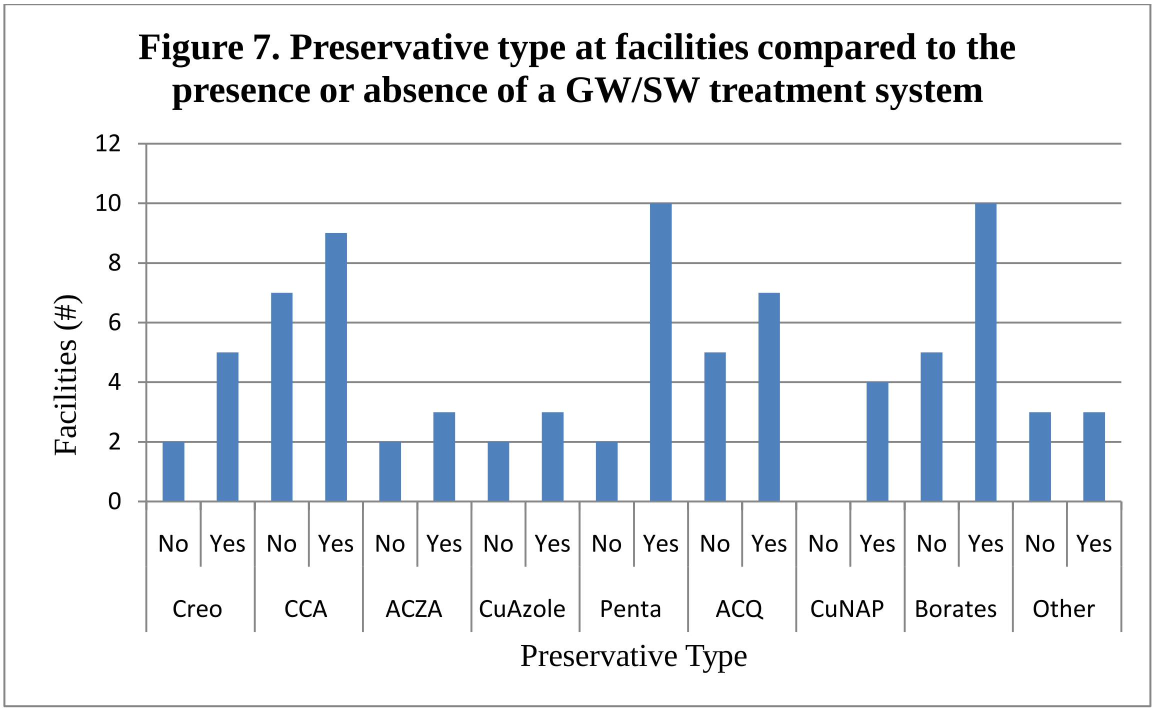
As mentioned previously, the rules under which many treating facilities operate have evolved over the past five decades and many practices that were acceptable at some points during that time are no longer allowed. Older plants are more likely to be dealing with issues related to these practices as they process stormwater and groundwater. This complicates their permitting and treatment issues. The age of a facility when compared to the presence or absence of a groundwater / stormwater treatment system did not indicate any trends, however it is interesting to note that the majority of facilities that were greater than 50 years in age did have treatment systems in place (figure 5).



Sixty percent (19) of the responding facilities treated with borates, fifty percent (16) with ACQ and forty-seven percent (15) treated with CCA. Oil-borne preservatives were used with less frequency at the facilities; twenty-five percent of the facilities were treating with pentachlorophenol, thirteen percent with CuNap and nine percent with creosote (Figure 6). The waterborne materials have been used to treat lumber for residential applications (CCA is no longer used for this purpose). Eleven plants used oil-based preservatives, which are primarily employed for industrial application.

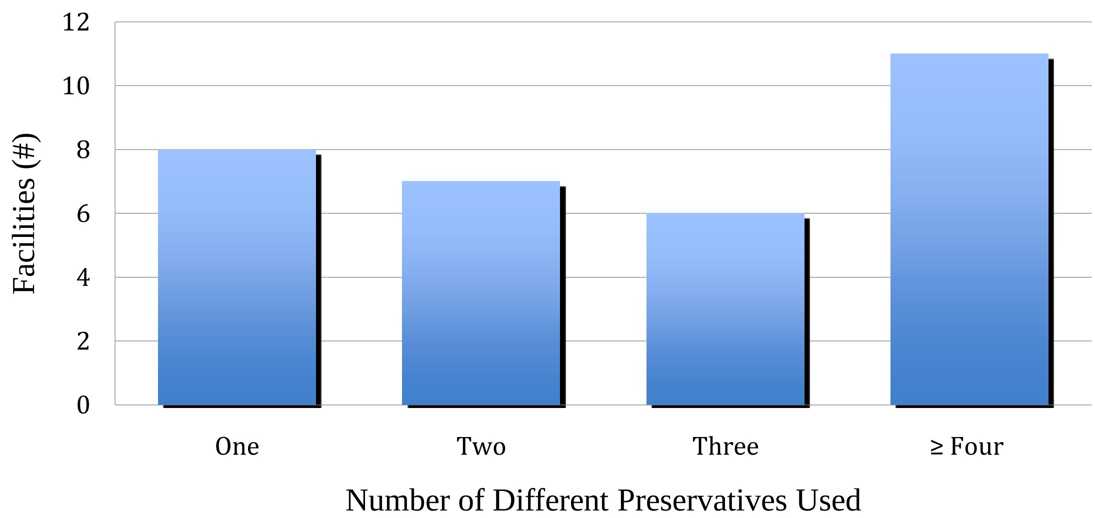


It is reasonable to assume that the type of preservatives used at a givin facility would impact how stormwater and groundwater is managed at a site, however a review of the data regarding preservative type comparing to the presence or absence of a water treatment system did not support this (figure 7).



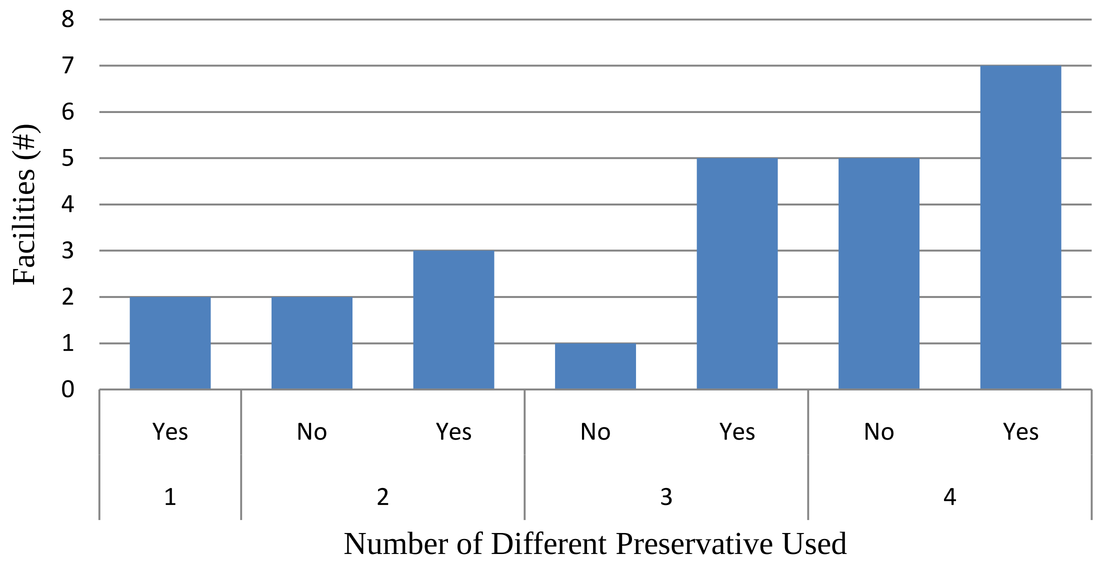
Eight responding facilites used only one preservative, while twenty-four facilities treated with more than one preservative and eleven of these twenty-four treated with four or more preservatives (Figure 8).

Figure 8. Number of preservatives used at responding facilities



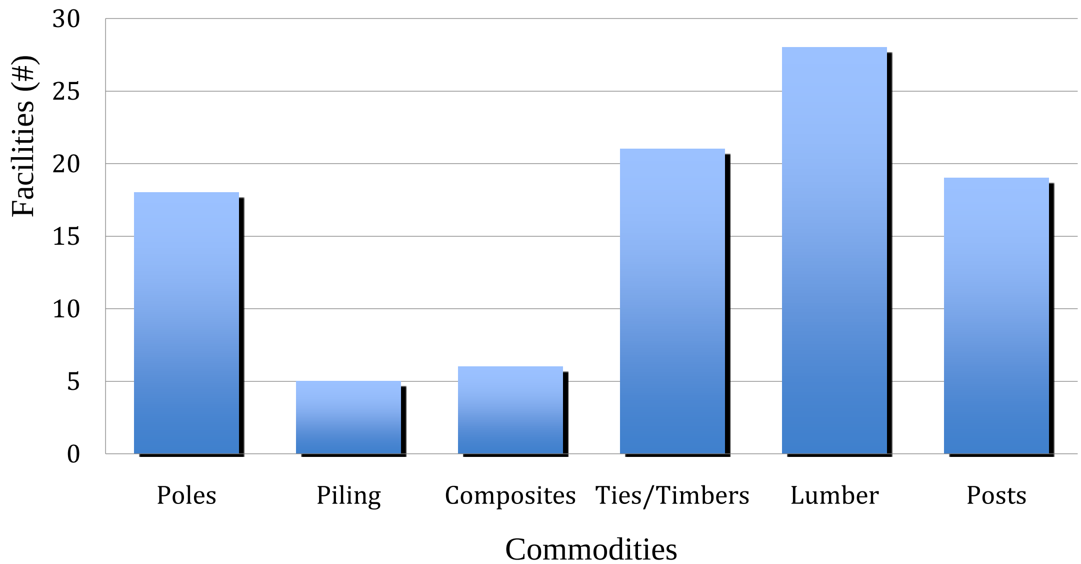
The use of multiple preservatives at a given facility may increase the complexity of water treatment systems, especially if both oil and water based preservatives are used at the same facility (Table 2). The data did not present any trends related to the number of preservatives used at a given site and the presence or absence of a groundwater or stormwater treatment system (figure 9, P-Value = 0.366).

