WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Washington State Dioxin Source Assessment

July 1998

Publication No. 98-320
Printed on Recycled Paper

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Washington State Dioxin Source Assessment

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July 1998

Publication No. 98-320

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Processed chlorine free, 20% post-consumer fiber.

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Executive Summary

Chlorinated dioxins and furans belong to a class of pollutants that build up (bioaccumulate) in human and animal tissue, persist in the environment, and are toxic. Pollutants with these characteristics are referred to as "bioaccumulative chemicals of concern" (BCCs). They raise special challenges for society and the environment because, long after being generated, they continue to pose threats in the food chain and the environment.

Within the Washington State Department of Ecology (Ecology), programs responsible for air quality, water quality, sediment quality and waste management share responsibility for these pollutants. The Bioaccumulative Chemicals of Concern (BCC) Committee is comprised of representatives for these programs and addresses agency-wide issues associated with toxic, persistent, and bioaccumulative pollutants.

The Washington State Dioxin Source Assessment is sponsored by the BCC Committee. The purposes of this report are to:

- Summarize what Ecology *knows* and *does not know* about dioxin sources in Washington State.

- *Recommend actions* Ecology might take to (1) improve its understanding of dioxin sources and (2) reduce the magnitude and impact of these sources on the state's citizens and environment.

This report provides background information on chlorinated dioxins and furans (collectively referred to in this report as "dioxins"). A simple source and fate model is presented to help describe the movement of dioxins from source to environmental and human receptors.

Next, the report discusses (1) steps taken to locate and process data for confirmed and potential dioxin sources in Washington State, and (2) the limitations imposed by sparse data. The data are presented, discussed and interpreted in the *Results and Discussion* section. This section also describes data gaps.

For the purposes of this report a "source category" is defined as a group of sources engaging in a similar process (e.g., incineration or wood-treating with pentachlorophenol). A "confirmed source category" is a source category for which there are adequate data to calculate a dioxin load from at least one individual source in that group.

Information provided for each of the confirmed source categories includes:

- Data on the amount of dioxin generated by, or released by, sources in each category.
- Potential for dioxin generated by facilities to be dispersed or contained.
- Number of facilities in each category and the relative data coverage (e.g., the proportion of facilities in each source category having dioxin data).
- Whether the calculated dioxin loads were from facilities that continue to operate, or from facilities that are now closed.
- National rank, estimated from the relative magnitude of each source category, based on EPA's 1994 national dioxin source assessment.

From this information each source category is assigned two *importance* rankings: 1) the importance of collecting additional dioxin data, and 2) the importance of additional source control and reduction. Table 1a summarizes the importance rankings for confirmed source categories.

Table 1a. Importance of Additional Data Collection and Source Control: Confirmed Source Categories

Source Category	Importance of Obtaining Additional Data	Importance of Source Reduction/Control
Incinerators	High	Variable[1]
Hog Fuel (Wood Waste) Boilers	High	Potentially High
Bleached Pulp and Paper	Medium	Medium
Cement Kilns	Medium/Low	Medium/Low
Activated Carbon Regeneration	Medium/High	Low
Municipal Wastewater Treatment	High	Potentially Medium

For some source categories, the amount of dioxin generated could not be determined from available data. These *potential* source categories are discussed and the available information presented. In some cases, available data show concentrations of dioxins associated with the source, but these data are inadequate to calculate the amount of dioxin being generated or released. Potential source categories include cleanup sites, wood treating facilities using pentachlorophenol, and oil refineries. The importance rankings of these sources are shown in Table 1b.

Table 1b. Evaluation of the "Importance" of Other Source Categories

Source Category	Importance of Additional Data Collection
Wood Treaters	High
Cleanup Sites	Variable
Oil Refineries	Medium

[1] Importance of sequestering fly ash is high.

Overall conclusions and associated recommendations, many of which are based on the importance ratings shown above, are presented. These are summarized below:

Conclusion 1. Dioxin data are incomplete.

Recommendations: A series of recommendations to fill high priority data gaps are provided. These recommendations focus on improving the quantity and quality of dioxin data available for hog fuel boilers, incinerators, bleached pulp mills, wood-treating facilities using pentachlorophenol, and several other sources.

Conclusion 2. Two of the facilities with some of the highest estimated dioxin loads ceased operation in 1997. These were the Rayonier pulp mill in Port Angeles and the Cameron-Yakima activated carbon regeneration facility in Yakima.

Recommendations: Carry out follow-up dioxin monitoring in the vicinity of these facilities to evaluate the extent of off-site contamination and provide a sound basis for future actions.

Conclusion 3. Hog-fuel (wood-waste) boilers and incinerators rate highest in importance for further source reduction.

Recommendations: Steps to reduce dioxin loads from these source categories are presented.

Conclusion 4. Compiling existing data on dioxin detected in Washington State's environment will help put these source data in context.

Recommendations: Compile soil, sediment, fish and shellfish dioxin data. Based on the results of this compilation, conduct monitoring to fill critical data gaps and track key environmental indicators. These indicators will show the effectiveness of actions taken to reduce dioxin in the environment.

Conclusion 5. This dioxin source assessment provides a major first step in implementing Ecology's strategy for managing bioaccumulative, persistent and toxic compounds.

Recommendation: Use information from this and subsequent BCC projects to advance and improve strategies that address the management and elimination of bioaccumulative pollutants.

Acknowledgments

We would like to thank Megan White and Keith Phillips for conceiving, initiating and supporting this project; and Bill Backous for his considerable support as current chair of the Bioaccumulative Chemicals of Concern Committee. We are also grateful for the funding provided by EPA and facilitated by the Hazardous Waste and Toxics Reduction Program (HWTR), as well as funding provided through the Environmental Investigations and Laboratory Services (EILS) Emerging Issues Fund.

We are particularly grateful to these people and organizations:

◊ The Bioaccumulative Chemicals of Concern Committee (BCC) for sponsoring the project.

◊ Keith Phillips (former EILS Program Manager) and Bill Backous (current EILS Program Manager) for their guidance and support.

◊ Megan White (former HWTR Program Manager) and Greg Sorlie (present HWTR Program Manager) for their guidance and support.

◊ Joe Williams (Air Quality Program Manager) for outreach to the local air pollution control agencies.

◊ Lorie Hewitt and Rob Kirkwood of HWTR for management support and grant management.

◊ Art Johnson, Will Kendra, Jim Knudson, Wayne Krafft, Bill Moore, Cheryl Niemi, and Carol Piening for their insightful peer reviews of the report.

◊ Joan LeTourneau for formatting and editing the final report.

Additional invaluable assistance from within Ecology, including consultation, record searches and review, from:

◊ Air Quality Program

◊ Industrial, Spills, and Sediments Sections of the Shorelines and Environmental Assessment Program

◊ Environmental Investigations and Laboratory Services Program

◊ Hazardous Waste and Toxics Reduction Program

◊ Nuclear and Mixed Waste Program

◊ Solid Waste and Financial Assistance Program

◊ Toxics Clean Up Program

◊ Water Quality Program

We also thank the following agencies and entities for their extensive help locating documents and other information, as well as providing perspective:

- ◊ AMTEST Air Quality, Inc.
- ◊ Benton County Clean Air Authority
- ◊ Northwest Air Pollution Authority
- ◊ Olympic Air Pollution Control Authority
- ◊ Puget Sound Air Pollution Control Authority
- ◊ Rayonier Pulp and Paper, Port Angeles, Washington
- ◊ Research Triangle Park, South Carolina
- ◊ Southwest Air Pollution Control Authority
- ◊ Spokane County Air Pollution Control Authority
- ◊ Tacoma City Light
- ◊ EPA Region X and Headquarters
- ◊ US Army, Fort Lewis
- ◊ US Environmental Protection Agency (EPA)
- ◊ Washington State Department of Health
- ◊ Yakima Regional Clean Air Authority

Funding

Funding was provided by EPA RCRA Grant # D-000742-97, the Hazardous Waste and Toxics Reduction Program, and the Environmental Investigations and Laboratory Services Program.

Acronyms

APC – Air Pollution Control
APCD – Air Pollution Control Device
AQP – Air Quality Program
ASB – Activated Sludge Basin
BAF – Bioaccumulation Factor
BCC – Bioaccumulative Chemicals of Concern (Committee)
BCF – Bioconcentration Factor
CKD – Cement Kiln Dust
d – Day
DMR – Daily Monitoring Report
EILS – Environmental Investigations and Laboratory Services
EPA – United States Environmental Protection Agency
HWTR – Hazardous Waste and Toxics Reduction Program
IARC – International Agency for Research on Cancer
LC50 – Concentration Lethal to 50% of the Population
mg – milligram
MTCA – Model Toxics Control Act
NPDES – National Pollutant Discharge Elimination System
NT – Not Tested
PCB – Polychlorinated Biphenyl
PCDD/F – Polychlorinated Dibenzodioxins and Furans
PCP – Pentachlorophenol
ppb – parts per billion
pptr – parts per trillion
QA/QC – Quality Assurance/Quality Control
RACT – Reasonable Available Control Technology
RCRA – Resource Conservation and Recovery Act
*SWFA*P – Solid Waste and Financial Assistance Program
TCDD – Tetrachlorodibenzodioxin
TCDF – Tetrachlorodibenzofuran
TCP – Toxics Cleanup Program
TEF – Toxicity Equivalent Factor
TEQ – Toxic Equivalent
WAC – Washington Administrative Code
WPLCS – Wastewater Permit Life Cycle System
WQP – Water Quality Program

Introduction

Purpose

Polychlorinated dioxins and furans belong to a class of pollutants that are persistent, toxic and bioaccumulative. Pollutants with these characteristics remain in the environment for decades, often moving from one media to another (e.g., from water or air to soil and sediment). Additionally, they enter and are distributed through the food web, accumulating in the tissues of animals, including humans. Because these contaminants cross boundaries between environmental media, they are regulated by a variety of laws, regulations and programs. For all these reasons they raise unique, often difficult, management challenges. The Washington State Department of Ecology (Ecology) Bioaccumulative Chemicals of Concern (BCC) Committee was formed to address these pollutants and respond to the challenges raised by managing them.

As an initial step toward improving the management of persistent, toxic, and bioaccumulative pollutants, the BCC Committee sponsored an effort to gather, consolidate and assess information about the sources of one group of these pollutants: the polychlorinated dioxins and furans. (In this report, this family of chemicals is referred to simply as "dioxins".) The federal Environmental Protection Agency (EPA) undertook a similar effort as part of a large national study (EPA, 1994a, 1994b). Although the EPA draft report provided much valuable information, it was not clear how relevant the information on sources was to conditions in Washington State.

The purpose of the Washington State Dioxin Source Assessment study is to identify actual ("confirmed") and potential in-state sources of dioxins. The magnitude of sources and importance of source categories are evaluated using existing data. Understanding the sources of dioxins is a logical first step towards an effective management strategy that will reduce their generation and dispersal.

This report:

- Summarizes what Ecology *knows* and *does not know* about dioxin sources in Washington State.
- Recommends actions Ecology might take to (1) improve its understanding of dioxin sources and (2) reduce the magnitude and impact of these sources on the state's citizens and environment.

Background

Dioxins are unintended byproducts formed during combustion of organic compounds in the presence of chloride, incineration of municipal and hospital wastes, and chlorine bleaching of wood pulp (Alcock and Jones, 1996; Birnbaum, 1994, Rappe, 1984). The production of certain chlorinated organic chemicals also produces dioxins; they are contaminants in certain chlorinated organic products (e.g., pentachlorophenol [PCP] – a wood preservative). Dioxins have no commercial or domestic applications and are not intentionally produced, except for small quantities used in research (ATSDR, 1989; Federal Register, 1997).

Chemical Structure

There are 210 different forms (or congeners) of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (dioxins and furans). These are identified by the number and location of chlorine atoms on the molecule. The most toxic of these congeners have chlorine atoms at four specific sites (the 2,3,7 and 8 positions). Figure 1 shows the structure and numbering system for these congeners. The most toxic of the dioxins is 2,3,7,8-tetrachloro dibenzo-p-dioxin (2,3,7,8-TCDD). The 16 other dioxins and furans with chlorines at the 2,3,7 and 8 positions have been assigned toxicity values relative to 2,3,7,8-TCDD.

These relative toxicity values are called toxicity equivalency factors (TEFs). 2,3,7,8-TCDD is assigned a TEF of 1, and the other congeners are assigned values less than 1. TEFs are used to express a total toxicity of dioxins when the concentration of each congener is multiplied by its TEF and all the products are added up (called dioxin equivalents or TEQs).

Concentrations of dioxins and furans in the environmental media (e.g., wastewater, tissue, ash) are typically expressed as TEQs. An example of this calculation is shown in Appendix A, Table A-1.

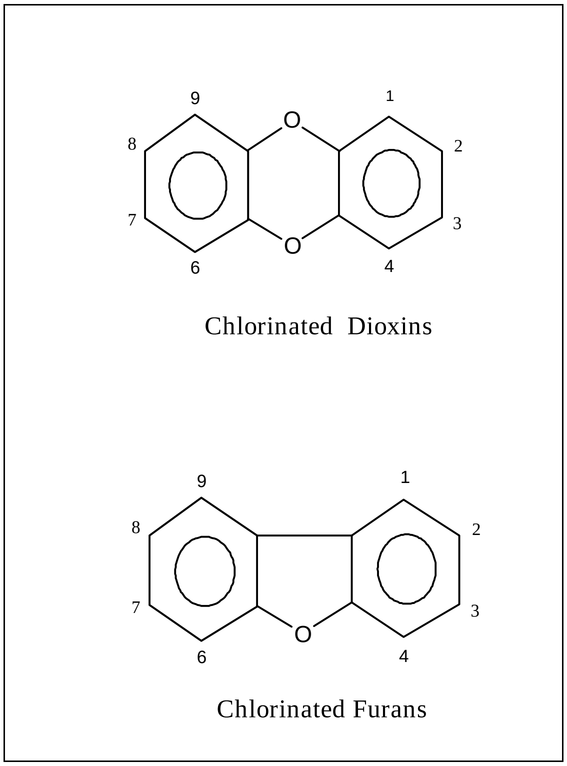


Figure 1. Chlorinated Dioxin and Furan Structures

Persistence, Bioaccumulation, and Toxicity

As previously noted, Ecology is focusing on the management challenges raised by toxic, persistent, and bioaccumulative pollutants. This section briefly characterizes dioxins with respect to these three attributes.

Persistence

Persistence is the resistance of chemicals to decomposition. One measure of persistence is half-life ($T_{1/2}$): the time required for 50% of the compound to degrade through chemical, biochemical, and photochemical processes (Environment Canada, 1994). Dioxins are extremely persistent in many environmental media. For example, their half-life in anaerobic soils is estimated to be 10 to 12 years; in sediments it may be decades or centuries (Atkinson, 1992). EPA (1994b) summarizes results from four studies of 2,3,7,8-TCDD concentrations in human subjects; estimates of its half-life ranged from 5.8 to11.3 years. Atkinson (1992) estimates the half-life for dioxins in human tissue at about five to seven years.