Figure 9. Number of preservatives used compared to the presence or absence of a GW / SW treatment system



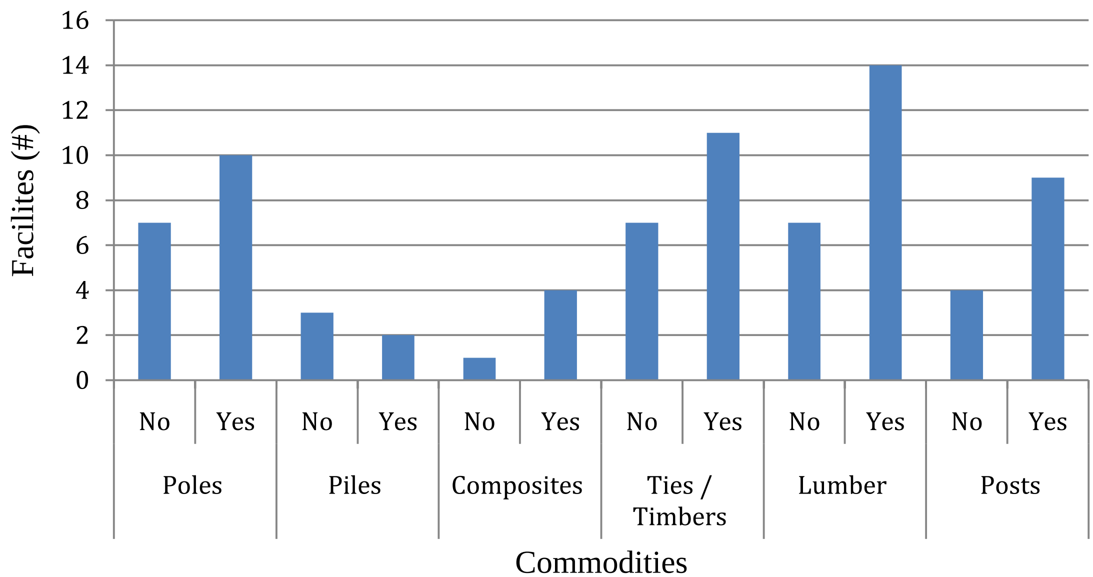
Eighty-eight percent (28) of survey respondents treated lumber products, followed by ties/timber at sixty-six percent (21), posts at sixty percent (19) and poles at fifty-six percent (18) (Figure 10). The type of commodity can affect preservative loss. For example, poles and piling are typically treated to much higher preservative retentions because of the conditons to which they are exposed and this creates a potential for higher preservative losses. These commodities are also often treated with oil-based preservatives, creating the potential for bleeding. Size can also affect the ability to protect a commodity. It is relatively easy to wrap bundled lumber or store it under cover to protect it from wetting, from rainfall, in the plant, but difficult to protect large poles or pilings.

Figure 10. Types of commodities treated at responding facilities



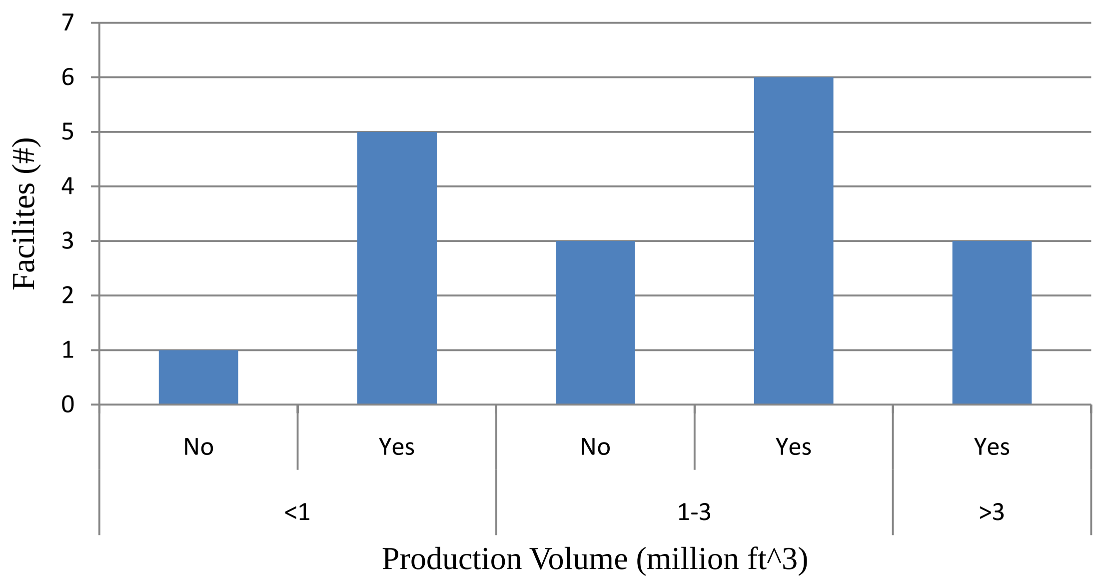
Despite differences in the commodities treated by responding plants, there seemed to be no connection between commodities treated and the use of a stormwater and/or groundwater treatment system (figure 11).

Figure 11. Commodities at facilities compared to the presence or absence of a GW/SW treatment system



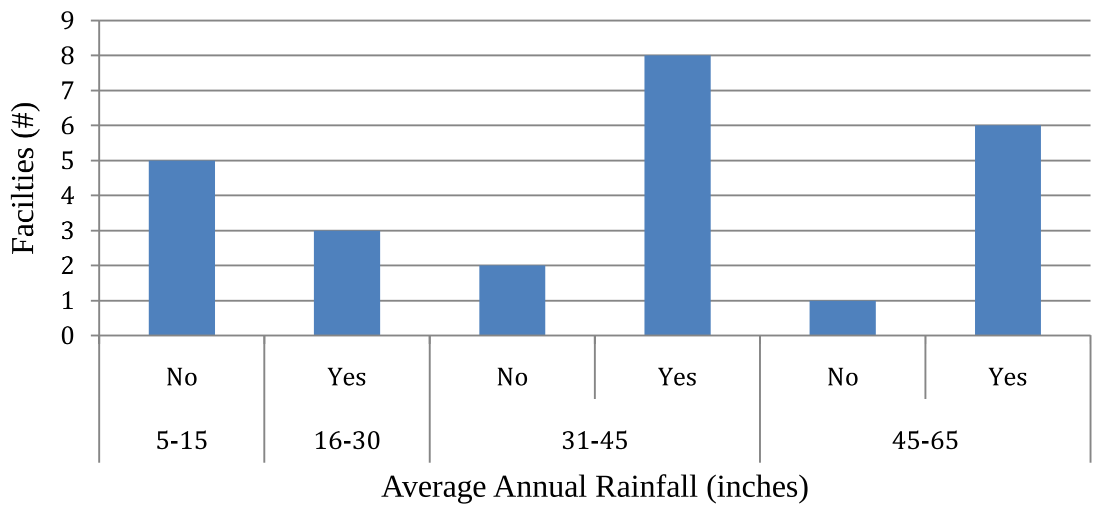
Production information was requested for a five-year average and by preservative type. In some cases respondents provided data in million board feet (MMBF) which was converted to cubic feet. There appeared to be no relationships between production volume and the presence of a stormwater/groundwater treatment system (Figure 12, P–Value = 0.018).

Figure 12. Production volume compared to the presence or absence of a GW/SW treatment system



Respondents provided data with regards to the average annual rainfall in the area of the facilities. This data when compared to the presence of absence of a stormwater or groundwater treatment system did indicate that in areas of rainfall greater than thirty-one inches that it was more likely to have some form of water treatment system in place (figure 13, P-Value = 0.784).

Figure 13. Rainfall compared to the presence or absence of a Stormwater or Groundwater Treatment System

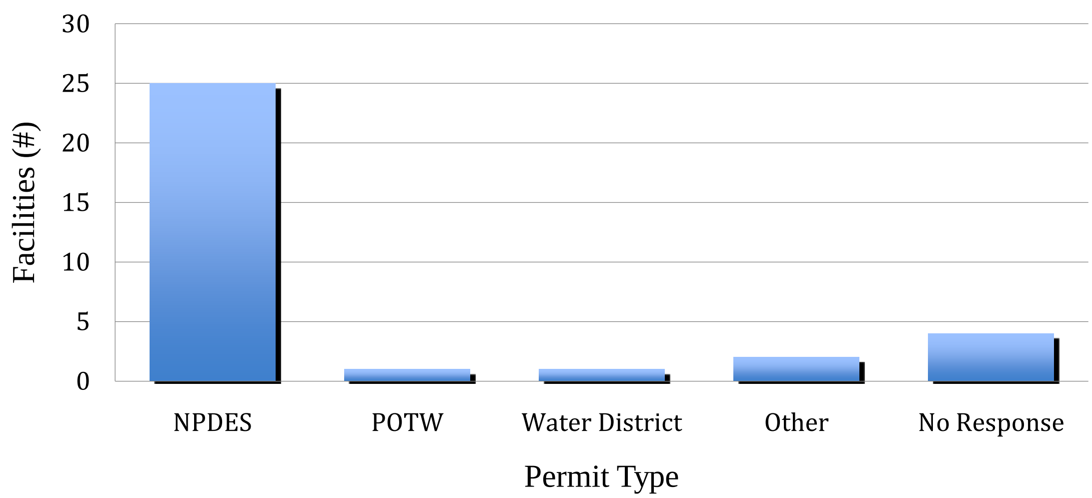


Permit Types & Water Treatment

Twenty-five (78%) of the thirty-two respondents stated they operated under an

NPDES permit, one respondent discharged to a POTW (which would be subject to pretreatment standards), one respondent reported holding a permit to discharge to a water district and the other respondents reported that they held other permits, but did not specify what type, or did not provide an answer (Figure 14). The EPA requires all wood treaters to obtain an NPDES permit for stormwater discharges to waters of the US (EPA, 1996). The lack of response to this question by facilities suggests that they either misunderstood the question or that there may be confusion about the types of permits required for specific facilities.