Bioaccumulation

Bioaccumulation is defined as the accumulation of chemicals in organisms from the surrounding media through absorption, ingestion and inhalation (Environment Canada, 1994). The bioaccumulation potential of a substance can be expressed as the bioaccumulation factor (BAF) or the bioconcentration factor (BCF) (Environment Canada, 1994). The BCF is the ratio of a chemical concentration in an organism to the chemical's concentration in the organism's surrounding media, assuming steady-state equilibrium. BCFs are calculated under controlled laboratory tests where chemical uptake is derived solely from surrounding media. The BAF is a similar ratio, but both surrounding media and food-chain uptake are considered. BAFs are often calculated from field data (Environment Canada, 1994).

Dioxins are lipophilic (fat-loving) compounds and are therefore readily accumulated by most animals. BCFs have been measured for 2,3,7,8-TCDD by many investigators and range from about 1,000 to 86,000 in aquatic organisms (Marty and Shusterman, 1992).

Toxicity

Toxicity covers a wide range of deleterious effects of a chemical on biological systems. These effects may be acute (immediate response) or chronic (long-term response). Dioxins are toxic at very low dosages. Mehrle *et al.* (1988) report that 50% of juvenile rainbow trout died when exposed to 0.045 parts 2,3,7,8-TCDD per trillion for 28 days.

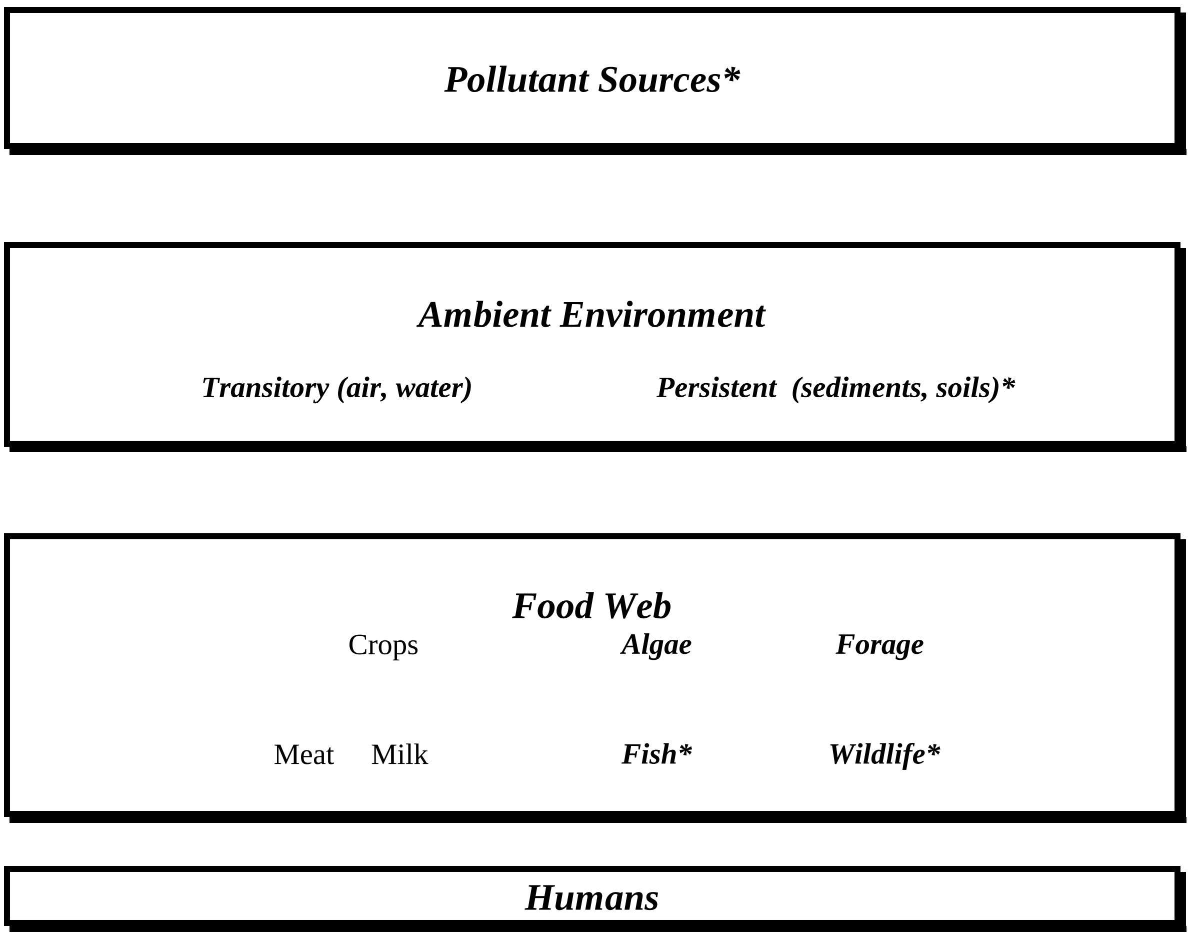
Chronic effects include soft tissue sarcomas, thymus and liver damage, birth defects, reproductive impairment, and immune system depression (Holloway, 1990; Birnbaum, 1994). Recently, the International Agency for Research on Cancer (IARC) concluded that 2,3,7,8-TCDD is a "known human carcinogen" (EPA, 1997a).

Recent concern about the effects of dioxins on organisms has increasingly focused on endocrine disruption and reproductive impairment (EPA, 1997b). The EPA states "…2,3,7,8-TCDD is one of the most, if not the most, potent reproductive/ developmental toxicants known" and "studies in various animal species have also demonstrated that the immune system is a target for toxicity of 2,3,7,8-TCDD" (Federal Register, 1997).

Because of dioxin's potency, regulatory standards and criteria are set at very low concentrations (Appendix Table A-2).

From Source to Human Exposure

Figure 2 shows a conceptual model for primary dioxin exposure pathways for most organisms, including humans. The top of the figure represents dioxin sources. Dioxins may be released directly to air, land, and water. They move from sources, through the environment and food web, to humans and other organisms by many paths.



Bold Italic – components included in Ecology's charge
* – components amenable to Ecology monitoring

Figure 2. Dioxin Source and Fate Conceptual Model

Dioxins are relatively insoluble in water. They bind quickly with carbon-based substrates (e.g., oils, fats) and particles (e.g., soils, sediments). Dioxins discharged to air may settle on water, land or vegetation. Stormwater runoff may carry dioxin-tainted soil from fields or urban sites to streams that ultimately deposit these sediments in lakes, reservoirs or marine waters. Dioxins in water, soil or sediment can be ingested by organisms and transferred through the food web. Thus, dioxins move from air and water to sediments, soils, and biological systems where they persist.

The primary route of dioxin exposure to humans is the food chain. This is probably the primary route for fish and wildlife as well. Wild *et al.* (1992) estimate that 99.96% of background human exposure to dioxins is through food intake. Airborne dioxins land on food or forage; waterborne dioxins may enter the aquatic food webs via filter or bottom feeders. Humans are exposed to dioxins primarily through the ingestion of fish, meat and milk (Albers *et al*., 1996).

Project Description

This section summarizes steps used to locate and process data for confirmed and potential dioxin sources in Washington State. To manage time and budget constraints, the scope of the assessment was defined by:

- Use of existing data; no resources were allocated for additional monitoring
- Focus on sources located in Washington State
- Use of data generated during the past 10 years
- Preferential focus on data reporting the full range of 2,3,7,8-substituted congeners

The quality of data used in this assessment is variable. Detailed review of data quality was beyond the scope of the project; however, every attempt was made to use published data or data that were available from the public record. For further information on sampling, analytical procedures, and quality assurance/quality control (QA/QC) the reader is directed to the source documents cited in the references.

Appendix B provides details on how we addressed the following issues:

- Data gathering
- Data processing conventions
- Detection limits

Understanding the limitations of this project will help the reader draw reasonable conclusions and exercise interpretive caution.

- No central or comprehensive database or comprehensive monitoring program for dioxin exists in Washington State. Therefore, these data are likely to be incomplete. If you know of additional data, please contact the authors at the Washington State Department of Ecology, PO Box 47600, Olympia, WA, 98504-7600.
- Data gathering was largely limited to public agencies; generally, private data held by sources were not available.
- Source loads were determined from analytical test data only. Unlike the EPA source evaluation work (EPA, 1994a), this project did not develop "emission factors" to estimate the total load from a category of sources.
- The source loads calculated for facilities may not be fully representative for the following reasons:
    - ◊ Data Frequency: The lack of multiple data points for most sources precludes estimating process variability. Dioxin generation rates are often a function of variables such as feed stock, combustion temperature, and throughput. Variation in dioxin loads can be considerable, as indicated from facilities where multiple

measures are available. Many of the loads we report are calculated from a single measurement. Many loads may have a high or unknown variability associated with them.

◊ Analytical Completeness: To minimize negative bias (underestimation of specific loads), we used only data that report the full range of 2,3,7,8-substituted congeners. The one exception was the use of wastewater and sludge data for bleached pulp and paper mills that report concentrations for only two of the 17 toxic congeners (2,3,7,8-TCDD and 2,3,7,8-TCDF).

◊ Calculated loads were not adjusted for the percent of time the facility was discharging. This is generally not an issue for loads to water or land (e.g., ash or sludge). However, air loads from small incinerators that operate on a batch mode or intermittently are calculated from short-term tests and may over-estimate long-term averages. For this reason, we have flagged the loads calculated for the Olivine Incinerator. There are probably loads from other small incinerators that would have been adjusted downward if we had located detailed information on their operating practices.

◊ The quality of data gathered here is variable. Although a comprehensive review of data quality was beyond the scope of this project, it was clear in several cases (e.g., estimates of ash generation rates from hog-fuel boilers) that the reliability of several estimates was uncertain.

Media Analyzed

Loads were calculated from analyses of a range of media including air emissions, sludges, ash, and wastewater discharges. Air emissions data were obtained primarily from source tests of stacks. Sludge loads were calculated from analyses of biosolids from treated municipal and industrial wastewaters. Wastewater loads were calculated primarily from analyses of process wastewaters; however, some other wastewaters including stormwater runoff, cooling water discharges and/or ash-quenching or wet-scrubber wastewaters were also addressed.

Ash loads were calculated from analyses of bottom ash, fly ash (air pollution control residues), and mixed ash produced by incinerators and industrial boilers. Bottom ashes are generally a mixture of grate ash and grate siftings. These materials fall to the bottom of the boiler/incinerator and are mechanically removed (EPA, 1996). Air pollution control (APC) residues include fly ash, absorbent materials, and condensation or reaction products. Fly ashes are non-combustible residual particles expelled by flue gas (EPA, 1996a). APC devices include cyclones, wet scrubbers, electrostatic precipitators, and baghouses. Mixed (or "total") ashes include both the bottom ash and fly ash generated by a facility.

Dioxin TEQ Loads

The reporting of dioxin loads is an important concept in this assessment. A "load" is defined as the rate at which dioxin is generated or discharged. Loads are expressed as a mass per unit time; in this report the units used are milligrams of dioxin TEQs per day (mg TEQ/d). To calculate a load, we first determined the TEQ for the material tested (e.g., air, water, ash). The TEQ is calculated by multiplying the concentration of each detected 2,3,7,8-substituted congener by the TEF for that congener.[1] The resulting TEQ for each congener is summed to determine the total TEQ of the sample. Appendix Table A-1 shows an example TEQ calculation for a sample containing many dioxin congeners.

The calculation of dioxin load requires two pieces of information: 1) the concentration of dioxin congeners in the medium produced or released, and 2) the rate at which that medium is generated and/or released. These two parameters are often available from the same data source: e.g., air emission source tests, discharge monitoring reports required by the National Pollutant Discharge Elimination System (NPDES) wastewater permits. Dioxin data and production rates for ash and sludge are often reported separately. Sometimes concentrations of dioxins are measured in soil, stormwater, or other media; but the rate of generation or discharge is not measured. Loads cannot be calculated in these cases.

Confirmed Dioxin Sources

Where adequate data allow, we calculate dioxin loads (i.e., the rate at which dioxins were generated) for individual sources. "Confirmed source categories" are source categories that have at least one facility with data adequate to calculate a dioxin load.
Both active and closed facilities with documented dioxin loads are included as "confirmed sources."

Potential Dioxin Sources

In addition to confirmed source categories, this assessment provides information on "potential sources categories". These include source categories for which there may be dioxin data but available data do not allow calculation of dioxin loads. For instance, potential sources include contaminated sites with confirmed dioxin contamination. Dioxin could potentially be moving from some of these sites, if they are not yet fully remediated. However, data are not available to calculate these loads.

Another potential source category is wood treating that uses pentachlorophenol (PCP). PCP is contaminated with low concentrations of dioxins, and many sites with confirmed dioxin contamination are former PCP wood-treating facilities. Although contamination

[1] The calculation of TEQ for a media sample containing 5 ppt 2,3,7,8-TCDD and 23 ppt 2,3,7,8-TCDF (considered 1/10 as toxic as TCDD, it has a TEF of 0.1) is: [5 + (0.1 x 23)] = 7.3 ppt TEQ.

of wood-treating sites with dioxin has been confirmed, the rate at which these dioxins are discharged in stormwater is available only for short-term storm events. These results are not directly comparable to the more continuous loads presented in the *Confirmed Sources* section, although rough estimates can be made. Other potential dioxin source categories include those identified by EPA (1994a) in their national dioxin source assessment but for which Washington State data are inadequate to calculate loads.

Results and Discussion

During the course of this project, available data allowed us to identify 25 facilities/ processes with measurable dioxin loads. Of these 21 are active and four are closed. Fifteen (twelve active, three closed) discharge to air; nine (eight active, one closed) to water; and nine (eight active, one closed) to land. For the purposes of this report, we account for dioxin loads in materials sent to landfills, as well as materials that are applied to land in other ways (i.e. soil amendments, land application).

The dioxin loads reported here were calculated from data from a variety of sources as described previously (see Project Description).

Appendix Table A-3 summarizes the calculated loads assuming that the concentration of undetected congeners is zero. Loads calculated using three different methods of handling detection limits are summarized in Appendix C. The data sets from which the loads were calculated are tabulated in Appendix D of this report.

Data Gaps

The available data on dioxin sources in Washington State are generally sparse. This is partly because Ecology's authority to require dioxin testing is limited. Appendix Table A-4 summarizes state and federal regulations authorizing or requiring dioxin monitoring.

Figure 3 displays some of the data gaps revealed by this assessment. Processes are displayed on one axis; the media to which a load is discharged is shown on the other axis. The dark portion of each bar represents the number of facilities engaged in that process with adequate data to determine at least one dioxin load. The open portion of the bar represents the number of facilities for which no dioxin loading data were available.

Data "completeness", as measured by the proportion of facilities in a source category with at least one dioxin load, varies greatly. A number of the source categories have loading data for each of the facilities engaged in that process. However, large segments of important source categories have no loading data. For example, wastewater loads could not be calculated for any of the approximately 250 municipal wastewater treatment plants, and biosolids loads were available for only one of the 250. Likewise, air loads were available for only 2 of 84 hog-fuel boilers, while ash loads were available for 3 of 84.

It is clear that the data are, at best, partial. We have taken these substantial data gaps into account in the process-by-process discussions that follow.

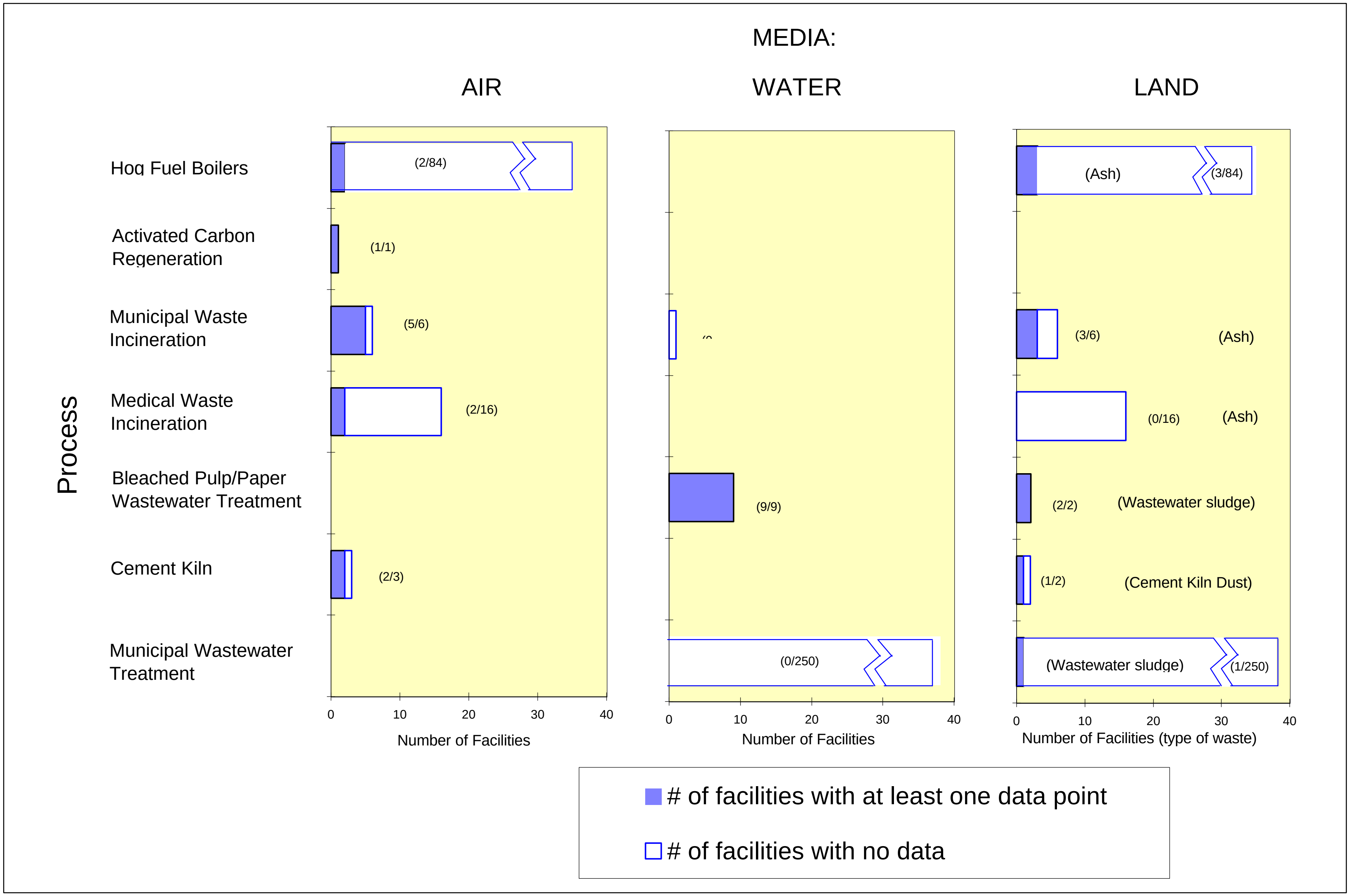


Figure 3. Number of facilities with dioxin data, by media. Categories include those for which there is at least one data point.

“Importance” of Source Categories

Information about each of the confirmed source categories[1] follows. This includes background information on each category, calculated dioxin loads, completeness of data coverage for facilities in the category, potential for the dispersion of dioxin loads, and the national rank of the category based on data reported by EPA (1994a).

EPA’s approach to estimating national dioxin loads differs from the approach used in this report. The main difference is that this study relies on monitoring data from specific facilities, while EPA developed “emission factors” for various activities and used them to estimate the total load generated by that activity. EPA (1998) offers this explanation of an emission factor:

> *“The emission factor relates mass of CDD/CDFs [dioxins]…released to the environment per some measure of activity (e.g., kilograms of material processed per year…). The emission factor was then multiplied by a national value for the activity level (e.g., total kg of material processed in the United States annually).”*

After information is presented on each of the source categories, the importance of the category is evaluated in two ways:

- Importance of obtaining additional data
- Importance of additional source control

The importance of obtaining additional data is based primarily on two considerations: the shortcomings in available data and the potential for the source category to be an important continuing source of dioxins.

The importance of source control is based on several considerations: the magnitude of confirmed dioxin loads associated with the source category, the potential magnitude of loads from untested facilities, and the potential for dispersion of loads generated by the facilities.

Recommendations at the end of this report are based, in large part, on these determinations of importance.

[1] In this report the term “confirmed source category” means a source category for which we have data adequate to calculate at least one dioxin load for at least one facility in that category.

Municipal and Medical Waste Incinerators

Background

We located information on 22 municipal waste incinerators and medical waste incinerators (Table 2). Municipal and medical waste incinerators are discussed jointly because of their similar functions and because of overlap in the materials burned by these facilities. Three currently operating incinerators primarily burn municipal solid waste: Spokane Municipal Incinerator (a waste-to-energy facility), US Army Fort Lewis Incinerator (Pierce County), and Olivine Municipal Incinerator (Whatcom County). A fourth municipal waste incinerator, the Skagit County Incinerator, ceased operation around 1994.

Table 2. Municipal and Medical Waste Incinerators

Municipal Waste Incinerators	**County**	**Status**	**Dioxin Data**
Spokane	Spokane	Active	Air, Ash
Fort Lewis	Pierce	Active	Air
Olivine	Whatcom	Active	Air
Skagit County	Skagit	Closed	
Cogeneration Facility			
Tacoma City Light #2	Pierce	Closed	Air
Municipal/Medical Incinerator			
Recomp	Whatcom	Active	Air, Ash
Medical Waste Incinerators			
Northwest Hospital	King	Active	Air
US Veterans Adm. Medical Center	King	Active	Air
Battelle Marine Sciences Lab	Clallam	Active	
Capital Medical Center	Thurston	Active	
Forks Community Hospital	Clallam	Active	
Grays Harbor Community Hospital	Grays Harbor	Active	
Island Hospital	Skagit	Active	
Kennewick General Hospital	Benton	Active	
Kittitas Valley Community Hospital	Kittitas	Active	
Mid Valley Hospital	Okanogan	Active	
North Valley Hospital	Okanogan	Active	
Swedish Hospital	King	Closed	
Providence Yakima Hospital	Yakima	Closed	
Skyline Hospital	Klickitat	Active	
St. Joseph Hospital	Stevens	Active	
Providence St. Peter Hospital	Thurston	Closed	

The Recomp Incinerator (formerly Thermal Reduction Company) in Whatcom County burns both municipal wastes and medical wastes; while Tacoma City Light Steam Plant #2, which closed in the spring of 1998, burned a mixture of “refuse-derived fuel,” wood waste and other fuels.

Sixteen medical waste incinerators were identified, three of which no longer operate. In general, these incinerators are smaller than those that burn municipal waste.

One other facility, Holnam Cement, Inc. of Seattle, conducted several air emissions tests while burning “Sterifuel,” a sterilized, pelletized medical waste. The Holnam cement kiln is discussed in the *Cement Kilns* section.

Table 3 summarizes loading data, facility status, and solid waste disposition information for all incinerators with dioxin data. Each of these categories is discussed in more detail below.

Loading Data

Of the 22 incinerators listed in this section, we are able to estimate dioxin loads in air emissions for seven and loads in ash for three (Table 3). The detailed loading data for each facility are provided in Appendix Table A-3. At one time there was a wastewater (cooling tower) discharge from the Recomp Incinerator; however, this discharge was eliminated approximately two years ago (Zinner, 1998). No dioxin data are available for this wastewater discharge.

Data are most complete for the Spokane Incinerator. Air emissions are represented by five source tests that yielded loads averaging 0.25 mg TEQ/day. Two series of ash tests yielded an average load of 31.2 mg TEQ/day. One ash test (1992) allows comparison of the grate ash load (0.02 mg TEQ/day) with the fly ash load (24.3 mg TEQ/day). Most of the dioxin from this facility is associated with captured fly ash. This appears to be the pattern for relatively new incinerators with highly effective air pollution control devices (APCDs).

Air and ash data are also available for the new Fort Lewis Incinerator. Based on a single set of source tests, the air emission from this facility is estimated at 0.003 mg TEQ/day. Based on one year’s composite samples, the dioxin load in fly ash was 0.76 mg TQ/day. No dioxins were detected in the bottom ash.

In recent years, the Olivine Incinerator has operated infrequently. Loads calculated from two source tests (1994, 1995) average 3.8 mg TEQ/day. Because of Olivine’s infrequent operation this load probably overestimates its discharge relative to other facilities. No data were available on dioxins in Olivine’s ash.

Table 3. Incinerator Dioxin Loads, Facility Status, and Solid Waste Disposition

Incinerators	Load to (mg TEQ/day) Air	Water	Land	Total	Facility Status	Solid Waste Disposition
Municipal Waste						
Spokane Municipal Incinerator, Spokane	0.25		31.2	31.5	Active	Ash disposed of at the Regional Ash Monofill in Roosevelt, WA.
Olivine Municipal Incinerator, Ferndale	3.8*			3.8*	Active but intermittent	Fly ash disposed of at the Regional Ash Monofill in Roosevelt, WA; previously disposed of at on-site landfills.
Fort Lewis Incinerator, Tacoma	0.0028		0.76	0.76	Active	Ash disposed of at the Regional Ash Monofill in Roosevelt, WA.
Total	**4.1***		**32.0**	**36.0**		
Medical Waste						
US Veterans Adm. Medical Center, Seattle	0.54			0.54	Active	Fly ash designates as hazardous waste; shipped to landfill in Utah. Bottom ash sent to Columbia Ridge Landfill in Arlington, OR.
Northwest Hospital, Seattle	0.15			0.15	Active	Fly and bottom ash sent to Columbia Ridge Landfill in Arlington, OR.
Total	**0.69**			**0.69**		
Medical/Municipal						
Recomp Incinerator, Ferndale	4.0		1.1	5.1	Active	Fly ash disposed of at the Regional Ash Monofill in Roosevelt, WA; previously disposed of at on-site landfill.
Total	**4.0**		**1.1**	**5.1**		
Cogeneration						
Tacoma City Light, Tacoma				0.078	Closed	Ash was sold to hazardous waste treatment and storage facilities.
Total				**0.078**		
Total	**8.8***		**33.1**	**41.9**		

*The Olivine Incinerator has operated infrequently in recent years. Therefore, these values probably overestimate typical dioxin loads.

Information on air emissions was also available for Tacoma City Light Steam Plant #2. Four source tests were conducted before the facility closed in 1998 and averaged 0.08 mg TEQ/day. No data were available for ash.

As noted previously, the Recomp Incinerator burns both municipal and medical wastes. Air emissions data are available for a single source test in 1988. This test yielded a load of 4 mg TEQ/d. Air pollution control systems at Recomp have changed substantially since the 1988 test. In 1988 the incinerator had an electrostatic precipitator. Currently air emissions pass through an evaporative cooling tower, Venturi reactors with hydrated lime injection and baghouses (Naismith, 1998). The effect of these changes on dioxin air emissions has not been measured. Three sets of ash results (1994-1996) yield an average load of 1.1 mg TEQ/day.

Of the 16 medical waste incinerators, air emissions data are available for two – each based on a single set of source tests. The load for the US Veterans Administration (VA) Medical Center in Seattle was estimated at 0.54 mg TEQ/day; the load for Northwest Hospital was estimated at 0.15 mg. TEQ/day. No dioxin data are available for ash.

Dispersion

Dioxin loads emitted to the air can be widely dispersed. Although many of these facility loads are small, several appear to be appreciable. Few of the medical waste incinerators have APCDs that remove fly ash prior to discharge: the VA Medical Center and Northwest Hospital are exceptions. Although no loading data are available for incinerators without APCDs, any load from these facilities would be discharged to the air and therefore dispersed.

Ashes generated and collected by incinerators are handled in several different ways. Ash generated by the Spokane and Fort Lewis incinerators goes to the Regional Ash Monofill in Roosevelt, Washington. This is also the destination for fly ash currently generated by the Recomp and Olivine incinerators. Prior to 1990, ash generated by Recomp and Olivine facilities was disposed of in on-site landfills. Ash generated by Tacoma City Light Steam Plant #2 was sold to hazardous waste treatment and storage facilities, where it was used to solidify liquid wastes prior to their disposal.

Several of the facilities currently sending their ash to the Roosevelt landfill are pursuing other alternatives that could increase dispersion potential.

Fly ash from the VA Medical Center Incinerator designates as hazardous waste. It is handled by Laidlaw Environmental Services and shipped to a landfill in Utah. Bottom ash from the VA Incinerator, as well as both fly ash and bottom ash from the Northwest Hospital Incinerator, are sent to the Columbia Ridge (Solid Waste) Landfill in Arlington, Oregon (Jill Trohimovich, 1998). Other medical waste incinerators apparently do not have APCDs that capture fly ash.

National Rank

EPA (1994), using a methodology different than the one used here, addressed medical waste and municipal waste incinerators as separate categories. Based on the sum of loads to all media, medical waste incinerators were the source category with the largest national load. Municipal waste incinerators had the second largest dioxin load.

EPA used an “emission factor” approach. This, in general, means that EPA tried to accounts for all sources when estimating loads. We report only the results of specific source tests from specific facilities.

Several aspects of EPA’s work should be noted, so comparisons between the two assessments for medical waste incinerators can be considered in context. The EPA assessment includes several types of “medical waste” incinerators that we did not address (e.g., veterinary incinerators, crematoria, and animal shelters). The EPA “emission factor” was derived from “uncontrolled emissions.” Thus, EPA would have accounted for particulates escaping in air emissions, that would be captured as fly ash if there were an air pollution control device in place. We have no data for dioxins in uncontrolled emissions, or fly ash captured in APCDs from medical waste incinerators. Our data, therefore, do not account for particulate/fly ash emissions from medical waste incinerators.