Figure 14. Permit types held by treating facilities responding to the survey



Pollutants of Potential Concern

Most industries are required to self-identify what potential pollutants might be exposed to stormwater on their site. This information is not determined by whether pollutants are documented to be present in the stormwater, but rather because they are part of the industrial process and by their very presence on the site, have the potential to reach stormwater. For example, in the wood preservation industry, a facility using CCA (which contains copper, chrome and arsenic) would identify their potential pollutants at this facility as copper, chrome and arsenic. POPCs are discussed in more detail in Chapter 3.

POPCs should be consistent with the preservatives used, both historically and currently, at the individual sites. Copper, chromium and arsenic were the most commonly reported POPC's at the responding facilities (Figure 15). These metals are components in the waterborne wood preservatives. Penta and PAH's were reported as a POPC at thirteen facilities and reflect the use or past use of pentachlorophenol and / or creosote at these facilities.

POPCs influence the type of water treatment systems in use at a facility. For example, pentachlorophenol and/or creosote were used at all ten of the facilities reporting the use of carbon filtration as a water treatment method. While there is consistency in the

POPCs among the wood preserving industry, the water treatment methods varied widely from no treatment to multiple treatment methods.

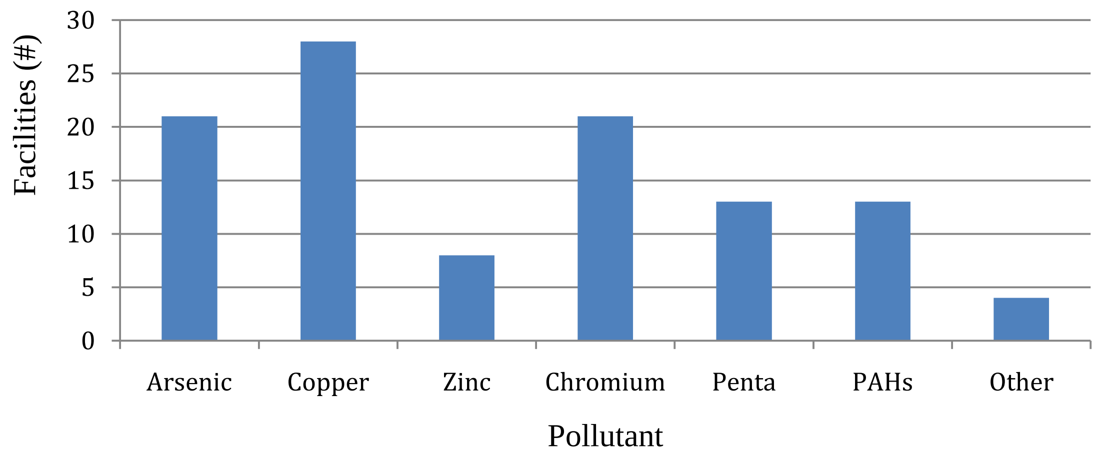


Figure 15. Pollutants of Potential Concern (POPCs) at responding treatment facilities

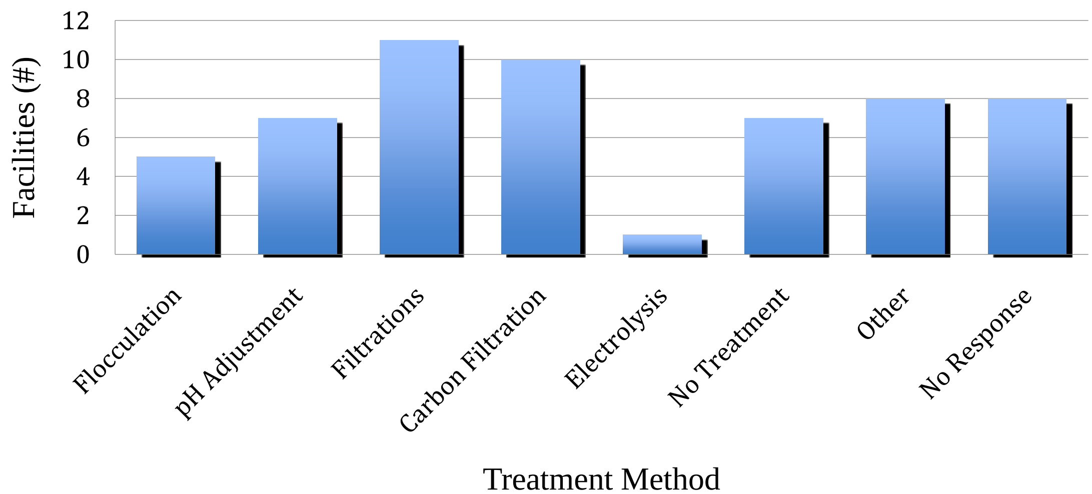
Water Quality Concerns

Water quality concerns, unlike the pollutants of potential concern, could not be determined by the preservative types used at a facility, with the exception of oil & grease. Therefore, response data was limited. Public records were used to obtain more detailed information regarding specific water quality standards. These findings will be discussed in more detail within the context of NPDES limits and benchmarks.

Groundwater and Stormwater Treatment Methods

The responding facilities used a variety of methods for process groundwater and stormwater, although eight facilities provided no information on the water treatments used. All respondents noted that either flocculation, pH adjustment, filtration or chemical addition were used, with filtration (carbon or otherwise) being the most common treatment method. Eight facilities reported having settling ponds, bioswales or in-situ treatment; all of these systems would help to reduce pollutants of potential concern prior to the use of more sophisticated treatment methods (figure 16).

Figure 16. Water treatment method used to process stormwater or groundwater at responding facilities



Three of the six responding facilities located outside of California, Oregon or Washington failed to provide data on their treatment systems and two of the facilities responded that no treatment was employed. The other facility reported having in-situ treatment and carbon filtration systems.

There of eleven responding facilities in Oregon reported having no form of a groundwater and/or stormwater treatment system. One facility did not provide answers concerning the presence of such a system. Seven facilities had some form of water treatment system in place. Three sites in Oregon reported having systems that included flocculation, pH adjustment, filtration and carbon filtration.

Four of the eight responding California facilities reported that they did not treat groundwater and/or stormwater while one used a passive system consisting of settling ponds and another used flocculation, pH adjustment, filtration and carbon filtration. Three did not provide information on stormwater/groundwater treatment.

All seven responding facilities located in Washington had some type of groundwater/stormwater treatment system in place. One of the seven facilities reported using catch-basins and vegetated bioswales. One facility used an enhanced in-situ treatment, while another reported using pH adjustment and electrolysis. Another facility reported using pH adjustment, filtration and carbon filtration. The final

Washington facility reported using flocculation, pH adjustment, filtration and carbon filtration.

The survey indicated that seventeen out of thirty-two facilities employed some treatment method for processing stormwater and / or groundwater. Amoung those responding, flocculation, pH adjustment and filtration were the most common treatment methods. This similarity likley reflects the limited number of cost-effective treatment technologies for the targeted pollutants of concern.

NPDES Limits and Benchmarks

The majority of survey respondants had NPDES permits. Additional information was requested on the questionnaire regarding associated limits for these permits. Thirteen of the thirty-two respondents reported following permit limits, eight respondents reported having benchmarks rather than limits and the remaining questionnaire respondents did not provide an answer and/or were not subject to either limits or benchmarks. The CWA describes permit limits as any restriction on quantities, rates or concentrations of chemical, physical, biological and other constituents (Thomson-West, 2004). Permit benchmarks are not limits, but rather guideline concentrations designed to assist the permittee in determining if the implementation of best managetment practices reduces pollutants concentrations to below levels of concern

(Thompson-West, 2004). Permit limits and benchmarks are established by the regulatory agency (either EPA or a State agency) based on the receiving body of water and its current volume and water quality. It is important to consider the current and historic preservatives utilized at a facility when interpreting benchmarks and limits. The NPDES limits and benchmark data will be discussed within the context of the state in which they are located.

Water Quality Parameters

Water quality parameters include typically biological oxygen demand (BOD), pH, Oil & Grease, Total Suspended Solids (TSS), whole effluent toxicity testing (WET Testing) and temperature (Table 7).

BOD is the measurement of biological activity within a sample that consumes oxygen and an elevated BOD measurement is associated with low oxygen within the water body, which negatively impacts water quality. Water quality is optimal relative to pH when it is near neutral (7.0). Oil and Grease, a common POPC associated with industrial operations, measures the level of oil and grease present in a water sample. Total Suspended Solids (TSS) is the measure of solids that stay suspended within a sample. Water quality may be negatively impacted at higher TSS levels. Whole effluent toxicity (WET) testing is conducted on aquatic life to determine the effects of pollutants that are potentially present in a sample over a period of time. The effect of temperature on a receiving body of water is considered when establishing benchmarks and limits because aquatic life can be adversely affected by warmer temperatures (Thomson-West, 2004).

Three California facilities reported having limits for pH, Oil & Grease and TSS. One facility had monitoring requirments for pH levels, two facilities had monitoring requirements with no limits or benchmarks established and one facility had monitoring requirements for TSS with no limits or benchmarks established. The remaining three facilities in California provided no data regarding water quality limits or benchmarks.

Every facility with an NPDES permit located in Oregon, reported limits or benchmarks for pH. The pH minimum ranged from 5.5 to 6.5 and the maximum ranged from 8.5 to 9. Two of the eleven facilities in Oregon reported BOD limits with a daily maximum of 45 mg/L and an average of 30 mg/L. Four facilities in Oregon report having benchmarks for Oil & Grease. Six Oregon facilities had benchmarks for TSS levels and one reported limits. Three facilities in Oregon reported having no limits or benchmarks for TSS. Two Oregon facilities reported having maximum temperature limits for certain periods of the year and only one other facility was required to monitor for temperature. Eight Oregon facilities were required to conduct

WET testing and seven of those facilities were required to have no toxicity in the results. Only three Oregon facilities had no WET testing requirements.