Finally, EPA notes that tests of “controlled-air medical waste incinerators” with a variety of emission controls yielded lower emission factors. They acknowledge that “based on these data, it appears that national releases [to air] from medical waste incinerators could be much lower…” than those they report.

Summary - Incinerators

Incinerators

Data Coverage	Air	Water	Land	Overall
Municipal	3 of 4		2 of 4	50-75%
Medical	2 of 16		0 of 16	0-10%
Medical/Municipal	1 of 1	0 of 1	1 of 1	0-100%
Cogeneration	1 of 1		0 of 1	0-100%
Total	7/22	0/1	3/22	0-32%
Confirmed Loads (mg/ TEQ/day)	**Air**	**Water**	**Land**	**Total**
Municipal	4.1[1]		32.0	36.0
Medical	0.69		-	0.69
Medical/Municipal	4.0		1.1	5.1
Cogeneration	0.078		-	0.078
Total	8.8[1]		33.1	41.9
Dispersion Potential	**Air**	**Water**	**Land**	**Overall**
Municipal	high		generally low	varies
Medical	high		unknown	varies
Medical/Municipal	high	discontinued	generally low	varies
Cogeneration	high		generally low	varies
Total	high		generally low	varies

Active vs. closed: 5 closed; others active

Estimated national rank: Municipal 2nd
Medical 1st

Importance of obtaining additional data: High

Rationale: Although data for some incinerators (especially the newer municipal waste incinerators, e.g., Spokane and Fort Lewis) are relatively robust, data for the others are sparse or entirely absent. For example, no fly ash data are available for the Olivine Incinerator, the Tacoma City Light Cogeneration Plant (now closed), or any of the medical waste incinerators. Air data for dioxins are not available for a number of medical waste incinerators; however, adoption of the new federal emissions guidelines for existing medical waste incinerators should address this data gap (see next page).
Importance of additional source control: Variable

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[1] Olivine Municipal Incinerator has operated infrequently in recent years. Therefore, this value probably overestimates average dioxin loads

Importance of sequestering fly ash: High

Rationale: The estimated overall load (41.8 mg TEQ/day) associated with incinerators is high in comparison to other source categories for which data are available. Most of this load was associated with fly ash. Two of the older incinerators accounted for most of the air load, although the available data may overestimate the importance of these sources. Medical waste incineration ranked 1st overall in EPA's national dioxin source assessment, while municipal waste incineration ranked 2nd.

Based on the available information, the source control of air emissions seems to be least stringent for the Olivine and Recomp incinerators. Control of air emissions may be an issue, as well, for the medical waste incinerators for which no air emissions data are available. Performance standards for new medical waste incinerators and emissions guidelines for existing medical waste incinerators will be incorporated into state regulations over the next several years. This means that air emissions from all medical waste incinerators will have been tested and will meet these new, federally promulgated limits by no later than 2004.

Much of the fly ash collected in APCDs is disposed of in the Roosevelt Ash Monofill or in other ways that appear to sequester this ash effectively. Because the highest loads of dioxins were associated with fly ash captured by air pollution control devices at these incinerators, it is important that this ash continue to be sequestered so it is not reintroduced into the general environment. There is, however, considerable interest by some facilities in finding less expensive ways of disposing of this ash. It is important that alternative methods of reuse or disposal continue to effectively sequester these wastes.

Hog-fuel Boilers

Background

Many industrial boilers in Washington are fired wholly or in part by wood-derived fuels. Fuel derived from waste wood is often called “hogged fuel”; facilities that burn this fuel are referred to as “hog-fuel boilers.” About 25% of the wood-waste boilers in the state are located at pulp and paper mills. In addition to wood waste, these boilers often burn wastewater sludges or fiber, as well as other fuels (Table 4). Burning salt-laden hog fuel (wood waste from logs rafted on saltwater) has been implicated in the production of dioxins (Luthe and Prahacs, 1993).

Ecology’s Air Quality Program (Ecology, 1997a) summarized and assessed much of the available information on Washington’s hog-fuel boilers. Data on boiler locations, operational status, and fuels, gathered by the Air Quality Program in support of that assessment (Ecology, 1997b), are summarized in Table 4.

Table 5 summarizes loading data, facility status, and solid waste disposition information for all hog fuel boilers with dioxin data. Each of these categories is discussed in more detail below.

Loading Data

Of the 84 hog-fuel boilers listed in Table 4, we were able to estimate dioxin loads in air emissions from two facilities and loads in ash from three (Table 5). Detailed loading data are provided in Appendix Table A-3. All of the facilities with dioxin data have air pollution control equipment that removes much of the fly ash before discharge to the air. These facilities also generate “bottom” (or “grate”) ash. Often fly ash and bottom ashes are mixed together prior to disposal.

We found reportable data for both air and ash loads for only one facility, the Rayonier Inc. pulp mill located in Port Angeles. The mill closed in 1997. Air emissions are represented by a single source test conducted in 1995 (Foster Wheeler, 1997). This test yielded a load of 0.17 mg TEQ/d.

Accurate estimates of the rate of ash generation were difficult to obtain. Like other such facilities, Rayonier was never required to measure ash generation rates. We were, however, able to obtain two estimates. Perlwitz (1997) estimated that ash was generated at the rate of three to six tons per day, while allowing that “possible ash generation rates as high as 15 tons per day could have occurred.” The second estimate

Table 4. Hog-fuel Boilers

Facility	County	Active/ Closed	Salt Water Access*	# of Boilers	Primary Fuels	Salty Fuels	Other Fuels
Allen Logging	Clallam	Active		1	Green sawdust & planer shavings		
Bennett Lumber	Asotin	Active		1	Bark		
Boise Cascade-Wallula	Walla Walla	Active		1	Wood & bark		Natural gas
Boise Cascade-Yakima	Yakima	Active		1	Wood & bark		
Boise Cascade-Kettle Falls Plywood	Stevens	Active		1	Wood & bark		Some auto oil
Boise Cascade-Kettle Falls Lumber	Stevens	Active		1	Wood & bark		
Brooks Manufacturing	Whatcom	Active	Yes	1	Dry planer shavings (10% moisture)	10% salty	Natural gas standby
Buffelen Woodworking	Pierce	Active	Yes	1	Wood & bark	No	Natural gas
Cascade Hardwood	Lewis	Active		1	Dried planer shavings & sawdust		Natural gas
CoastCraft	Pierce	Active	Yes	2	Wood	Unknown	
Columbia Harbor Lumber	Lewis	Active		1	Hog bark & planer shavings	No	
Colville Indian Precision Pine	Okanogan	Active		1	Hog fuel		
Cowlitz Stud-Morton	Lewis	Active		1	Hog fuel & planer shavings	No	
Cowlitz Stud-Randle	Lewis	Active		1	Hog fuel & planer shavings	No	
Daishowa America	Clallam	Active	Yes	1	Hog fuel - bark wood waste	Possible	Residual Oil #6; sludges
Georgia Pacific	Whatcom	Active	Yes	4	Wood waste 91-100%	unknown %	Nat. gas at start-up; clarifier solids 0-9%
GN Plywood/Mt Baker Plywood	Whatcom	Active	Yes	1	97% wood, 3% various	20% salty	
Grays Harbor Paper LP	Grays Harbor	Active	Yes	2	Hog fuel	Unknown	#6 fuel oil & tires
High Cascade Lumber	Clark	Active		1	Hog fuel		
High Cascade Veneer	Skamania	Active		1	Wood bark	No	
Hoquiam Plywood	Grays Harbor	Active	Yes	1	Wood & bark	Unknown	
Fort James Paper	Clark	Active		1	Hog fuel	No	Pulp mill screenings; natural gas; effluent clarifier solids (35% solid)
Jeld-Wen Fiber of Washington	Yakima	Active		1	Hog fuel		
Jeld-Wen of Everett	Snohomish	Active	Yes	1	Hog fuel	No	Natural gas
Kimberly-Clark	Snohomish	Active	Yes	1	80% wood; sawdust, bark, other wood waste	Possible	# 2 oil; 20% natural gas; 60% wood fiber primary & 40% secondary sludge
Kinnear of Washington	Lewis	Active		1	Sawdust & shavings		
Koenig FA & Sons	Snohomish	Active		1	Sawdust		
K-Ply	Clallam	Active		2	75% wood, 20% bark, 5% wood dust	40% salty	
Laymans Lumber	Yakima	Active	No	1	Wood & bark		
Longview Fibre	Chelan	Active	No	1	Bark & sawdust		
Longview Fibre	Cowlitz	Active	Yes	3	Hog fuel & non-condensable gases not included in fuel rates	No	#6 fuel oil, #1& #2 distil-late oil, tall oil residual, natural gas; OCC rejects, mill trash; turpentine
Mayr Brother Logging	Grays Harbor	Active	Yes	1	50% bark, 50% wood		
Morton Forest Products	Lewis	Active		1	70% bark, 30% wood chips	No	
NW Hardwoods	Cowlitz	Active		1	Fine wood fibers, sander dust	10% salty	Natural gas

* If the facility is located on the Pacific Ocean or Puget Sound, “yes” is entered

Facility	County	Active/ Closed	Salt Water Access*	# of Boilers	Primary Fuels	Salty Fuels	Other Fuels
NW Hardwoods	Lewis	Active		1	Sander dust	22% salty	Natural gas
NW Hardwoods	Skagit	Active		1	Green sawdust		
NW Hardwoods	Snohomish	Active		1	Wood & sander dust	15% salty	Natural gas
Oeser Company	Whatcom	Active	Yes	1	Hog fuel	No	Natural gas to limit opacity
Omak Wood Products	Okanogan	Active		2	Wood & Bark		
Pacific Hardwoods	Pacific	Active	Yes	1	Wood & bark	No	
Pacific Veneer	Grays Harbor	Active	Yes	1	Wood & bark	No	
Packwood Lumber	Lewis	Active		1	Bark & sawdust	No	
Plum Creek Manufacturing-Arden	Stevens	Active		1	70% bark, 30% white wood waste		
Port Townsend Paper	Clallam	Active	Yes	1	Hog fuel	Possible	#6 residual oil; RFO; primary sludge
Rainier Veneer	Pierce	Active		1	Wood & bark		
Rayonier Inc. (Pulp)	Clallam	Closed	Yes	1	80-90% hog fuel	2% salty	Oil supplement; 10-15% primary/secondary sludge
SDS Lumber	Klickitat	Active		1	Bark & sander dust planings		Natural gas for start-up
Shakertown	Lewis	Active		1	Hog fuel, sawdust, shavings		
Simpson Tacoma Kraft	Pierce	Active	Yes	1	Wood	50% salty	Residual oil; natural gas; bio-solids, wood fiber, & rec. fiber derived fuel
Simpson Timber*	Grays Harbor	Active	Yes	1	Dry hog fuel, sawdust, sander dust		
Simpson Timber	Mason	Active	Yes	1	Hog fuel	20% salty	Tire derived fuel
Smith Street Mill	Snohomish	Active	Yes	1	Sawdust & dry shavings	Unknown	
Stone Consolidated	Pierce	Active	Yes	1	Hog fuel	10% salty	Residual oil; natural gas; clarifier solids, sludge
Summit Timber	Snohomish	Active		1	Hog fuel & sawdust		
Tacoma City Light	Pierce	Active	Yes	2	Wood	5% salty	Natural gas; RDF; coal; distillate oil
Tebb Fred & Sons	Pierce	Active	Yes	1	Wood	Unknown	
Vaagen Brothers Lumber-Colville	Ferry	Active		1	60% Bark, 40% wood, hog fuel, & dry shavings		
Vaagen Brothers Lumber-Republic	Stevens	Active		2	80% wood, 20% other		
Washington Water Power	Stevens	Active		1	Hog fuel		Natural gas
West Coast Door	Pierce	Active	Yes	1	Wood	Unknown	
West Coast Forest Products	Snohomish	Active		1	Wood		Natural gas
Western State Hospital	Pierce	Active	Yes	1	Wood	Unknown	Natural gas
Weyerhaeuser-Longview	Cowlitz	Active		7	Hog fuel & wood	No	Mixed shredded paper, mixed paper cubes; coal; deinked fiber; solid waste; oil; sludge
Weyerhaeuser-Cosmopolis	Grays Harbor	Active	Yes	1	Wood residuals, biomass	No	Residual oil, distillate, on-spec; propane
Weyerhaeuser-Snoqualmie	King	Active		2	Wood		
Weyerhaeuser-Raymond	Pacific	Active	Yes	1	Hog fuel	No	

* If the facility is located on the Pacific Ocean or Puget Sound, “yes” is entered.

Table 5. Hog-fuel Boiler Dioxin Loads, Facility Status, and Solid Waste Disposition

Hog-fuel Boilers	Load to (mg TEQ/day) Air	Water	Land	Total	Facility Status	Solid Waste Disposition
Rayonier Pulp and Paper, Port Angeles	0.17		22.2	22.4	Closed	Ash was disposed of in private landfills.
Fort James Pulp and Paper, Camas			0.54	0.54	Active	Fly ash is marketed as "Nutrilime" and applied to land.
Weyerhaeuser Pulp and Paper, Longview	0.11			0.11	Active	
Daishowa Pulp and Paper, Port Angeles			0.012	0.012	Active	Ash disposed of in private landfills.
Total	**0.28**		**22.8**	**23.0**		

was provided in an application for a disposal site permit submitted by Rayonier to Clallam County (Jones, 1989). The application estimates the mass of "ash and clinkers" at 6000 tons per year, or 16.4 tons per day. We chose to use a rate of 6 tons per day to calculate TEQ loads associated with Rayonier's ash. Based on this, the five available ash analyses yielded loads ranging from 1.2 to 69 mg TEQ/d, averaging 22.4 mg TEQ/day. Thus, the Rayonier data indicate that most of the dioxin load is associated with ash.

Data were available to estimate dioxin in air emissions from Weyerhaeuser Pulp and Paper, Longview. Information on potential dioxin loads from this facility are contained in a notable and comprehensive study conducted by Weyerhaeuser (1991) that evaluated disposal options for sludge and examined how the burning of various fuels affected dioxin production. For estimating air emissions we used information from a test which burned wood waste and coal – the test that reflected standard operating conditions at the boiler. The load associated with this test was 0.11 mg TEQ/d.

Weyerhaeuser measured dioxin concentrations in ash, as well as fuel and air emissions, for one set of fuel conditions – burning wood waste, coal and sludge from their waste water treatment plant. The fuels used in this test do not represent operating conditions at the plant (e.g., wastewater sludge is disposed of in a landfill, see *Deposition* section). The resulting loads were, therefore, not included in load calculations presented in Appendix Table A-3. Nonetheless, the test provides useful information.