None of the facilities located in Washington reported having benchmarks or limits for BOD. pH minimum range limits were 6.0 – 6.5 and the maximum was 8.5 – 9.0 and no benchmarks were reported for pH. Six of the seven facilities in Washington reported having an Oil & Grease limit of 10 mg/L. The TSS limit for five of the seven Washington facilities was 50 mg/L. One facility only reported having a monitoring requirement while another reported having no requirements relative to TSS. Two Washington facilities had “no toxicity” requirements for WET testing and five facilities did not have requirements for WET testing.

It is unclear why only two of the thirty-two responding facilities surveyed had BOD limits, particuarly since many other facilities used similar preservatives. The TSS for Washington consists of mostly limits and remains fairly consistent from facility to facility, while most of the TSS for Oregon were higher and were benchmarks. BOD test results, in conjunction with knowledge of water conditions in the receiving water body, can provide an indicator of potential impacts of water discharge from a plant. However, this approach does not appear to be consistently used by regulatory authorities for this purpose.

The majority of responding Oregon facilities had a “no toxicity” requirement for WET testing, while only two of the Washington facilities had WET testing requirements and none of the respondents in other states report having requirements for this type of testing. A finding of toxicity in a sample compared to labortory controls is a challenge because the tests can be variable making it difficult to determine the cause of the toxicity. The process of identifying the cause of the toxicty is burdensome and costly.

Pollutants of Potential Concern

Pollutants of potential concern (POPCs) specific to the wood industry include arsenic, copper, zinc, chromium, pentachlorophenol (penta), polycyclic aromatic hydrocarbons (PAH) and dioxins and furans (dioxins). Some limits and benchmarks are expressed by varying arsenic and chromium forms, such as arsenic V, arsenic III, chromium III and chromium VI. Concentrations measured for metals, unless otherwise stated, are totals. Limited data were obtained in relation to POPCs for states outside of California, Oregon and Washington. Colorado facilities reported monitoring requirements rather than limits and benchmarks (Table 8).

No responding facilities in California currently treat with creosote, penta or copper naphthenate (CuNAP); therefore, the lack of penta, PAH and dioxin limits and/or benchmarks is consistent with data obtained. Two facilities in California reported relatively low limits for arsenic, copper and chromium when compared to other responding facilities. Only one other facility in California reported a limit for copper. No facilities in California were monitoring for limits and/or benchmarks for dioxins, reflecting the absence of penta treating facilities in this state.

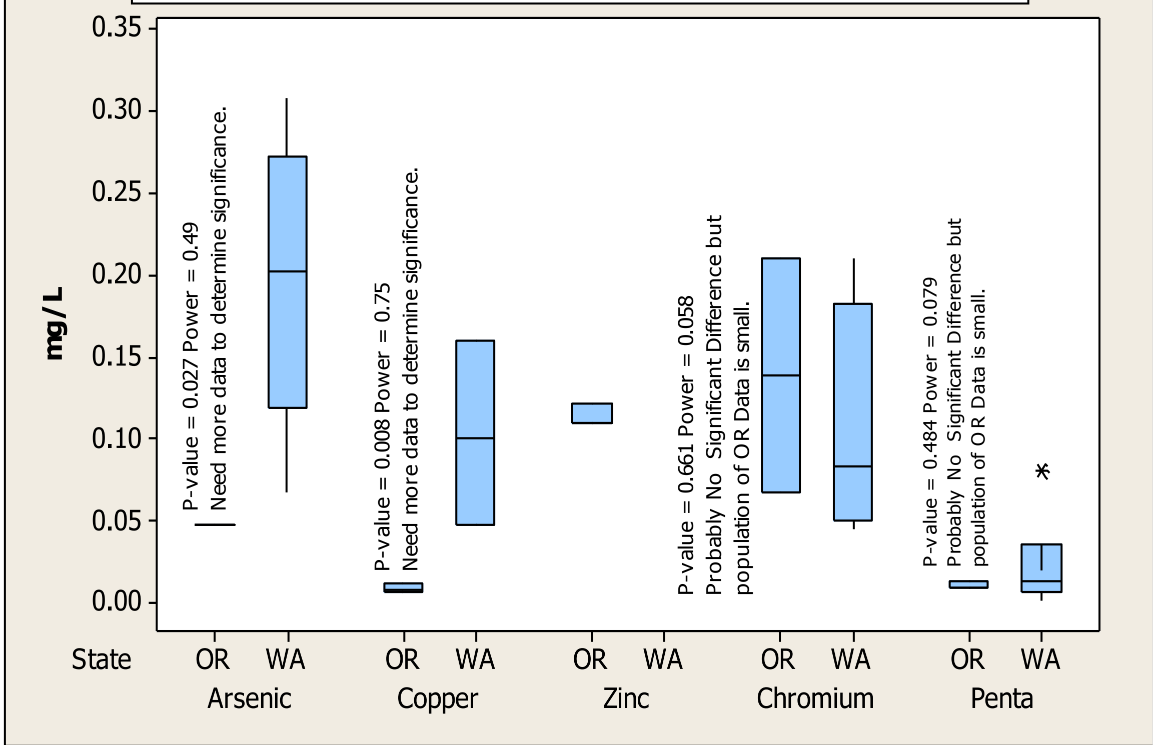
Five of the eight responding facilities in Oregon with arsenic as a POPC had limits and benchmarks for this metal. Two of the facilities in Oregon had benchmarks for arsenic instead of limits. Four Oregon facilities reporting on copper had benchmarks, while five report limits. It is interesting to note that the limits sometimes varied from discharge point to discharge point within a single facility. Two facilities in Oregon had similar discharge limits for zinc. Three facilities in Oregon reported benchmarks for zinc ranging from 0.036 mg/L to 1.128 mg/L. There appeared to be no connection between whether a facility in Oregon had zinc as a pollutant of potential concern and had a limit or benchmark in place for zinc. Monitoring for chromium in Oregon includes monitoring for trivalent, hexavalent and total chromium and limits and/or benchmarks were wide-ranging. There was also variability in limits from outfalls within the same facility. Only one facility in Oregon had monitoring requirements for PAH. Three facilities reported having monitoring requirements for dioxins.

Four facilities in Oregon reported penta as a POPC and all of these facilities had discharge limits. Two of these facilities had penta limits relative to pH range. The range of effluent discharge limits for penta in NPDES permits for these two facilities were a minimum of 0.0031 mg/L at a pH range of 6.5 to 7.0 and a maximum of 0.0137 at a pH range of 8.0 to 8.5. The rationale behind a lower discharge limit at a lower pH reflects higher bio-availability of penta at a lower pH.

It should be noted, that unlike in California and Oregon, discharge limits in Washington are only set as daily maximum limits, rather than monthly averages. Four facilities in Washington reported limits for arsenic, copper and chromium. Two of those reporting facilities had more than one outfall, and limits were different for each outfall. Discharge limits for arsenic, copper and chromium varied from 0.067 mg/L to 0.309 mg/L, from 0.046 mg/L to 1.0 mg/L and 0.045 mg/L to 0.30 mg/L, respectively.

Four facilities in Washington reported that they currently used penta and all four of those facilities had discharge limits for penta ranging from 0.001 mg/L to 0.081 mg/L. One facility using penta also reported limits for PAH, and another had monitoring requirements for PAH. Of the two facilities reporting dioxins in Washington, one had only a monitoring requirement for thesecompounds, while the other had a limit of 0.6 ppq (parts per quadrillion).

Figure 17. NPDES Limits for Oregon & Washington



Limitations

If given the opportunity to resurvey the sample population of wood treaters in the Western United States, requesting additional information from the questionnaire recipients would be advantageous. For instance, additional information would have been useful for the average and maximum length of commodities in order to learn if there was any opportunity for post-treatment storage under cover, and if so, if these treated products were currently being stored undercover.

It also might have been useful to request that respondents identify preservatives no longer used at the particular facilities, without any reference to groundwater and stormwater management. The questionnaire provided no option for stating whether a permit was necessary, specifically in relation to groundwater treatment. Additional information would have helped identify whether groundwater had been impacted by past practices.

Finally, the survey questionnaire requested facilities to report on monitoring requirements and associated limits at each of the facilities. Because the information requested required extensive detail, it may have been more useful to request copies of the discharge limitation and sampling requirement sections of existing permits. This might have improved both the response rate and quality of the responses

Chapter 8 - Conclusion

The main objective of this survey was to collect and synthesize data on groundwater and stormwater treatment practices for wood treatment facilities in the Western United States and identify common groundwater and stormwater treatment processes.

Information gathered included: age of the facility, types of preservatives in use and previously used at the facility, effect on groundwater and stormwater, production information related to preservative type and volume, size of real property subject to water management requirements, volume of water managed, methods of treatment of groundwater and stormwater and regulatory permits and monitoring requirements. While these data were used to identify common strategies for overcoming challenges related to water treatment and regulatory compliance, no trends were noted. Other than the similarity of NPDES requirements, few trends were noted regarding wood treatment and stormwater and groundwater management.

There was a relation between plants receiving the greatest rainfall and the presence of a water treatment system, however the sample size is small. Treatment system types varied from passive systems such as bioswales to active systems utilizing pH adjustment, floculation, filteration, and carbon filteration. While there was consistency, due to the preservatives utilized at a facility, with respect to the pollutants of potential concern among the respondents, the treatment methods used to combat the contamination occurring from these pollutants varied from no water treatment to multiple water treatment methods.

There were similarities relative to regulatory discharges limits, under NPDES permits for wood treaters within surveyed states and there was a trend for more stringent limits for groundwater and stormwater. The information concerning water treatment technologies may be useful for facilities seeking improved technologies to enable them to meet new regulatory limits. Limits for pentachlorophenol and copper based on the bioavailability of contaminates at various pH ranges and hardness, respectively, were a relatively new development. The sharing of strategies to meet environmental regulatory statues within the wood preservative industry will be a benefit to all.

BIBLIOGRAPHY

American Wood Protection Association. (2010). *2010 AWPA Book of Standards*. Birmingham, AL. AWPA.

Aspen Law & Business. *RCRA Regulations & Keyword Index* (2001 ed.). (2001). Aspen Law & Business.

Board of Regents of the University of Wisconsin System Nelson Institute for Environmental Studies (21-Apr-2010). *Meet Gaylord Nelson, founder of Earth Day*. Retrieved from http://nelsonearthday.net/nelson/index.htm.