Weyerhaeuser (1991) measured loads in fuel (wood, coal and sludge) and in the air and ash emissions of the hog-fuel boiler. The results are shown below:

Table 6. TEQ Loads Into and Out of a Hog-fuel Boiler (Weyerhaeuser, Longview)

Loads in Fuels (mg TEQ/day)		**Loads in Emissions (mg TEQ/day)**	
Wood	0.00	Air Emission	0.33
Coal	0.00	Grate Ash	0.00
Sludge	6.74	Cyclone Fly Ash	7.92
		Electroscrubber Fly Ash	10.58
Total	**6.74**		**18.83**

These data lead to several useful observations:

- The dioxin load from this test yields air and ash loads quite similar to those reported for the Rayonier hog-fuel boiler.
- The distribution of dioxin loads between air (low) and ash (high) is quite similar for the two boilers.
- Essentially all the dioxin ash load is associated with fly ash rather than grate ash.
- There is a net increase in dioxin load across the boiler (the load leaving the hog-fuel boiler is greater than the load entering it).

The sludge burned in this test was generated prior to substantial reductions in chlorine bleaching at this and other Washington mills.

Data from the Fort James Pulp Mill in Camas provides a second fly ash load. The fly ash was analyzed by Ecology in 1997 as part of a fertilizer and soil amendment study (Magoon, 1997). The load is estimated at 0.54 mg TEQ/day based on a 1997 production rate of 6,166 tons/year (Le, 1998a) for fly ash applied to farmland as a soil amendment. This fly ash is marketed as “Nutrilime.”

Data from the Daishowa mill in Port Angeles provides the third ash load: an estimated 0.012 mg TEQ/ day.

Dispersion

Dioxin loads emitted to the air have the potential to be widely dispersed. For the few facilities having both data and relatively efficient air pollution control devices, most of the load is captured in the fly ash prior to being dispersed to the air. Air emissions from boilers without particulate controls will be widely dispersed. *Ecology's Wood Waste Boiler Survey* (Ecology, 1997a) found that 12% of hog fuel boilers had no air pollution control equipment, while an additional 13% had relatively inefficient "mechanical collection."

Fly ash captured by air pollution control devices is handled in several different ways. Ash from Rayonier and Daishowa was/is sent to nearby private landfills (Matthews, 1998). Fly ash from Fort James is marketed as "Nutrilime" and is applied to agricultural land (Cascade Earth Sciences Ltd,, 1996). Although we have no loading estimates for other hog-fuel boiler ash loads, we located some information on the disposition of these ashes. For instance, portions of the ash from the Boise Cascade mill at Wallula have been landfilled on-site, added to biosolids for composting and sent to Holnam Cement in Seattle where it is used in the production of Portland cement (EGR and Associates, Inc., 1997). Fly ash from the Simpson Tacoma Kraft mill is sent to the regional Rabanco landfill in Roosevelt, Washington, while the grate ash goes to a private landfill in Shelton, Washington (McEntee, 1997).

Based on available information, the potential for ash dispersion is variable depending on the practices at each facility.

National Rank

EPA (1994), using a different methodology, provides national estimates that rank wood waste boilers 5th largest among source categories. It is likely that this category of sources is more important in Washington State than nationally for several reasons:

- Timber-related industries represent a much larger portion of commerce in Washington than nationally.
- The potential for salt-laden hog fuel, derived from logs rafted on salt-water, is much higher in Washington than nationally.
- Burning of other fuels in wood waste boilers is prevalent (Table 4). These fuels include sludges from mill wastewater treatment plants, chipped tires and used oil.
- EPA's national assessment appears to have considered only emissions to air. We found the highest loads to be associated with fly ash. Thus EPA may have underestimated the importance of this source nationally.

Summary - Hog-fuel Boilers

Hog-fuel Boilers

	Air	Water	Land	Overall/Total
Data Coverage	2 of 84		3 of 84	~3%
Confirmed Loads (mg/ TEQ/day)	0.28		22.8	23.0
Dispersion Potential	High		Variable	High/Variable

Active vs. closed: 1 closed; most active

Estimated national rank: 5th

Importance of obtaining additional data: High

Rationale: The combination of few data (loads available for only about 3% of the boilers) and high dioxin loads from at least some of those facilities argues strongly for the collection of additional information on hog-fuel boilers. This process category has a relatively high number of facilities (84), with high variability in the factors that lead to dioxin formation and control (e.g., boiler design and operation, fuels, air pollution control devices).

Importance of additional source control: Potentially high

Rationale: The estimated overall load (23 mg TEQ/day) associated with hog-fuel boilers is high in comparison to other source categories for which data are available. Industrial wood burning rated 5th overall in EPA's national dioxin source assessment. It is likely to be relatively more important in Washington State. The boiler that was the largest confirmed source ceased operations in 1997. However, there are a number of facilities of equivalent size, burning similar fuels that are likely, in aggregate, to generate significant loads of dioxin.

The confirmed load associated with fly ash (22.8 mg TEQ/day) was much greater than the confirmed load associated with air emissions (0.28 mg TEQ/day). This is probably because the facilities for which data are available have sophisticated particulate control devices. Many hog-fuel boilers have less sophisticated (or no) particulate controls. The potential for dispersion of air emissions is high; the potential for the dispersion of fly ash captured by APCDs is variable. Some fly ash is disposed of in landfills, some is marketed as a "soil amendment." The disposition of much of it is unknown.

Bleached Pulp and Paper Mills

Background

Seven mills in Washington currently produce bleached pulp and/or paper. An eighth, the Rayonier Mill in Port Angeles, ceased operation in 1997. A ninth, Longview Fiber, no longer operates a bleach plant. In the early 1990s, Washington mills shifted from chlorine bleaching to chlorine dioxide bleaching which decreased the production and release of dioxins. This section addresses the dioxin loads associated with wastewater discharges from these facilities.

As process wastewaters are treated, sludges (which can also contain dioxins) are generated. One facility, the Boise Cascade Mill in Wallula, composts its sludge for subsequent on-site land application. A second facility, the Weyerhaeuser Mill in Longview, landfills its sludge. The other mills burn their sludges in hog-fuel boilers.

Although all of the mills have hog-fuel boilers, this section focuses on dioxin loads associated with the bleached pulp and paper process.

Table 7 summarizes loading data, facility status, and solid waste disposition informa-tion for bleached pulp and paper mills. Each of these categories is discussed below.

Table 7. Bleached Pulp and Paper Mill Loads, Facility Status, and Solid Waste Disposition

Bleached Pulp and Paper Mills	Load to (mg TEQ/day)				Facility Status	Solid Waste Disposition
	Air	Water	Land	Total		
Rayonier Pulp and Paper, Port Angeles		4.9		4.9	Closed	
Weyerhaeuser Pulp and Paper, Longview		0.13	1.8	1.9	Active	Sludge disposed of in private landfill.
Fort James Pulp and Paper, Camas		1.9		1.9	Active	
Georgia-Pacific Pulp and Paper, Bellingham		1.7		1.7	Active	
Boise Cascade Pulp and Paper, Wallula		0.76	0.081	0.84	Active	Sludge is both composted and landfilled on site.
Longview Fiber Pulp and Paper, Longview		0.71		0.71	Active	
Kimberly-Clark Pulp and Paper, Everett		0.40		0.40	Active	
Weyerhaeuser Pulp and Paper, Cosmopolis		0.20		0.20	Active	
Simpson Kraft Pulp and Paper, Tacoma		0.00		0.00	Active	
Total		**10.7**	**1.9**	**12.6**		

Loading Data

Bleached pulp and paper mills are required to treat and test their wastewater prior to discharge. Since 1991 treated effluent from these mills has been tested for 2,3,7,8-TCDD and 2,3,7,8-TCDF. Wastewater treatment sludges have been tested for the same two congeners. Results have been reported to Ecology's Industrial Section (McCall, 1997). Because of these testing requirements, data for this source category are relatively complete. However, the monitoring requires testing for only 2 of the 17 toxic dioxin and furan congeners; calculated TEQ loads probably underestimate actual TEQ loads.

Table 7 summarizes the dioxin loads determined by averaging all the loads calculated for each facility.

Most of the data (summarized in Appendix Table A-5) are "self-reported". In general, these self-reported data represent conditions at the mills after they were required to institute dioxin control measures including 1) minimizing the introduction of dioxin precursors into the pulping and bleaching sequences, and 2) minimizing the use of elemental chlorine by substitution with chlorine dioxide.

All dioxin loads associated with bleached pulp and paper mills are included in Appendix Table A-3. These include self-reported data, as well as loads calculated for a limited number of other effluent tests. These additional tests include data from Ecology compliance monitoring inspections, as well as several tests conducted at the Rayonier Mill in Port Angeles between 1990 and 1994. These latter tests were reported in a summary of information about the mill prepared for Rayonier by Foster Wheeler Environmental Corporation (1997) as the mill prepared to close.

As noted above, the self-reported data for the bleached pulp and paper mills are restricted to two congeners: TCDD and TCDF. Because 15 congeners with TEFs were not included in self-reported data, the TEQ loads associated with these data probably underestimate full TEQ loads from these sources. As an example, Figure 4 shows the relative percentages of the full TEQ contributed by the TCDD and TCDF for wastewater and sludge as calculated using the data (Foster Wheeler, 1997) for the Rayonier mill in Port Angeles. Similar graphs for air emissions and ash are shown for comparison purposes.

Figure 4.

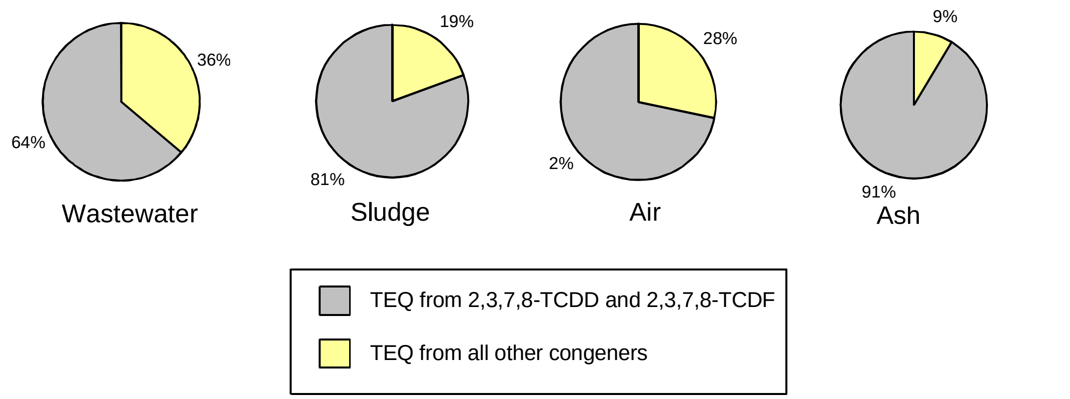

Figure 4. TEQ distribution in Rayonier, Inc. wastewater, sludge, air, and ash.

Dispersion

Dioxin loads discharged to water have the potential to be widely dispersed.

One mill (Boise Cascade, Wallula) composts its sludge, and is, on a trial basis, applying it to an on-site cottonwood plantation (Le, 1998b). A second mill, Weyerhaeuser (Longview) disposes of its sludge in a privately owned landfill. Other mills burn wastewater sludges in their hog-fuel boilers. Overall, the potential for the dispersion of dioxins associated with sludges is variable.

National Rank

EPA (1994), using a different methodology than the one used here, provides estimates that rank bleached pulp and paper as the fourth largest source category nationally. This category is likely to be relatively more important in Washington State than nationally, because pulp and paper bleaching represents a relatively large portion of Washington State commerce. The EPA assessment could also present a somewhat different picture than our assessment because:

- EPA included dioxin loads from sludges – with the exception of Boise Cascade (Wallula) and Weyerhaeuser (Longview) – while Ecology did not.
- EPA included estimates for dioxin loads in pulp and paper products, while Ecology did not.

Summary – Bleached Pulp and Paper

Bleached Pulp and Paper

	Air	**Water**	**Land**	**Overall/Total**
Data Coverage		9 of 9[1]	2 of 2[1]	100%[1]
Confirmed Loads (mg/ TEQ/day)		10.7	1.9	12.6
Dispersion Potential		high	variable	high/variable

Active vs. closed: 1 closed; others active

Estimated national rank: 4th

Importance of obtaining additional data: Medium

Rationale: Of all the source categories addressed in this assessment, wastewater-related discharges from bleached pulp and paper production have been measured and reported most often. This is the only facility category with requirements for frequent discharge monitoring. On the other hand, this monitoring requires testing for only 2 of the 17 dioxin/furan congeners with TEFs. Only a few tests results are available that provide data for the full range of toxic congeners.

Importance of additional source control: Medium

Rationale: The estimated overall load (12.6 mg TEQ/day) associated with bleached pulp and paper production is moderate in comparison to other source categories for which data are available. The mill with the largest average load is no longer operating. Data for this source category appear to be more complete than for many other categories. Bleached pulp and paper production rated 4th overall in EPA's national dioxin source assessment; it is likely to be relatively more important in Washington State. Actions taken in the early 1990s have decreased dioxin loads from the mills.

The relationship between sludge burning and dioxin destruction/production is not well quantified.

[1] 2 out of 17 toxic congeners measured.

Cement Kilns

Background

Washington has two presently operating cement kilns: Holnam Cement, Inc. and Ash Grove Cement Company, both located in Seattle. Cement kilns, which produce cement from materials including lime, use multiple fuels including coke, used oil, and tire-derived fuel. The Holnam facility has also conducted several test burns using "Sterifuel," a shredded, sterilized medical waste.

The Holnam facility also produces cement kiln dust (CKD), a fine cement-like material captured by their electrostatic precipitator (an air pollution control device) from the kiln exhaust. Ash Grove apparently generates no cement kiln dust.

The Lehigh Portland Cement Company (Metaline Falls) operated a coal-fired kiln in which ceased operation in 1990. A large pile of cement kiln dust was left at this site (Stoffel, 1998).

Table 8 summarizes loading data, facility status, and solid waste disposition for cement kilns; these categories are discussed in more detail below.

Table 8. Cement Kiln Dioxin Loads, Facility Status, and Solid Waste Disposition

Cement Kilns	Load to (mg TEQ/day)				Facility Status	Solid Waste Disposition
	Air	Water	Land	Total		
Holnam Inc., Seattle	1.26		0.055	1.31	Active	Cement kiln dust is marketed for agricultural uses, waste stabilization, road building, backfill, etc.
Ash Grove Cement, Seattle	ND[1]				Active	
Total	**1.26**		**0.06**	**1.31**		

Loading Data

Both currently operating cement kilns have tested their stack emissions. Results from stack tests at Holnam conducted between 1994 and 1996 allowed calculation of six loads (Appendix Table A-3). The average of these six loads was 1.26 mg TEQ/day. The single test of air emissions available for the Ash Grove facility (Valid Results, Inc., 1996) detected no dioxins.

Holnam's cement kiln dust has been tested three times. The average load from these tests is 0.055 mg TEQ/day.

[1] ND = Not Detected

Table 8 summarizes the dioxin loads determined by averaging all the loads for cement kilns.

Dispersion

Dioxin loads discharged to air can be widely dispersed.