Cafaro, Philip. (2011). *Rachel Carson's environmental ethics.* Retrieved from http://www.eoearth.org/article/rachel_carson's_environmental_ethics.

California Environmental Protection Agency. (9-Jun-1998). *Pentachlorophenol (PCP)Risk Characterization Document*.

Cha, D; Chiu, P; Kim, S; & Chang, J. (1999). Treatment Technologies. *Water Environment Research, Vol. 16,* 870-885.

Cushman. (2006). *Biological Wastewater Treatment.* Retrieved from http://engineering.dartmouth.edu/~cushman/courses/engs37/biotreatmenttypes.pdf

Dahlgren, S. & Hartford, W. (Jan-1972). Kinetics and Mechanism of Fixation of Cu-Cr-As Wood Preservatives. *Holzforschung: International Journal of the Biology, Chemistry, Physics, and Technology of Wood.* Germany.

Durham, D.; Marshall, L.; Miller, J.; & Chmurny, A. (Sept-1994). Characterization of Inorganic Biocarriers That Moderate System Upsets during Fixed-Film Biotreatment Processes. *Applied and Environmental Microbiology, Vol. 60, No. 9, pp. 3329-3335*.

Fister, Anna. (1995). *History of the Cuyahoga River*. Retrieved from http://www.grc.nasa.gov/WWW/k-12/fenlewis/History.html

Frank, Clean Water Deskbook & Rodgers. (n.d.) *Federal Water Pollution Control Act (1948).* Retrieved from http://www.answers.com/topic/federal-water-pollution-control-act-1948

BIBLIOGRAPHY (Continued)

Freeman, M.H.; Shupe, T.F.; Vlosky, R.P.; & Barnes, H.M. (Oct-2003). Past, Present, and Future of the Wood Preservation Industry. *Forest Products Journal, Vol. 53, No. 10, pp. 8-15.*

Ghosh, U.; Weber, A.S.; Jensen, J.N.; & Smith, J.R. (1999). Granular Activated Carbon and Biological Activated Carbon Treatment of Dissolved and Sorbed Polychlorinated Biphenyls. *Water Environment Research, Vol. 2, No. 71, pp. 232-240.*

Graham, RD. (1973). *History of Wood Preservation. In: Wood Deteriation and its Penetration by Preservative Treatments. Vol 1. Degradation and Protection of Wood. (*DD Nicholas ed.). Volume 1. Syracuse University Press, Syracuse, New York. pp. 1-30.

Hunt, G. & Garratt, G. *Wood Preservation*. (1938). McGraw-Hill Company. York, PA.

Kresic, Neven. *Groundwater Resources: Sustainability, Management, and Restoration*. (2009). McGraw-Hill.

Lear, Linda. (1998). *Rachel Carson's Biography.* Retrieved from http://www.rachelcarson.org/

Matilainen, A.; Tuhkanen, T.; & Vieno, N. (15-March-2005). Efficiency of the activated carbon filtration in the natural organic matter removal. *Enivironmental International, 32,* 324-331.

National Academy of Sciences: Global Health and Education Foundation. *Safe Drinking Water is Essential.* (2008). Retrieved from http://drinking-water.org/html/en/Treatment/Coagulation-Flocculation-technologies.html

National Oceanic and Atmospheric Association. (25-March-2008). *Nonpoint Source Pollution: A Brief History of Pollution.* Retrieved from http://oceanservice.noaa.gov/education/kits/pollution/02history.html

National Resources Defense Council (16-Apr-1997). *The Story of Silent Spring.* Retrieved from http://www.nrdc.org/health/pesticides/hcarson.asp.

BIBLIOGRAPHY (Continued)

Nicholas, Darrel D. (1973). *Wood Deterioration and its Prevention by Preservative Treatment.* Syracuse University Press, New York.

Preston, Alan F. (Sept-2002). Wood Preservation: Trends of today that will influence the industry of tomorrow. *Forest Products Journal, Vol. 50, No. 9, pp. 12-19.*

Selected Environmental Law Statutes (2004-2005 Educational Edition). (2004). Thomson – West.

Southwestern Water Conservation District. (Mar-2009). *Rachel Carson – Mother to Environmental Protection Agency and Clean Water Act.* Retrieved from http://www.waterinfo.org/node/4672

Thompson, Warren S. (1973). *Pollution Control*. *In: Wood Deterioration and its Prevention by Preservative Treatments. Vol. 2. Preservatives and Preservative Systems.* (DD Nicholas ed.). Volume 2. Syracuse University Press, Syracuse, New York. pp. 345-390.

United States Census Bureau. (3-May-2007). *Geographic Distribution – Wood Preservation 2007.* Retrieved from http://www.census.gov/econ/industry/geo/g321114.htm

United States Environmental Protection Agency. (29-Apr-2011). *EPA History.* Retrieved from http://www.epa.gov/history/timeline/index.htm

United States Environmental Protection Agency. (30-Jul-2010). *EPA turns 40 this year!* Retrieved from http://www.epa.gov/earthday/history.htm.

United States Environmental Protection Agency. (01-May-2011). *History of the Clean Water Act.* Retrieved from http://www.epa.gov/lawsregs/laws/cwahistory.html

United States Environmental Protection Agency. (1996). *Wood Preserving Resource Conservation and Recovery Act (RCRA) Compliance Guide: A Guide to Federal Environmental Regulations.*

APPENDIX A

Management and Treatment of Water at Western Wood Preserving Facilities: An Analysis of Current Treatment Methods of Groundwater and Stormwater

Phase I: Individual Questionnaire

1. How many locations does your company have for pressure treating wood?

2. Where are these facilities located? (Please provide city and state)
   Plant 1:______________________________________

   Plant 2:______________________________________

   Plant 3:______________________________________

3. How long have these facilities been pressure treating wood?

Age of plant in years	**Plant 1**	**Plant 2**	**Plant 3**
< 5 yr			
6 – 10 yr			
10 – 20 yr			
20 – 30 yr			
40 – 50 yr			
> 50 yr			

4. Place a checkmark in the appropriate box to indicate which preservatives are currently used at each facility?

Preservative	**Plant 1**	**Plant 2**	**Plant 3**
Creosote			
CCA			
ACZA			
Pentachlorophenol			
Copper Azole			
Copper naphthenate			
ACQ			
Borates			
Other (Please specify)			

5. Place a checkmark in the appropriate box to indicate if your facility water management is affected by preservative no longer used at the facility.

	Plant 1		**Plant 2**		**Plant 3**	
Preservative	**GW**	**SW**	**GW**	**SW**	**GW**	**SW**
Creosote						
ACZA						
CCA						
Pentachlorophenol						
Copper Azole						
Copper naphthenate						
ACQ						
Borates						
Other (Please specify)						

6. Please describe how each of the preservatives indicated above currently affects plant water management?

7. Place a checkmark in the appropriate boxes to indicate the commodities treated at each facility?

Product	**Plant 1**	**Plant 2**	**Plant 3**
Poles			
Piling (marine)			
Piling (foundation)			
Composites			
Timbers			
Ties			
Lumber			
Posts			
Other (Please specify)			

8. Five year average volume of wood treated annually by preservative type.

	Volume of wood treated (ft^3)		
Preservative	**Plant 1**	**Plant 2**	**Plant 3**
Creosote			
Pentachlorophenol			
CuAzole			
CCA			
ACZA			
Copper naphthenate			
ACQ			
Borates			
Other (Please specify)			

9. Average annual rainfall in inches at each plant site?

	Plant 1	**Plant 2**	**Plant 3**
Rainfall in inches			

10. How many acres is each plant?

	Plant 1	**Plant 2**	**Plant 3**
Size of the plant in acres			

11. Estimated discharge volume of water per plant.

Estimated discharge volume	**Plant 1**		**Plant 2**		**Plant 3**	
	GW	**SW**	**GW**	**SW**	**GW**	**SW**
Actual Discharge Volume, gallons						
Outfall Drainage Area, acres						
% Heavy Industrial Use (RC=0.75)						
% Light Industrial Use (RC=0.65)						
% Paved and/or Roofed (RC=0.90)						
% Railroad Yard Areas (RC=0.30)						
% Unimproved Areas (RC=0.20)						

12. Please indicate below any permits your facility has for groundwater or stormwater.

	Plant 1		**Plant 2**		**Plant 3**	
Permit types	**GW**	**SW**	**GW**	**SW**	**GW**	**SW**
National pollution discharge elimination system (NPDES)						
Discharge permit to city stormwater						
Discharge permit to a POTW						
Discharge permit to a water district						
Other (Please specify)						

13. Please indicate below how water is treated prior to discharge.

Treatment method	**Plant 1**		**Plant 2**		**Plant 3**	
	GW	**SW**	**GW**	**SW**	**GW**	**SW**
Flocculation						
pH adjustment						
Filtrations						
Biological treatment						
Carbon filtration						
Reverse osmosis						
Electrolysis based treatment						
Chemical addition						
Other (Please specify)						

14. When were the water treatment system(s) installed?

	Plant 1		**Plant 2**		**Plant 3**	
	GW	**SW**	**GW**	**SW**	**GW**	**SW**
System installation date						

15. Have the system(s) been modified since installation- if so, how?

16. What are the monitoring requirements and associated limits for each permit at the plants?

Monitoring requirements	**Plant 1**		**Plant 2**		**Plant 3**	
	GW	**SW**	**GW**	**SW**	**GW**	**SW**
Flow gpm						
BOD mg/L						
Arsenic mg/L						
Copper mg/L						
Zinc mg/L						
Chromium mg/L						
Pentachlorophenol mg/L						
Polynuclear Aromatic Hydrocarbons mg/L						
pH						
Oil & Grease mg/L						
TSS mg/L						
Lead mg/L						
PCDD, PCDF pg/L						
Temperature °F						
Bioassay testing						
Diesel range organics mg/L						
Other (Please specify)						

17. What are the Contaminants of potential concern (check all that apply)?

	Plant 1		Plant 2		Plant 3	
Contaminants of potential concern	**GW**	**SW**	**GW**	**SW**	**GW**	**SW**
Arsenic						
Copper						
Zinc						
Chromium						
Pentachlorophenol						
Polynuclear Aromatic Hydrocarbons						
pH						
Oil & Grease						
TSS						
Lead						
PCDD, PCDF						
Temperature						
Diesel range organics						
Other (Please specify)						

18. Please rank the following sources for technical information regarding groundwater or stormwater discharge (1 most important, 7 least important):

___Vendors
___Consultants
___Other treaters
___Local regulator (City/County)
___State regulator
___Federal regulator
___Other (Please specify)

APPENDIX B

Table 1. Characteristics of responding treating facilities.[a]													
Plant #	**Location**	**Size (acres)**	**Age (Yr)**	**Production (million ft³)**	**Commodities Treated**							**Water Treatment**	**Permit**
					Poles	**Piles**	**Composites**	**Ties / Timbers**	**Lumber**	**Posts**	**No Response**		
101	AZ	20-40	21-30	NR	+	+	-	+	+	-	-	No	NR
126	CA	<20	6-10	1-3	-	-	-	+	+	-	-	Yes	Yes
131	CA	<20	21-30	1-3	+	-	-	+	+	+	-	No	Yes
132	CA	<20	21-30	<1	+	-	-	+	+	+	-	No	Yes
110	CA	<20	21-30	NR	-	-	-	-	+	+	-	NR	NR
125	CA	<20	21-30	>3	-	-	-	-	+	+	-	NR	Yes
130	CA	20-40	31-40	NR	-	-	-	-	+	-	-	NR	NR
105	CA	20-40	31-40	NR	+	+	+	+	+	-	-	No	Yes
119	CA	20-40	>50	<1	-	-	-	+	+	+	-	Yes	Yes
113	CO	<20	21-30	<1	-	-	-	+	+	+	-	NR	Yes
128	CO	<20	21-30	1-3	-	-	+	+	+	+	-	NR	Yes
114	MT	NR	31-40	NR	+	-	-	-	+	+	-	NR	NR
106	NV	>40	21-30	NR	+	-	-	+	+	+	-	No	Yes
103	OR	<20	11-20	1-3	+	+	-	+	+	+	-	No	Yes
129	OR	<20	11-20	>3	-	-	-	+	+	+	-	NR	Yes
104	OR	<20	21-30	<1	-	-	-	+	+	+	-	Yes	Yes
108	OR	20-40	21-30	>3	+	-	+	+	+	+	-	Yes	Yes
102	OR	20-40	41-50	NR	+	+	+	+	+	+	-	Yes	Yes
122	OR	20-40	> 50	1-3	+	-	-	-	+	-	-	Yes	Yes
117	OR	>40	> 50	1-3	+	+	+	+	+	+	-	Yes	Yes
118	OR	>40	>50	1-3	+	-	-	+	-	-	-	No	Yes
115	OR	>40	>50	NR	-	-	-	-	+	-	-	No	Yes
116	OR	NR	11-20	1-3	-	-	-	-	+	-	-	Yes	Yes
121	OR	<20	>50	NR	-	-	-	-	-	-	**NR**	Yes	Yes
127	SD	>40	> 50	<1	+	-	-	+	+	+	-	Yes	Yes
109	WA	<20	21-30	>3	+	-	-	+	+	+	-	Yes	Yes
112	WA	<20	41-50	1-3	+	-	-	+	+	-	-	Yes	Yes
111	WA	20-40	21-30	NR	-	-	+	+	+	-	-	Yes	Yes
124	WA	20-40	> 50	<1	+	-	-	-	-	+	-	Yes	Yes
107	WA	>40	31-40	>3	+	-	-	+	+	+	-	Yes	Yes
120	WA	>40	41-50	1-3	+	-	-	-	-	-	-	Yes	Yes
123	WA	<20	>50	<1	-	-	-	-	+	-	-	Yes	Yes

[a] Where (+) = yes, (-)= no and NR= no response.

Table 2. Preservatives used at responding treating facilities.[a]

Plant #	Location	Size (Acres)	Age (Yr)	Production (million ft³)	Preservative Type										Water Treatment	Permit
					Creo	CCA	ACZA	Penta	CuAzole	CuNAP	ACQ	Borates	Other	# Preservatives		
101	AZ	20-40	21-30	NR	+	+	-	-	-	-	+	+	-	4	No	NR
126	CA	<20	6-10	1-3	-	-	-	-	+	-	-	+	-	9	Yes	Yes
131	CA	<20	21-30	1-3	-	*	-	-	-	-	+	+	**Fire Retardant**	3	No	Yes
132	CA	<20	21-30	<1	-	*	-	-	-	-	+	+	-	2	No	Yes
110	CA	<20	21-30	NR	-	+	-	-	-	-	+	+	**Fire Retardant**	4	NR	NR
125	CA	<20	21-30	>3	-	-	-	-	+	-	-	-	-	1	NR	Yes
130	CA	20-40	31-40	NR	-	-	-	-	-	-	+	+	-	2	NR	NR
105	CA	20-40	31-40	NR	-	+	+	-	-	-	+	+	**Fire retardant**	5	No	Yes
119	CA	20-40	>50	<1	*	-	+	*	-	-	+	-	-	2	Yes	Yes
113	CO	<20	21-30	<1	-	+	-	-	-	-	-	-	-	1	NR	Yes
128	CO	<20	21-30	1-3	-	-	-	-	-	-	+	+	**PTI[b], Mcironized CU**	4	NR	Yes
114	MT	NR	31-40	NR	-	+	-	-	-	-	-	-	-	1	NR	NR
106	NV	>40	21-30	NR	-	+	-	+	+	-	+	-	-	9	No	Yes
103	OR	<20	11-20	1-3	-	+	+	-	+	-	-	+	-	4	No	Yes
129	OR	<20	11-20	>3	-	-	-	-	-	-	+	+	-	2	NR	Yes
104	OR	<20	21-30	<1	-	+	+	-	+	-	-	+	-	9	Yes	Yes
108	OR	20-40	21-30	>3	-	+	-	-	-	-	+	+	-	3	Yes	Yes
102	OR	20-40	41-50	NR	*	*	-	*	-	+	+	+	-	3	Yes	Yes
122	OR	20-40	> 50	1-3	-	-	-	+	-	-	-	-	-	1	Yes	Yes
117	OR	>40	> 50	1-3	+	*	+	+	-	-	+	-	-	4	Yes	Yes
118	OR	>40	>50	1-3	+	-	-	*	-	-	-	-	-	1	No	Yes
115	OR	>40	>50	NR	-	+	-	-	-	-	-	-	**Fire Retardant**	2	No	Yes
116	OR	NR	11-20	1-3	-	+	-	-	-	-	-	+	**Fire Retardant**	3	Yes	Yes
121	OR	<20	>50	NR	-	-	-	+	-	+	-	+	**Permetherin, Fire Retardant, IPBC**	6	Yes	Yes
127	SD	>40	> 50	<1	*	-	-	*	-	+	-	-	-	1	Yes	Yes
109	WA	<20	21-30	>3	-	+	-	-	-	-	+	+	-	3	Yes	Yes
112	WA	<20	41-50	1-3	-	+	-	-	-	-	+	+	**Fire Retardant**	4	Yes	Yes
111	WA	20-40	21-30	NR	-	+	-	-	-	-	+	+	-	3	Yes	Yes
124	WA	20-40	> 50	<1	*	-	-	+	-	-	-	-	-	1	Yes	Yes
107	WA	>40	31-40	>3	-	+	-	+	+	-	-	+	-	4	Yes	Yes
120	WA	>40	41-50	1-3	-	-	-	+	-	+	-	-	-	2	Yes	Yes
123	WA	<20	>50	<1	-	-	-	+	-	-	-	-	-	9	Yes	Yes

[a] Where (+) = yes, (-)= no, (*) = preservative no longer used at the facility and NR= no response.

[b] Propiconazole Tebuconazole Imidacloprid (PTI)

[c] 3-lodo-2-propynol butylcarbamate (IPBC)

Table 3. Permits held by responding treating facilities in order to manage stormwater and groundwater.[a]

Plant #	Location	Size (Acres)	Age (Yr)	Production (million ft³)	Average Annual Rainfall (in)	Permit Type						Water Treatment
						NPDES	City SW	POTW	Water District	Other	No Response	
101	AZ	20-40	21-30	NR	6	-	-	-	-	-	**NR**	No
126	CA	<20	6-10	1-3	17	+	-	-	-	-	-	Yes
131	CA	<20	21-30	1-3	14	+	-	-	-	-	-	No
132	CA	<20	21-30	<1	39	+	-	-	-	-	-	No
110	CA	<20	21-30	NR	5	-	-	-	-	-	**NR**	NR
125	CA	<20	21-30	>3	37	+	-	-	-	-	-	NR
130	CA	20-40	31-40	NR	18	-	-	-	-	-	**NR**	NR
105	CA	20-40	31-40	NR	13	-	-	-	-	+	-	No
119	CA	20-40	>50	<1	24	-	-	-	+	-	-	Yes
113	CO	<20	21-30	<1	16	+	-	-	-	-	-	NR
128	CO	<20	21-30	1-3	14	+	-	-	-	-	-	NR
114	MT	NR	31-40	NR	16	-	-	-	-	-	**NR**	NR
106	NV	>40	21-30	NR	5	+	-	-	-	-	-	No
103	OR	<20	11-20	1-3	38	+	-	-	-	-	-	No
129	OR	<20	11-20	>3	23	+	-	-	-	-	-	NR
104	OR	<20	21-30	<1	63	+	-	-	-	-	-	Yes
108	OR	20-40	21-30	>3	63	+	-	-	-	-	-	Yes
102	OR	20-40	41-50	NR	49	+	-	-	-	-	-	Yes
122	OR	20-40	> 50	1-3	40	+	-	-	-	-	-	Yes
117	OR	>40	> 50	1-3	45	+	-	-	-	-	-	Yes
118	OR	>40	>50	1-3	12	-	-	-	-	+	-	No
115	OR	>40	>50	NR	55	+	-	-	-	-	-	No
116	OR	NR	11-20	1-3	45	+	-	-	-	-	-	Yes
121	OR	<20	>50	NR	45	+	-	-	-	-	-	Yes
127	SD	>40	> 50	<1	25	+	-	-	-	-	-	Yes
109	WA	<20	21-30	>3	44	+	-	-	-	-	-	Yes
112	WA	<20	41-50	1-3	41	+	-	+	-	-	-	Yes
111	WA	20-40	21-30	NR	41	+	-	-	-	-	-	Yes
124	WA	20-40	> 50	<1	38	+	-	-	-	-	-	Yes
107	WA	>40	31-40	>3	40	+	-	-	-	-	-	Yes
120	WA	>40	41-50	1-3	47	+	-	-	-	-	-	Yes
123	WA	<20	>50	<1	33	+	-	-	-	-	-	Yes

[a] Where (+) = yes, (-)= no and NR= no response.