The CKD dioxin load from Holnam is quite small. Since 1987, a majority of Holnam's CKD has gone for agricultural use, but construction uses have increased steadily over the past several years. Currently, about 50% goes for agricultural use. The remainder is used for a range of other uses: 1) stabilizing sludge-like hazardous wastes, 2) drying and stabilizing soils, 3) providing a low-grade underlayer for road bed building, and 4) providing engineered backfill – mixed with wet soils prior to backfilling in mining or construction (Smith, 1998). The potential for dispersion for CKD is variable.

Approximately 600 tons of CKD was left at the Lehigh site. We have no data regarding concentrations or loads associated with this facility. Although the storm water has been diverted from the pile which has also been covered with a clay liner, leachate from groundwater contact is still migrating offsite (Stoffel, 1998)

National Rank

EPA (1994), using a different methodology than the one used here, provides estimates that rank cement kilns as the 3rd largest source category nationally (well behind municipal and medical waste incineration). EPA's assessment includes kilns that burn hazardous waste. Neither of the Washington kilns burns hazardous wastes. In both assessments the loads are associated primarily with air emissions.

Summary – Cement Kilns

Cement Kilns

	Air	Water	Land	Overall/Total
Data Coverage	2/3		1/2	50-67%
Confirmed Loads (mg/ TEQ/day)	1.26		0.06	1.32
Dispersion Potential	high		variable	high/variable

Active vs. closed: one facility closed, two active.

Estimated national rank*:* 3rd

Importance of obtaining additional data: Medium-low

Rationale: Loads from the Holnam facility appear to be well characterized assuming that there are no major changes in fuels, raw materials or operating parameters at the kiln. The single test at Ash Grove is probably not adequate. This is the only air emissions test for a facility assessed in this review that failed to detect even one of the 17 toxic dioxin and furan congeners. No data are available for CKD at Lehigh; however, based on the results from Holnam, this may not be a high priority.

Importance of additional source control: Medium-low

Rationale: The estimated overall load (1.32 mg TEQ/day) associated with cement kilns is fairly low in comparison to other source categories for which data are available. Cement kilns rated 3rd overall in EPA's national dioxin source assessment; under current operating conditions they are likely to be relatively less important in Washington State.

Municipal Wastewater Treatment

Background

Washington has approximately 250 NPDES-permitted municipal treatment plants. These facilities treat mixtures of domestic, commercial and industrial wastewaters. Wastewater treatment apparently does not generate dioxins; however, treated wastewaters discharged from these facilities, as well as associated biosolids (sludges), can contain dioxins passed along from sources that discharge to the plant.

Table 9 summarizes loading data, facility status, and solid waste disposition for municipal wastewater treatment plants; these categories are discussed in more detail below.

Table 9. Municipal Wastewater Treatment Loads, Facility Status, and Solid Waste Disposition

Wastewater Treatment Plants	Load to (mg TEQ/day) Air	Water	Land	Total	Facility Status	Solid Waste Disposition
Renton Sewage Treatment Plant, Renton			0.347	0.347	Active	Most biosolids land-applied at several eastern and western Washington sites.

Loading Data

No data were found that could be used to calculate loads associated with treated wastewater effluent. Biosolids data were available for a single facility. Appendix Table A-3 includes loading data calculated from two sets of sample results (1987 and 1997) for biosolids generated by the Renton Wastewater Treatment Plant. The average load calculated from these measurements was 0.347 mg TEQ/day. Although these data represent only one of approximately 250 municipal treatment plants, the Renton plant generates about 15-20% of Washington's biosolids.

Dispersion

Although we have no data on the magnitude of dioxin loads discharged to water, any such loads would have the potential to be widely dispersed.

Most biosolids are land-applied. Some facilities give biosolids away to people who use them on their home gardens (Dorsey, 1997). In 1998, Renton biosolids were used for silvicultural fertilization (about 62%), agricultural fertilization (about 31%), commercial compost production (about 7%), and other uses including mine restoration research and hybrid poplar fertilization (King, 1998). The dispersion potential for sludge is high.

National Rank

EPA (1994), using a different methodology than the one used here, provides estimates that rank municipal wastewater treatment plants as the 7^{th} largest source category nationally. This estimate was based entirely on biosolids loads; no wastewater discharge data were included.

Summary – Municipal Wastewater Treatment Plants

Municipal Wastewater Treatment

	Air	Water	Land	Overall/Total
Data Coverage		0/250	1/250	0-0.4%
Confirmed Loads (mg/ TEQ/day)			0.347	0.347
Dispersion Potential		high	high	high

Active vs. closed: Active

Estimated national rank: 7^{th}

Importance of obtaining additional data: Medium

Rationale: Although not expected to be among the major sources of dioxins, loads associated with municipal wastewater treatment are not well characterized. Data for biosolids are available for one of approximately 250 facilities; no data are available for wastewater discharges.

Importance of additional source control: Potentially Medium

Rationale: Additional data are required to assess the magnitude of dioxin loads associated with municipal wastewater treatment. Based on available information about the size of dioxin loads, this source category does not appear to rank near the top; however, the potential for dispersion is high. Because treatment plants do not appear to generate dioxin, any source control efforts would be targeted at sources to wastewater treatment plants.

Activated Carbon Regeneration

Background

A single activated carbon regeneration facility, Cameron-Yakima, Inc., operated until recently in Washington. Cameron-Yakima had ceased all carbon regeneration and waste processing activities by the end of 1997.

Cameron-Yakima had two combustion units that reprocessed activated carbon using heat and steam to desorb contaminants. These contaminants included benzene, toluene, ethylbenzene, xylene, semi-volatile organics, pesticides, and metals (Bison Engineering, 1995).

Loading Data

A single set of air emission tests was conducted on the two treatment units at Cameron-Yakima in 1994. These tests, required by Ecology, specified a specially prepared feed material: activated carbon loaded with a known mixture of contaminants (Bison Engineering, 1995). This feed material represented conditions close to “worst case” (Warner, 1997). Based on these results (Appendix Table A-3) the total load from this facility was 37.4 mg TEQ/day, the highest loading rate reported for an individual facility.

Table 10. Activated Carbon Regeneration Loads

	Load to (mg TEQ/day)			
	Air	**Water**	**Land**	**Total**
Cameron-Yakima, Inc.	37.4			37.4
Total	**37.4**			**37.4**

Dispersion

Dioxins loads discharged to air can be widely dispersed.

National Rank

EPA (1994), using a different methodology than the one used here, provides estimates that place activated carbon regeneration far down the list of source categories that generate dioxin loads. EPA's evaluation is probably not directly applicable to Washington because, while EPA estimated that the total annual amount of granular activated carbon treated in the US was about 48,000 metric tons (EPA, 1994), Cameron-Yakima treated about 4,500 metric tons annually (Warner, 1997). This represents about 10% of the national production. Thus, while Cameron-Yakima was operating, Washington State ranked well above the average in this activity. In addition, EPA's emission factor was based on only two source tests, while the loading reported for the single Washington State source is based on a single "moderate worst case" test that may over-represent emissions from this facility.

Summary – Activated Carbon Regeneration

Activated Carbon Regeneration

	Air	**Water**	**Land**	**Overall/Total**
Data Coverage	1/1			100%
Confirmed Loads (mg/ TEQ/day)	37.4			37.4
Dispersion Potential	high			high

Active vs. closed: Only source ceased operation in 1997

Estimated national rank: Low

Importance of obtaining additional data: Medium-high (follow-up sampling)

Rationale: Because the facility is no longer operating, the need for additional source assessment monitoring is low. However, because source testing at Cameron-Yakima yielded the highest dioxin load for a facility documented by this assessment, and because the potential for this dioxin to be dispersed is high, we rate the need for follow-up monitoring high. This monitoring should focus on evaluating potential dioxin contamination downwind of the facility.

Importance of additional source control: Low

Rationale: Cameron-Yakima, Inc. was the only Washington State facility engaging in this activity. This facility no longer regenerates activated carbon.

Small Miscellaneous Sources with Calculated Loads

For each of three miscellaneous facilities, air emissions loads of less than 0.05 mg TEQ/d were calculated. These facilities include (1) Kaiser Trentwood Rolling Mill, an aluminum remelt furnace in Spokane Valley, (2) Kalama Chemical, an industrial boiler in Kalama, and (3) Conrad Industries, a pyrolysis unit manufacturer in Chehalis. The Kaiser Trentwood values may be the most significant of the three, since the reported calculated load represents only one of ten furnaces at this facility. The loads are shown in Appendix Table A-3.

Other Source Categories

The presence of dioxins has been confirmed but dioxin loads could not be reliably calculated for several source categories. These are therefore included as *Other Source Categories.* For these sources, ratings are given for the importance of obtaining additional data. No ratings are given for the importance of source reduction or control, because additional information would be needed to make that determination.

Cleanup Sites

Dioxins may be present at sites regulated under the state Model Toxics Control Act (MTCA) authority, federal Superfund authority administered by EPA, and sites requiring RCRA corrective actions and closures. Table 11 summarizes information for these sites.

Of the 38 sites in Table 11, dioxins were detected at 26 sites. Dioxins are suspected at six additional sites. Included in this table are three where pentachlorophenol (PCP) contamination is confirmed. PCP is typically contaminated with low levels of dioxins. Cleanup sites are not routinely tested for dioxins.

Table 11. Cleanup Sites

Facility	County	Status	Description	Dioxin Detected	Media Tested
American Crossarm & Conduit	Lewis	Clean Up Complete; Continued Monitoring	Landfill; PCP Wood Treating	Confirmed	Surface Water, Soil, Sediment
Buffalo Don Murphy Rd	Pierce	Ranked, Awaiting Clean Up	Chlorinated Phenolic Waste Storage/Staging	Confirmed	Soil
Cameron Yakima, Inc.	Yakima	Interim Action Complete; Site Study in Progress	Activated Carbon Regeneration/ TSD	Confirmed	Air, Soil
Cascade Pole & Lumber Co Tacoma	Pierce	No Further Action	PCP Wood Treating	PCP	Surface Water, Soil, Groundwater
Cascade Pole McFarland	Thurston	Clean Up in Progress	PCP Wood Treating	Confirmed	Groundwater, Surface Water, Soil
Eagle Harbor	Kitsap	Clean Up in Progress	PCP Wood Treating	Confirmed	Sediment
Eagle Harbor Wyckoff	Kitsap	Clean Up in Progress	PCP Wood Treating	Confirmed	Soil
East Waterway	Snohomish	Ranked, Awaiting Clean Up	Embayment of Puget Sound	Suspected	Soil, Sediment
Frank Brooks Manufacturing	Whatcom	Ranked, Awaiting Clean Up	PCP Wood Treating	PCP	Soil, Groundwater, Sediment
Hanford	Benton	Unknown	2,4-D Contaminated Soil Disposal Site	Confirmed	Soil
International Paper Longview	Cowlitz	Clean Up in Progress	PCP Wood Treating	Suspected	Soil, Groundwater
JH Baxter/Port Quendall	King	Clean Up In Progress	Lumber & Wood Products	Confirmed	Soil
Malarkey Asphalt Company	King	Independent Clean Up In Progress	Asphalt Felts & Coatings	Confirmed	Soil
Mount Solo Landfill	Cowlitz	Clean Up Complete; De-listed	Weyerhaeuser Landfill	Confirmed	Groundwater, Surface Water, Air, Soil
Oeser Company	Whatcom	Awaiting Clean Up; Proposed for EPA National Priority Listing	PCP Wood Treating	Confirmed	Soil, Groundwater
Olympic Wood Products	Mason	Ranked, Awaiting Clean Up	Saw Mill	PCP	Soil
Pacific Sound Resources (formerly Wyckoff-West Seattle)	King	Clean Up In Progress	PCP Wood Treating	Confirmed	Soil, Water, Sediments, Groundwater
Pacific Wood Treating	Clark	Interim Action Complete; Clean Up in Progress	PCP Wood Treating	Testing Underway	Soil, Sediment
Port of Anacortes	Skagit	Awaiting Clean Up	Pulp Mill	Confirmed	Sediment
Port of Seattle Terminal 91 Tank	King	Clean Up In Progress; RCRA Corrective Action	Former Petroleum Bulk Terminal; Waste Oil Recycling; Chemical Reprocessing	Suspected	Groundwater, Surface Water, Soil, Sediment
Reichhold Chemical Lone Star	King	Ranked, Awaiting Clean Up	Chemical Manufacturing	Suspected	Groundwater, Surface Water, Soil
Facility	**County**	**Status**	**Description**	**Dioxin Detected**	**Media Tested**
Reichhold Chemical Inc.	Pierce	RCRA Corrective Action/Post Closure	Chemical Manufacturing	Suspected	Groundwater, Soil

Ross Electric of WA Coal Creek	Lewis	Cleanup In Progress	Unclassified Establishment	Confirmed	Soil
Simpson	Pierce	Clean Up Complete; Remediated	Pulp Mill	Confirmed	Groundwater, Surface Water, Air, Soil
Simpson Timber Company	Mason	Clean Up Complete; Remediated	Pulp Mill	Confirmed	Groundwater, Soil, Sediment, Air
Strandly Manning	Kitsap/Pierce	Clean Up In Progress; Site Study	Junkyard/Transformer Recycler	Confirmed	Sediment, Ash
Tacoma Redevelopment Property	Pierce	Remediated Or Clean Up in Progress	Thea Foss Waterway Brownfields Redevelopment	Confirmed	Groundwater, Surface Water, Soil, Sediment
US Army Ft Lewis Multisite	Pierce	Awaiting Clean Up	Landfill	Confirmed	Soil
US BPA Ross OUA	Clark	Clean Up Complete; De-listed	Electric Power Generation	PCP	Soil
US Navy Station Everett	Snohomish	Independent Clean Up In Progress	Jetty in Port Gardner Bay, Old WWII Navy Base	Suspected	Groundwater, Soil, Sediment
US Navy Sub-base	Kitsap	Clean Up In Progress	HW Disposal Site	Confirmed	Soil
US Navy Sub-base OU3	Kitsap	Clean Up Complete; Continued Monitoring	HW Disposal Site	Confirmed	Soil
US Navy Whidbey OU2 (Ault Field)	Island	Clean Up In Progress	HW Disposal Site	Confirmed	Groundwater, Soil
US Navy Whidbey OU3	Island	Clean Up In Progress	HW Disposal Site	Confirmed	Groundwater, Soil, Sediment
USACE Manchester Annex	Kitsap	Clean Up In Progress	Landfill	Confirmed	Soil, Sediment
Weyerhaeuser-Everett	Snohomish	Unknown	Bleach Plant Site	Confirmed	Water, Surface Runoff
Weyerhaeuser-Everett	Snohomish	Unknown	Sludge Ponds	Confirmed	Sludge
Weyerhaeuser-Everett East	Snohomish	Clean Up Complete	Saw Mill	Undetected	Soil

Both on-going and closed sites are included in this table.

Sediments are also a consideration at many clean-up sites. Sediments accumulate in retention ponds and may be potential sources of dioxins. They may be particularly mobile during cleanup, remediation actions, or adjacent dredging operations. The Ecology Sediments Management Unit maintains a database of contaminated sediments, including those contaminated with dioxins.