Table 4. Pollutants of Potential Concern and treating methods at responding treating facilities.[a]

Plant #	Location	Size (Acres)	Age (Yr)	Pollutants of Potential Concern (POPCs)							Treatment Methods							
				As	Cu	Zn	Cr	Penta	PAH[b]	PCDD, PCDF	Flocculation	pH Adjustment	Filtrations	Carbon Filtration	Electrolysis	No Treatment	Other	No Response
101	AZ	20-40	21-30	+	+	-	+	-	+	-	-	-	-	-	-	+	-	-
126	CA	<20	6-10	-	+	-	-	-	-	-	-	-	-	-	-	-	Settling pond	-
131	CA	<20	21-30	+	+	-	+	-	-	-	-	-	-	-	-	+	-	-
132	CA	<20	21-30	+	+	-	+	-	-	-	-	-	-	-	-	+	-	-
110	CA	<20	21-30	+	+	-	+	-	-	-	-	-	-	-	-	-	-	NR
125	CA	<20	21-30	-	+	-	-	-	-	-	-	-	-	-	-	-	-	NR
130	CA	20-40	31-40	-	+	-	-	-	-	-	-	-	-	-	-	-	-	NR
105	CA	20-40	31-40	+	+	+	+	-	-	-	-	-	-	-	-	+	-	-
119	CA	20-40	>50	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
113	CO	<20	21-30	+	+	-	+	-	-	-	-	-	-	-	-	-	-	NR
128	CO	<20	21-30	-	+	-	-	-	-	-	-	-	-	-	-	-	-	NR
114	MT	NR	31-40	+	+	-	+	-	-	-	-	-	-	-	-	-	-	NR
106	NV	>40	21-30	+	+	+	+	+	+	+	-	-	-	-	-	+	-	-
103	OR	<20	11-20	+	+	+	+	-	-	-	-	-	-	-	-	+	-	-
129	OR	<20	11-20	-	+	-	-	-	-	-	-	-	-	-	-	-	-	NR
104	OR	<20	21-30	+	+	+	+	-	-	-	-	-	+	-	-	-	-	-
108	OR	20-40	21-30	+	+	-	+	-	-	-	-	-	+	-	-	-	-	-
102	OR	20-40	41-50	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
122	OR	20-40	> 50	-	-	-	-	+	+	+	+	+	+	+	-	-	-	-
117	OR	>40	> 50	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
118	OR	>40	>50	-	-	-	-	+	+	+	-	-	-	-	-	-	Water Evaporated	-
115	OR	>40	>50	+	+	-	+	-	-	-	-	-	-	-	-	+	BMP	-
116	OR	NR	11-20	+	+	-	+	-	-	-	-	-	-	-	-	-	[c]	-
121	OR	<20	>50	-	+	-	-	+	+	+	-	-	+	+	-	-	-	ion exchange removed
127	SD	>40	> 50	-	+	-	-	+	+	+	-	-	+	+	-	-	in- situ	-
109	WA	<20	21-30	+	+	-	+	-	-	-	-	+	-	-	+	-	-	-
112	WA	<20	41-50	+	+	-	+	-	-	-	-	-	-	-	-	-	biotreatment pond / catch basin	-
111	WA	20-40	21-30	+	+	-	+	-	-	-	-	-	-	-	-	-	bioswales, BMP	-
124	WA	20-40	> 50	-	-	-	-	+	+	+	-	-	+	+	-	-	-	-
107	WA	>40	31-40	+	+	-	+	+	+	+	-	+	+	+	-	-	-	-
120	WA	>40	41-50	-	+	-	-	+	+	+	+	+	+	+	-	-	in-situ	-
123	WA	<20	>50	-	-	-	-	+	+	+	-	-	-	+	-	-	-	-

[a] Where (+) = yes, (-)= no and NR= no response

[b] Contained in creosote and hydrocarbon carrier oils

[c] finished product covered, oil/H2O sep, swell that overflows to river

Table 5. Water quality concerns of responding treating facilities.[a]

Plant #	Location	Size (Acres)	Age (Yr)	Average Annual Rainfall (in)	Install Date		Water Quality Concerns					
					GW	SW	pH	Oil & Grease	TSS	Temp	TPH	No Response
101	AZ	20-40	21-30	6	-	-	-	-	-	-	-	-
126	CA	<20	6-10	17	-	2004	-	-	-	-	-	**NR**
131	CA	<20	21-30	14	-	-	-	**+**	-	-	-	**-**
132	CA	<20	21-30	39	-	-	-	-	-	-	-	-
110	CA	<20	21-30	5	-	-	-	**+**	-	-	**+**	-
125	CA	<20	21-30	37	-	-	-	**+**	-	-	-	-
130	CA	20-40	31-40	18	-	-	-	-	-	-	-	-
105	CA	20-40	31-40	13	-	-	-	-	-	-	-	-
119	CA	20-40	>50	24	-	-	-	**+**	-	-	-	-
113	CO	<20	21-30	16	-	-	-	-	-	-	-	-
128	CO	<20	21-30	14	-	-	-	**+**	-	-	-	-
114	MT	NR	31-40	16	-	-	-	-	-	-	-	-
106	NV	>40	21-30	5	-	-	-	**+**	-	-	**+**	-
103	OR	<20	11-20	38	-	-	-	-	-	-	-	-
129	OR	<20	11-20	23	-	-	-	**+**	-	-	-	-
104	OR	<20	21-30	63	-	2004	-	-	-	-	-	-
108	OR	20-40	21-30	63	-	2009	-	**+**	**+**	-	-	-
102	OR	20-40	41-50	49	-	1999	-	**+**	-	-	-	-
122	OR	20-40	> 50	40	-	1993	-	-	-	-	-	**NR**
117	OR	>40	> 50	45	1993	1998	**+**	**+**	**+**	-	-	-
118	OR	>40	>50	12	-	-	-	**+**	-	**+**	-	-
115	OR	>40	>50	55	-	-	-	-	-	-	-	**NR**
116	OR	NR	11-20	45	-	1993	**+**	**+**	**+**	-	-	-
121	OR	<20	>50	45	-	2004	-	**+**	**+**	-	-	-
127	SD	>40	> 50	25	1993	-	-	-	-	-	**+**	-
109	WA	<20	21-30	44	-	2001	-	**+**	-	-	-	-
112	WA	<20	41-50	41	-	-	**+**	**+**	**+**	-	-	-
111	WA	20-40	21-30	41	-	-	-	-	-	-	-	**NR**
124	WA	20-40	> 50	38	-	1989	**+**	**+**	**+**	-	-	**-**
107	WA	>40	31-40	40	1995	1985, 2000	-	-	-	-	-	**NR**
120	WA	>40	41-50	47	2008	2005	**+**	**+**	**+**	-	-	-
123	WA	<20	>50	33	2008	-	-	-	-	-	-	-

[a] Where (+) = yes, (-)= no and NR= no response.

Table 6. Groundwater and stormwater treating methods of responding facilites.[a]

Plant #	Location	Size (Acres)	Age (Yr)	Average Rainfall (in.)	Install Date		Volume of Water Discharged		Groundwater/ Stormwater Treatment Methods								Water Treatment	Permit
					GW	SW	GW (Gallons)	SW (Gallons)	Flocculation	pH Adjustment	Filtrations	GAC / Carbon Filtration	Electrolysis	No Treatment	Other	No Response		
101	AZ	20-40	21-30	6	-	-	0	0	-	-	-	-	-	+	-	-	No	NR
126	CA	<20	6-10	17	-	2004	-	6,353,594	-	-	-	-	-	-	Settling pond	-	Yes	Yes
131	CA	<20	21-30	14	-	-	-	1,900,000	-	-	-	-	-	+	-	-	No	Yes
132	CA	<20	21-30	39	-	-	-	4,800,000	-	-	-	-	-	+	-	-	No	Yes
110	CA	<20	21-30	5	-	-	-	-	-	-	-	-	-	-	-	NR	NR	NR
125	CA	<20	21-30	37	-	-	-	-	-	-	-	-	-	-	-	NR	NR	Yes
130	CA	20-40	31-40	18	-	-	-	-	-	-	-	-	-	-	-	NR	NR	NR
105	CA	20-40	31-40	13	-	-	-	-	-	-	-	-	-	+	-	-	No	Yes
119	CA	20-40	>50	24	-	-	-	4,000,000	+	+	+	+	-	-	-	-	Yes	Yes
113	CO	<20	21-30	16	-	-	-	-	-	-	-	-	-	-	-	NR	NR	Yes
128	CO	<20	21-30	14	-	-	-	-	-	-	-	-	-	-	-	NR	NR	Yes
114	MT	NR	31-40	16	-	-	-	-	-	-	-	-	-	-	-	NR	NR	NR
106	NV	>40	21-30	5	-	-	-	-	-	-	-	-	-	+	-	-	No	Yes
103	OR	<20	11-20	38	-	-	-	-	-	-	-	-	-	+	-	-	No	Yes
129	OR	<20	11-20	23	-	-	-	-	-	-	-	-	-	-	-	NR	NR	Yes
104	OR	<20	21-30	63	-	2004	-	8,575,817	-	-	+	-	-	-	-	-	Yes	Yes
108	OR	20-40	21-30	63	-	2009	-	-	-	-	+	-	-	-	-	-	Yes	Yes
102	OR	20-40	41-50	49	-	1999	-	10,636,000	+	+	+	+	-	-	-	-	Yes	Yes
122	OR	20-40	> 50	40	-	1993	17,408,502	13,132,786	+	+	+	+	-	-	-	-	Yes	Yes
117	OR	>40	> 50	45	1993	1998	25,681,750	11,022,400	+	+	+	+	-	-	-	-	Yes	Yes
118	OR	>40	>50	12	-	-	-	-	-	-	-	-	-	-	Water is evaporated	-	No	Yes
115	OR	>40	>50	55	-	-	-	-	-	-	-	-	-	+	BMP	-	No	Yes
116	OR	NR	11-20	45	-	1993	-	-	-	-	-	-	-	-	[b]	-	Yes	Yes
121	OR	<20	>50	45	-	2004	-	-	-	-	+	+	-	-	-	ion exchange removed	Yes	Yes
127	SD	>40	> 50	25	1993		-	-	-	-	+	+	-	-	in- situ	-	Yes	Yes
109	WA	<20	21-30	44	-	2001	-	-	-	+	-	-	+	-	-	-	Yes	Yes
112	WA	<20	41-50	41	-	-	-	-	-	-	-	-	-	-	[c]	-	Yes	Yes
111	WA	20-40	21-30	41	-	-	-	-	-	-	-	-	-	-	bioswales, BMP	-	Yes	Yes
124	WA	20-40	> 50	38	-	1989	-	-	-	-	+	+	-	-	-	-	Yes	Yes
107	WA	>40	31-40	40	1995	1985, 2000	-	-	-	+	+	+	-	-	-	-	Yes	Yes
120	WA	>40	41-50	47	2008	2005	-	-	+	+	+	+	-	-	in-situ	-	Yes	Yes
123	WA	<20	>50	33	2008	-	-	-	-	-	-	+	-	-	-	-	Yes	Yes

[a] Where (+) = yes, (-)= no and NR= no response.

[b] finished product covered, oil/H2O sep, swell that overflows to river

[c] biotreatment pond / catch- basin

Table 7. NPDES limits and benchmarks regarding water quality for responding treating facilities.[a]

Plant #	Location	Size (Acres)	Age (Years)	BOD			pH			Oil & Grease			Total Suspended Solids			WET Testing	NPDES	Remarks
				Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks	Min (s.u.)	Max (s.u.)	Benchmarks	Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks	Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks			
101	AZ	20-40	21-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
126	CA	<20	6-10	-	-	-	-	-	6.0 - 9.0	-	-	15	-	-	100	-	+	-
131	CA	<20	21-30	-	-	-	-	-	-	-	0.96[b]	-	-	10	-	-	+	-
132	CA	<20	21-30	-	-	-	-	-	Monitored	-	0.96[b]	-	-	10	-	-	+	-
110	CA	<20	21-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
125	CA	<20	21-30	-	-	-	-	-	Monitored	-	-	Monitored	-	-	Monitored	-	+	-
130	CA	20-40	31-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Cleanup monitoring
105	CA	20-40	31-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119	CA	20-40	>50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
113	CO	<20	21-30	-	-	-	-	-	Monitored	-	-	Monitored	-	-	Monitored	-	+	-
128	CO	<20	21-30	-	-	-	-	-	Monitored	-	-	Monitored	-	-	Monitored	-	+	-
114	MT	NR	31-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
106	NV	>40	21-30	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
103	OR	<20	11-20	-	-	-	-	-	5.5-9.0	-	-	10	-	-	130	No Toxicity	+	-
129	OR	<20	11-20	-	-	-	-	-	6.5-8.5	-	-	10	-	-	130	No Accute Toxicity	+	-
104	OR	<20	21-30	-	-	-	-	-	5.5-8.5	-	-	10	-	-	130	No Toxicity	+	-
108	OR	20-40	21-30	-	-	-	-	-	6.5-8.5	-	-	-	-	-	130	No Toxicity	+	Iron bm 1
102	OR	20-40	41-50	-	-	-	6.0	9.0	-	10	-	-	-	-	-	No Toxicity	+	NH3
122	OR	20-40	> 50	45	30	-	6.5	8.5	-	-	-	-	-	-	130	No Toxicity	+	COD; some benchmarks
117	OR	>40	> 50	-	-	-	6.5	8.5	-	15	10	-	75	50	-	No Toxicity	+	-
118	OR	>40	>50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115	OR	>40	>50	-	-	-	6.5	8.5	-	15	10	-	50	75	-	-	+	-
116	OR	NR	11-20	-	-	-	6.0	9.0	-	10	-	-	-	-	130	No Toxicity	+	Also monitoring sodium, boron and iron
121	OR	<20	>50	-	-	-	6.5	8.5	-	10	-	-	-	-	Monitored	-	+	-
127	SD	>40	> 50	-	-	-	-	-	-	-	-	-	-	-	-	-	+	TPH
109	WA	<20	21-30	-	-	-	6.0	9.0	-	10	-	-	50	-	-	-	+	-
112	WA	<20	41-50	-	-	-	6.0	9.0	-	10	-	-	50	-	-	No Toxicity	+	-
111	WA	20-40	21-30	-	-	-	6.0	9.0	-	10	-	-	50	-	-	-	+	-
124	WA	20-40	> 50	-	-	-	6.0	9.0	-	10	-	-	-	-	Monitored	-	+	TPH Monitored
107	WA	>40	31-40	-	-	-	6.0	9.0	-	10	-	-	50	-	-	No Toxicity	+	-
120	WA	>40	41-50	-	-	-	6.5	8.5	-	-	-	-	-	-	-	-	+	TPH 0.5
123	WA	<20	>50	-	-	-	6.5	8.5	-	10	-	-	50	-	-	No Toxicity	+	-

[a] Where (+) = yes, (-)= no and NR= no response.

[b] umho/cm units are likely an error

Table 8. NPDES limits and benchmarks regarding pollutants of potential concern for responding treating facilities.[a]

Plant #	Location	Size (Acres)	Age (Year)	Arsenic			Copper			Zinc			Chromium			Penta			PAH			Dioxins & Furans	Remarks
				Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks	Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks	Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks	Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks	Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks	Daily Max (mg/L)	Monthly Average (mg/L)	Benchmarks		
101	AZ	20-40	21-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
126	CA	<20	6-10	-	-	-	0.0636	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
131	CA	<20	21-30	-	0.01	-	-	0.01	-	-	-	-	-	0.005	-	-	-	-	-	-	-	-	-
132	CA	<20	21-30	-	0.01	-	-	0.01	-	-	-	-	-	0.005	-	-	-	-	-	-	-	-	-
110	CA	<20	21-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
125	CA	<20	21-30	-	-	-	-	-	Monitored	-	-	-	-	-	-	-	-	-	-	-	-	-	-
130	CA	20-40	31-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Cleanup monitoring
105	CA	20-40	31-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
119	CA	20-40	>50	-	-	0.005	-	-	0.005	-	-	0.01	-	-	0.005	-	-	0.0003	-	-	0.001	-	-
113	CO	<20	21-30	-	-	Monitored	-	-	Monitored	-	-	-	-	-	Monitored	-	-	-	-	-	-	-	-
128	CO	<20	21-30	-	-	-	-	-	Monitored	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114	MT	NR	31-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
106	NV	>40	21-30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
103	OR	<20	11-20	-	0.19 III, 0.048 V	-	-	0.09	-	-	0.6	-	-	8.5 III, 0.08 VI	-	-	-	-	-	-	-	-	-
129	OR	<20	11-20	-	-	-	-	-	0.153	-	-	1.128	-	-	0.29	-	-	-	-	-	-	-	-
104	OR	<20	21-30	-	-	0.807	-	-	0.0048	-	-	0.036	-	-	0.558 III, 0.016 VI	-	-	-	-	-	-	-	-
108	OR	20-40	21-30	-	-	0.013 V, 0.036 III	-	-	0.0029	-	-	-	-	-	0.011 VI, 0.210 III	-	-	-	-	-	-	-	Iron bm 1
102	OR	20-40	41-50	0.85	0.48	-	0.018	0.012	-	0.12	0.11	-	-	-	-	0.02	0.013	-	-	-	-	-	NH3
122	OR	20-40	> 50	-	-	-	-	-	0.0276	-	-	0.1743	-	-	-	0.0053-0.0238	0.0031-0.0137	-	-	-	-	-	COD; some benchmarks
117	OR	>40	> 50	0.850, 0.850	0.048, 0.048	-	0.011, 0.018	0.0063, 0.012	-	0.120, 0.120	0.110, 0.110	-	0.558, 1.700	0.067, 0.210	-	0.0053-0.0238	0.0031-0.0137	-	-	-	Monitored	-	-
118	OR	>40	>50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115	OR	>40	>50	0.079 V	0.046 V	-	0.014, 0.012	0.008, 0.007	-	-	-	-	0.015 VI	0.009 VI	-	-	-	-	-	-	-	-	-
116	OR	NR	11-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Also monitoring sodium, boron and iron
121	OR	<20	>50	-	-	-	0.043	-	-	-	-	Monitored	-	-	Monitored	-	-	Monitored	-	-	-	-	-
127	SD	>40	> 50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Monitored	-	-	Monitored	-	TPH
109	WA	<20	21-30	0.17, 0.26	-	-	0.16	-	-	-	-	-	0.048 V, 0.022 V, 0.3 Total, 0.13 Total	-	-	-	-	-	-	-	-	-	-
112	WA	<20	41-50	0.067	-	-	0.1	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-
111	WA	20-40	21-30	0.309	-	-	0.046	-	-	-	-	-	0.21	-	-	-	-	-	-	-	-	-	-
124	WA	20-40	> 50	-	-	-	-	-	-	-	-	-	-	-	-	0.009	-	-	-	-	-	-	TPH Monitored
107	WA	>40	31-40	0.136, 0.236	-	-	-	-	-	-	-	-	0.066, 0.045	-	-	0.081, 0.0172	-	-	0.074, 0.100	-	-	Monitored	-
120	WA	>40	41-50	-	-	-	-	-	-	-	-	-	-	-	-	0.001	-	-	-	-	Monitored	0.6 ppq	TPH 0.5
123	WA	<20	>50	-	-	-	-	-	-	-	-	-	-	-	-	0.02, 0.009	-	-	-	-	-	Monitored	-

[a] Where (-)= no and NR= no response.