No estimates of dioxin loading could be calculated for these sites. Once they are cleaned up or stabilized, the chance of continuing off-site contamination is minimized.

The importance of obtaining additional data for these sites is variable, depending on the nature of the site. For sites with likely dioxin contamination and the potential for dioxin to be transported off-site, the importance is high. For sites with little potential for dioxin, or those fully remediated, the importance is low.

Wood Treating Facilities

Table 12 lists information for four active and five closed wood treating facilities that treat(ed) wood with pentachlorophenol (PCP). PCP generally contains measurable concentrations of various dioxins.

Table 12. Wood Treating Facilities

Facility	County	Facility Status	Cleanup Site	Stormwater Runoff Receiving Body
American Crossarm & Conduit	Lewis	Closed	EPA	Dillenbaugh Creek
Cascade Pole Company	Pierce	Active	MTCA	Blair Waterway
Cascade Pole Company	Thurston	Closed	MTCA	Budd Inlet
Eagle Harbor-Wykcoff	Kitsap	Closed	MTCA	Eagle Harbor
Frank Brooks Manufacturing	Whatcom	Active	MTCA	Whatcom Creek
International Paper	Cowlitz	Closed	MTCA	Area ditches, Groundwater, Columbia River
JH Baxter	Snohomish	Active	MTCA	Groundwater
Oeser Company	Whatcom	Active	EPA	Little Squalicum Creek
Pacific Wood Treating	Clark	Closed	MTCA	Lake River

All of the facilities are, or have been, EPA Superfund cleanup sites or sites regulated under the Model Toxics Control Act (MTCA) and are also listed in Table 11. Dioxin contamination is confirmed at many of these sites; the source most likely is PCP.

The four active facilities have NPDES permits regulating stormwater discharge to surface or ground waters. Their existing permits call for dioxin analyses of their stormwater runoff; however, only the J.H. Baxter facility has started this monitoring. This facility discharges to groundwater via stormwater detention ponds. Stormwater runoff was sampled for dioxin and PCP at four drain sites during two rainfall events. The dioxin TEQ concentrations measured in the stormwater averaged 5,340 pg/L for the two rainfall events (Martin, 1998). If this represents average stormwater conditions, the average annual load would be 0.92 mg TEQ/day (based on inches of rain during the monitored event and average annual rainfall). Because of the highly variable nature of stormwater runoff, these loads were not considered to be directly comparable to the confirmed loads presented in earlier sections.

The importance of obtaining additional data for wood treating facilities is high, based on the high concentrations measured at the one facility with dioxin data. The dispersion potential for these facilities is high.

Oil Refineries

Catalytic reformer wastewater effluent may contain dioxins that are formed during regeneration of the reformer catalyst. Different types of reformers are regenerated at different time intervals. Some are regenerated infrequently (every 12 to 18 months) while other types are regenerated more frequently. In some cases reformer regeneration wastewater is produced daily.

Five refineries in Washington State have the potential to generate dioxin from their catalytic reformers. System wash waters were tested for dioxins at three refineries (Table 13). 2,3,7,8-TCDD and 2,3,7,8-TCDF were found at relatively high concentrations (225 pg/L and 5100 pg/L, mean of duplicates, respectively) in one-third of the samples collected at the Texaco Refinery. At ARCO, only 2,3,7,8-TCDD and 2,3,7,8-TCDF were analyzed; neither was detected. At U.S. Oil, all 17 toxic congeners were analyzed for; none were detected. Total TCDF's and HxCDF's were found at low concentrations.

It is not possible to calculate a dioxin load for these facilities, because flow rates of wash water are unknown. However, the wash water flows are estimated to be very small, so the loads associated with these facilities would be small and in some cases infrequently generated.

Limited data are available for several of Washington's refineries as mentioned above. More data will be collected as a result of requirements to be included in the refinery NPDES permits when they are renewed. The planned dioxin sample points include regeneration wastewater and refinery wastewater plant sludges where the dioxin is expected to concentrate. Flow rates will also be recorded so dioxin loads can be calculated. The available Washington State refinery data and national data (EPA, 1996b) indicate that oil refineries are not a significant source of dioxin. The data collected as part of the NPDES requirements should provide additional information on the Washington State refineries.

Because few data are available for dioxins in Washington state oil refineries, the importance of obtaining additional data is considered to be medium. Additional data will enable Ecology to better evaluate the significance of dioxin loads from refineries.

Table 13. Oil Refineries

Facility	County	Facility Status	Media Tested
Texaco	Skagit	Active	Refinery catalytic reformer caustic wash wastewaters (Texaco, 1990)
ARCO	Whatcom	Active	Refinery catalytic reformer wastewaters (Lynch, 1990)
US Oil & Refining	Pierce	Active	Refinery catalytic reformer wastewaters (Riley, 1990)
Shell Anacortes	Skagit	Active	Not tested
TOSCO Refining	Whatcom	Active	Not tested

Potential Source Categories

For these categories, we found no dioxin data. However, because of the types of processes and presence of chlorine/chloride, carbon, heat and/or combustion, they are potential dioxin source categories.

Structure Fires

Dioxins are potentially produced by structure fires. Although any structure fire could produce dioxins, fires involving the following are probably the most likely to produce significant amounts of dioxins: polyvinyl chloride (PVC) materials, chlorinated organic chemicals, or transformers and other electrical equipment containing PCBs. Other structures that might produce larger amounts of dioxins when burned include wood-treating facilities, any facility storing PCP, and PCP-preserved wood structures.

No data or information on dioxins produced in structure fires in Washington State were found.

Illegal Burning of Prohibited Materials

The illegal burning of prohibited materials such as PCBs, PVCs, pesticide containers and PCP-treated wood probably generates dioxins. We found no information on this category for Washington.

Metal Smelting and Refining

EPA's draft Dioxin Reassessment (EPA, 1994a) identifies the following industry types as potentially producing dioxins:

- Primary nonferrous metal smelting/refining (aluminum, copper, lead)
- Secondary nonferrous metal smelting/refining (aluminum, copper, lead)
- Drum and barrel reclamation and incineration
- Scrap electric wire recovery

We did not find any dioxin data associated with these industries in Washington State.

In a separate study, Ecology tested several fertilizers and soil amendments for dioxins. Ecology found that several had high concentrations of dioxins, particularly those fertilizers made from electric arc furnace dust from steel mills (K061 wastes). Previously, K061 wastes had not been analyzed for dioxins. (Ecology also tested materials made from cement kiln dust and hog-fuel boiler fly ash; these data are included in the section dealing with *Confirmed Sources*.)

The steel foundry dust imported by Bay Zinc, Inc. to make fertilizer had a dioxin load calculated at 11.6 mg TEQ/d, higher than loads associated with Holnam Cement kiln dust and Ft. James fly ash, both of which are also used as fertilizers or soil amendments. The imported steel foundry dust load is not discussed in the *Confirmed Sources* section of this report because the original source of dioxin was not within Washington State.

This fertilizer study showed that steel foundry dust (K061 waste) is likely to be contaminated with dioxins. Table 14 lists Washington State generators of K061 waste and shows current disposal locations.

Table 14. Sources and Disposition of Steel Foundry Dust (KO61)

Facility	County	Facility Description	RCRA K061 Waste	Disposition
Seattle Port of Kent Site	King	Primary Metal Products; Former Jorgensen site	K061 (1993, one-time, non-recurrent electric arc dust)	Sent to Arlington, OR Subtitle C Hazardous Waste Landfill. They are investigating the SuperDetox process (Reuter, 1998)
Birmingham Steel Corp Seattle Division	King	Blast Furnaces & Steel Mills	K061 (from APCD)	Sent to EnviroSource in Idaho; SuperDetox process renders cement-like solid waste that is landfilled in Subtitle D Solid Waste Landfill (Reuter, 1998)
Jorgensen Forge Corp	King	Iron & Steel Metal Forgings	K061 (from APCD)	Sent to Arlington, OR Subtitle C Hazardous Waste Landfill. They are investigating the SuperDetox process (Reuter, 1998)

Ecology will be conducting additional investigations into dioxin levels of dioxins in fertilizers and soil amendments, including waste-derived products that may contain K061.

Additional Potential Sources

We did not locate any information for many small, potential sources of dioxin production. Tire combustion, spills responded to by Ecology and sewage sludge incineration were investigated as potential dioxin sources, but no data were found. Other potential sources identified in EPA's 1994 Dioxin Reassessment include:

- Charcoal briquette combustion (residential)
- Coal combustion (residential, industrial, utility)
- Kraft black liquor boilers
- Motor vehicle fuel combustion (diesel, leaded, unleaded)
- Oil combustion (residential, industrial)
- Organic chemical manufacture
- PCB combustion (transformers, office buildings)
- PCP treated surfaces
- Pyrolysis of brominated flame retardants
- Sewage sludge incineration
- Tire combustion
- Wood burning (residences, forest fires)

Conclusions and Recommendations

The conclusions and recommendations reached during this study derive, in large part, from the importance assigned to additional data collection and source control for each of the confirmed source categories. Tables 15a and 15b summarize the information that led to these importance ratings.

The Washington State Dioxin Source Assessment leads to five general conclusions and associated recommendations.

Conclusion 1

Dioxin source data are incomplete.

Washington's dioxin source data are sparse. The data summarized in this report vary in quality and completeness. Although these data provide a useful perspective, they are not comprehensive. The absence of comprehensive source data is not surprising, given the lack of comprehensive requirements for dioxin source monitoring.

Recommendation

Fill priority data gaps.

Recommendations to fill data gaps are listed below in priority order. These priorities are based, in large part, on the importance ratings provided in Tables 15a and 15b.

1. Improve the quantity and quality of data available on dioxin loads in air emissions and fly ash generated by hog-fuel boilers. Factors to consider in setting priorities for data collection include:
   - Whether facilities are burning salty hog fuel, sludge, or other materials containing chloride or chlorine.
   - The size and throughput of the facilities.

2. Improve the completeness of dioxin load data for incinerators.
   - Obtain adequate fly ash data for incinerators where these data are sparse or absent.
   - Obtain adequate air emissions data for medical waste incinerators. Implementation of EPA's new use performance standards for new medical waste incinerators and emissions guidelines for existing medical waste incinerators will address these data needs.

Table 15a. Evaluation of the "Importance" of Confirmed Source Categories[1]

Source Category	Data Coverage			Confirmed Loads (mg/day, estimated)				Facility Status Summary	National Rank	Dispersion Potential			Importance: Obtaining Additional Data	Importance: Source Reduction/ Control
	Air	Water	Land	Air	Water	Land[2]	Total			Air	Water	Land[2]		
Incinerators	7/22	0/1	3/22	8.8	-	33.1	41.9	largely active	1st	high	-	generally low	**High**	**Variable[3]**
Hog-Fuel Boilers	2/84	-	3/84	0.3	-	22.8	23.0	1 closed, 83 active	5th	high	-	variable	**High**	**Potentially High**
Bleached Pulp and Paper	-	9/9	2/2	-	10.7	1.9	12.6	active	4th	-	high	variable	**Medium**	**Medium**
Cement Kilns	2/3	-	1/2	1.3	-	0.1	1.4	1 closed, 2 active	3rd	high	-	medium	**Medium /Low**	**Medium /Low**
Activated Carbon Regeneration	1/1	-	-	37.4	-	-	37.4	closed	low	high	-	-	**Medium /High**	**Low**
Municipal Wastewater Treatment	-	0/250	1/250	-	-	0.3	0.3	active	7th	-	high	high	**Medium**	**Potentially Medium**

[1] The development of "importance ratings" and the information contained in this table are discussed in the *Results and Discussion* chapter of this report

[2] Loads to land incorporate a range of practices including land application and disposal in landfills. The potential for dispersion associated with these practices is addressed in the body of this report

[3] Importance of fly ash sequestering – High

Table 15b. Evaluation of the "Importance" of Other Source Categories

Source Category	Importance of Additional Data Collection
Wood Treaters	High
Cleanup Sites	Variable
Oil Refineries	Medium

3. When the NPDES permits for the bleached pulp and paper production facilities are renewed include, as a minimum, requirements to report data on the full range of dioxin/furan congeners in effluent.

4. Require dioxin and furan testing from all wood-treating facilities currently using pentachlorophenol.

5. Test steel foundry dust for dioxins.

6. Because dioxins are preferentially associated with solids rather than water, increase testing of municipal wastewater treatment biosolids for dioxins. This increased testing should be prioritized based on known or likely industrial sources of dioxins to the municipal wastewater facility, as well as the volume and final disposition of biosolids generated by the facility. Based on the results of this testing, re-evaluate biosolids management practices and initiate testing of wastewater effluents, as necessary.

7. Most bleached pulp and paper mills burn sludges generated by the treatment of their wastewaters. Determining whether this process produces or destroys dioxins is an important step in effectively managing these sludges.

8. This project only addresses sources of dioxin originating within Washington State. Further evaluation of out-of-state sources that may contribute loads to Washington is recommended. These include industrial sources discharging to shared watersheds and airsheds, as well as imported products including fertilizers and soil amendments. Fertilizer testing authorized by 1998 legislation (SSB 6474) should assist in this effort.

9. To completely assess the role of cement kilns in dioxin production, additional air emissions tests at the Ash Grove kiln would be necessary.

10. Where there is a likely potential for dioxin to be present at MTCA, Superfund and RCRA cleanup sites, the site should be tested for dioxins. This includes sites with residues from the incineration of PCBs or other chlorinated organics, sites (such as wood-treating sites) that have a history of pentachlorophenol use, and sites where 2,4,5-T is present at significant concentrations.

Conclusion 2

Two of the facilities with some of the highest estimated loads ceased operations in 1997.

The Rayonier bleached pulp mill (Port Angeles) and the Cameron-Yakima activated carbon regeneration facility (Yakima) ceased operation in 1997. When in operation, these facilities had among the highest overall dioxin loads estimated during this assessment. Both sites are in the initial phases of site characterization for cleanup.

Recommendations

1. Conduct follow-up environmental monitoring for dioxins downwind of the Cameron-Yakima facility.

2. EPA is engaged in a large monitoring effort near the Rayonier, Port Angeles, site. Substantial data on dioxin concentrations in soil and sediment will be available in summer 1998. These data should provide a sound basis for future steps.

Conclusion 3

The importance of further source reduction/control was rated high for incinerators and hog-fuel boilers.

Recommendations

We suggest Ecology take the following initial actions to reduce the magnitude and dispersion of these loads:

Incinerators

1. Continue steps to adopt regulations that incorporate (a) federal air emissions performance standards for new medical waste incinerators, and (b) emissions guidelines for existing medical waste incinerators.

2. Pursue opportunities for waste reduction and recycling, thereby limiting the amount of waste disposed of through incineration.

Hog-fuel Boilers

3. Ecology is developing Reasonably Achievable Control Technology (RACT) for hog-fuel boilers. The production and release of dioxins by these boilers will be considered as RACT is defined. One goal of RACT analysis and implementation will be to reduce the dispersion and overall production of dioxins from these boilers.

General

4. Determine if solid and dangerous waste designations adequately capture dioxin-containing wastes including fly ash generated by hog-fuel boilers, municipal waste incinerators and medical waste incinerators. Expand testing to fill data gaps and assure that appropriate sequestration of these wastes continues.

Conclusion 4

Compiling existing environmental data would provide critical supplemental information.

This project, through compilation of existing data, provides a useful beginning in evaluating dioxin sources. During this project we identified a number of references containing environmental dioxin data. Compiling existing data on dioxin concentrations in Washington's environment and filling the data gaps revealed by this compilation would:

1. Increase our knowledge of dioxin sources. Additional environmental data are likely to identify dioxin "hot spots" and presently unrecognized sources.

2. Give context to environmental dioxin data. Washington's background dioxin concentrations are unknown. Site assessments for dioxin are difficult to perform without knowing an area's background dioxin levels.

3. Represent a logical progression, expanding our knowledge from sources to the ambient environment as displayed by the Dioxin Source and Fate Conceptual Model (Figure 2, page 5).

Recommendations

1. Compile existing environmental data to address dioxin concentrations in Washington's environment. This project should emphasize compilation of data on:
   - Freshwater and marine sediments
   - Soils (including data being generated under 1998 SSB 6474)
   - Freshwater and marine fish and shellfish

2. Based on the results of this compilation, design the scope-of-work to fill critical gaps in ambient data. Such a study should consider use of fish and/or wildlife tissue analysis. Animal indicators provide integration of cross-media spatial and temporal dioxin exposures.

3. Identify key environmental indicators (e.g., concentrations in the tissue of selected birds, fish or mammals, and concentrations in sediment cores) based on environmental monitoring results that are consistent with the dioxin source and fate conceptual model. Tracking these indicators over time will show whether or not actions taken to reduce the release of dioxins to the environment are effective.

Conclusion 5

This report represents a major first step in developing a strategy for managing bioaccumulative, persistent, and toxic compounds.

The process of looking at dioxin sources across media, organizational, and regulatory boundaries was successful in providing a snapshot view of dioxin releases to the environment, to the extent existing information allows.

Recommendation

1. Ecology, under the direction of Ecology's Bioaccumulative Chemicals of Concern Committee and in cooperation with other agencies, should continue to invest in projects that further our understanding of bioaccumulative, persistent, and toxic compounds in Washington State.

2. This report is an early step in a strategy to reduce production and dissemination of dioxins. Subsequent steps could include the virtual elimination of man-made sources and the dispersion of dioxin. Information generated by this effort should inform the development of subsequent strategies to effectively manage and eliminate other bioaccumulative, persistent, and toxic compounds.

Glossary

Air Pollution Control Device (APCD) – In this report, a device that collects particulate matter from an air emission before it is released to the environment. Examples include electrostatic precipitators (ESPs), cyclones, multi-cyclones, wet scrubbers, and baghouses.

Bottom Ash – Ash too heavy to be carried up the stack by flue gas; sometimes referred to as “grate ash”; may be mixed with grate siftings.

Confirmed Source – A facility or process for which a dioxin load was calculated.

Congener – A series of compounds with the same base structure but varying degrees of substituted functional groups.

Dioxin – In this report, “dioxin” refers to all toxic (2,3,7,8-chlorine-substituted) forms of the dioxins and furans.

Fly Ash – Ash too light to fall out as grate or bottom ash; therefore, ash emitted from the source. Also, ash collected by air pollution control devices rather than being emitted from the stack in the flue gas.

Load – The rate at which dioxins are generated or emitted by a source. Calculated from test data measuring release to air, water, and land. Expressed as mg TEQ/day.

Mixed Ash – A mixture of fly ash and grate and/or bottom ash.

Potential Source – Facilities with same or similar processes as confirmed sources but for which no dioxin load could be calculated.

Toxicity Equivalency Factor (TEF) – A measure of the potency of one congener relative to that of 2,3,7,8-TCDD. The congener’s concentration is multiplied by the toxicity equivalency factor to obtain the toxic equivalents for that sample.

Toxic Equivalents (TEQ) – The equivalent toxicity relative to 2,3,7,8-TCDD for each of the 2,3,7,8-chlorine-substituted dioxin and furan congeners. Also refers to the total equivalent toxicity if a compound contains more than one congener.

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Appendices

Appendix A

Supplemental Tables

Table A-1. Example calculations of dioxin TEQ and load.

Facility		XYZ Facility				
Sample Name		Ash Analysis				
Lab		A-1 Analytical Services				
Sample Number		123456				
Date		1/1/94				
		Value (ng/kg)	Qual.	TEQ (ng/kg) <Detection Limit = *		
Congener	TEF			0	1/2DL	DL
TCDD		**16.2**				
2,3,7,8-TCDD	1	2.1	U	0		2.1
PCDD		**7.31**				
1,2,3,7,8-PCDD	0.5	5.4	U	0		2.7
HxCDD		**84.9**				
1,2,3,4,7,8-HxCDD	0.1	**5.68**		0.568		0.568
1,2,3,6,7,8-HxCDD	0.1	**7.24**		0.724		0.724
1,2,3,7,8,9-HxCDD	0.1	**12.3**		1.23		1.23
HpCDD		**184**				
1,2,3,4,6,7,8-HpCDD	0.01	**94.4**		0.944		0.944
OCDD	0.001	**551**		0.551		0.551
TCDF		**223**				
2,3,7,8-TCDF	0.1	**30.6**		3.06		3.06
PCDF		**120**				
1,2,3,7,8-PCDF	0.05	**8.53**		0.4265		0.4265
2,3,4,7,8-PCDF	0.5	**12.7**		6.35		6.35
HxCDF		**128**				
1,2,3,4,7,8-HxCDF	0.1	**34.6**		3.46		3.46
1,2,3,6,7,8-HxCDF	0.1	**13.7**		1.37		1.37
2,3,4,6,7,8-HxCDF	0.1	**25.5**		2.55		2.55
1,2,3,7,8,9-HxCDF	0.1	1.9	U	0		0.19
HpCDF		**218**				
1,2,3,4,6,7,8-HpCDF	0.01	**160**		1.6		1.6
1,2,3,4,7,8,9-HpCDF	0.01	**13.6**		0.136		0.136
OCDF	0.001	**118**		0.118		0.118
EPA TEQ				23.09		28.08
Waste Production Rate (tons/year				8,762		8,762
TEQ load (mg/day)				0.503	0.557	0.611

U = Less than detection limit

* = 0: if congener not detected, concentration assumed = 0

½ DL: if congener not detected, concentration assumed = ½ detection limit

DL : if congener not detected, concentration assumed = detection limit

Table A-2. Comparative 2,3,7,8 – TCDD Levels Established for Human Health Protection.

Concentration	**Criteria or Criterion**	**Comments**
0.000000013 ug/L (ppb)	USEPA National Toxics Rule (1992)	Criterion protecting humans consuming water & organisms
0.000000014 ug/L (ppb)	USEPA National Toxics Rule (1992)	Criterion protecting humans consuming organisms only
0.0000006 ug/L (ppb)	Chapter 173-300 WAC Water Quality Standards for Ground Waters of the State of Washington (1990)	Carcinogen criterion
1.00 ng/kg (pptr)	US Food & Drug Administration (1997)	"Level of Concern" for edible tissue of chicken eggs & catfish sold for use in human food.
6.67[1] ng/kg (pptr)	Washington State Model Toxics Control Act (MTCA) Cleanup Levels and Risk Calculations (CLARC II) Update (1996)	Method B Residential Soil Standard

USEPA. 1992. National Toxics Rule. U.S. Environmental Protection Agency, Federal Register Volume 57, No. 246, December 22, 1992.

US Food & Drug Administration (FDA). 1997. FDA/CFSAN Letter to Egg Producers and Catfish Farmers and Processors. July 8, 1997. Subject: Dioxin Contaminated Animal Feed. Available on the world wide web at: http://www.fda.gov/

Washington State Department of Ecology. 1996. Model Toxics Control Act Cleanup Levels and Risk Calculations (CLARC II) Update. Publication #94-145, Updated 1996.

Washington State. 1990. Chapter 173-200 Washington Administrative Code (WAC). 1990. Water Quality Standards for Ground Water of the State of Washington. 8 pgs.

[1] Expressed as TEQ

Table A-3. Dioxin Loads from Tested Facilities (page 1 of 3)

Facility	Location	Process	Year	Load to (mg TEQ/day): Air	Water	Land	Total	Citation	N
Ash Grove Cement	Seattle	Cement Kiln	1996	0.0			**0.0**	Valid Results, Inc., 1996.	
Boise Cascade Pulp and Paper	Wallula								Sludge is both compo
		Bleach Pulp & Paper	1991-1997		0.78	0.081		McCall, 1997.	[1] (Ave. of 24 results)
			1992		0.32			Johnson and Heffner, 1992.	[2]
			Average		0.76	0.081	**0.84**		Average of all results.
Cameron-Yakima (NO LONGER ACTIVE)	Yakima	Activated Carbon Regeneration	1994	37.4			**37.4**	Bison Engineering, 1995.	
Conrad Industries	Chehalis	Manufacture of Pyrolysis Units	1994	0.000405			**0.00041**	Hansen, Guenthoer, and Blaisdell, 1994.	
Daishowa Pulp and Paper	Port Angeles	Hog Fuel Boiler	1996	NT		0.012	**0.012**	Hannah, 1996.	Ash disposed of at ne
Fort James Pulp and Paper	Camas								Ash is marketed as "N
		Hog Fuel Boiler	1997			0.54		Magoon, 1997	land.
		Bleach Pulp & Paper	1991-1997		1.9			McCall, 1997.	[1] (Ave. of 15 results)
			Average		1.9	0.54	**2.39**		
Fort Lewis Incinerator	Tacoma	Municipal Incinerator	1997	0.0028				Weston, 1997	Ash disposed of at th Roosevelt, WA.
			1997			0.76		Peterson, 1996.	Fly and bottom ash
			Average	0.0028		0.76	**0.76**		
Georgia-Pacific Pulp and Paper	Bellingham	Bleach Pulp & Paper	1991-1997		1.7			McCall, 1997.	[1] (Ave. of 22 results)
			1993		0.00			Golding, 1994.	None Detected. [2]
			Average		1.7		**1.7**		Average of all results.
Holnam Inc.	Seattle	Cement Kiln	1994	0.71		NT		Hansen, Guenthoer, Orton, and Blaisdell, 1994.	Cement kiln dust is m waste stabilization, ro
			1995	2.9				Hansen, Mackey, and Blaisdell, 1995.	
			1995	1.1		NT		Hansen, Mackey, and Blaisdell, 1995.	
			1996	1.2				Hansen, Blaisdell and Mackey, 1996.	
			1996	1.0		0.0038		Hansen, Blaisdell and Mackey, 1996; Smith, 1996.	
			1996	0.64				Hansen, Blaisdell and Mackey, 1996.	
			1997			0.0948		Magoon, 1997	
			1997			0.0674		Magoon, 1997	
			Average	1.3		0.055	**1.3**		
Kaiser Aluminum Rolling Mill	Spokane	Remelt Furnace(s)	1997	0.031			**0.031**	Hansen, Blaisdell and Anderson, 1996.	Test for 1 of 10 remel
Kalama Chemical Co.	Kalama	Industrial Boiler/Waste Burner	1996	0.00029			**0.00029**	International Technology Corp., 1996.	

Table A-3. Dioxin Loads from Tested Facilities (page 2 of 3)

Facility	Location	Process	Year	Load to (mg TEQ/day): Air	Water	Land	Total	Citation	N
Kimberly-Clark Pulp and Paper	Everett	Bleach Pulp & Paper	1991-1997		0.40		**0.40**	McCall, 1997.	[1] (Ave. of 11 results)
Longview Fiber Pulp and Paper	Longview	Bleach Pulp & Paper	1993		0.020			Stasch, 1996.	
			1991-1997		0.76			McCall, 1997.	[1] (Ave. of 14 results)
			Average		0.71		**0.71**		Average of all results.
Northwest Hospital	Seattle	Medical Waste Incinerator	1995	0.15		NT	**0.15**	Hansen, Orton and Blaisdell, 1995c.	
Olivine Municipal Incinerator	Ferndale	Municipal Incinerator	1994	7.2		NT		Emission Technologies, Inc., 1995.	Operated infrequently
			1995	0.41		NT		Emission Technologies, Inc., 1996.	Ash disposed of at th Roosevelt, WA.
			Average	3.8		NT	**3.8**		
Rayonier Pulp and Paper **(NO LONGER ACTIVE)**	Port Angeles	Hog Fuel Boiler	1989(1)	NT		1.2		Foster Wheeler, 1997; Perlwitz, 1997	Ash was disposed of "Fly Ash", Calc. @ 6
			1989(2)	NT		12.5		Foster Wheeler, 1997; Perlwitz, 1997	"Filter Ash", Calc. @
			1993	NT		68.9		Redman, 1993; Perlwitz, 1997.	"Filter Ash", Calc. @
			1995	0.17		NT		Foster Wheeler, 1997; Perlwitz, 1997	
			1997	NT		6.27		Foster Wheeler, 1997; Perlwitz, 1997	"Ash, vacum filter & g
		Bleach Pulp & Paper	1989		12.3			Foster Wheeler, 1997; Perlwitz, 1997	"#3 Mill Effluent"
			1990(1)		15.3			Foster Wheeler, 1997; Perlwitz, 1997	"Extended Outfall"
			1990(2)		0.19			Foster Wheeler, 1997; Perlwitz, 1997	"Extended Outfall"
			1991		51.9			Foster Wheeler, 1997; Perlwitz, 1997	"Extended Outfall"
			1992(1)		27.1			Foster Wheeler, 1997; Perlwitz, 1997	"Final Effluent"
			1992(2)		10			Foster Wheeler, 1997; Perlwitz, 1997	"Final Effluent"
			1992(3)		3.5			Foster Wheeler, 1997; Perlwitz, 1997	"Final Effluent"
			1994		0			Foster Wheeler, 1997; Perlwitz, 1997	"Extended outfall"
			1992(4)		20.7			Foster Wheeler, 1997; Perlwitz, 1997	"Final Effluent"
			1993-1996		0.10			McCall, 1997.	[1] (Ave. of 20 results)
			Average	0.17	4.93	22.2	**27.3**		Average of all results.
Recomp Incinerator	Ferndale	Medical/Municipal Waste Incinerator	1988	4.0		NT		Hansen, Guenthoer, and Blaisdell, 1989.	Ash disposed of at th Roosevelt, WA; previ
			1994	NT		0.62		Recomp of Washington, 1995.	
			1995	NT		0.62		Recomp of Washington, 1996.	
			1996	NT		2.2		Recomp of Washington, 1997.	
			Average	4.0		1.1	**5.1**		
Renton Sewage Treatment Plant	Renton	Municipal Wastewater Treatment	1989		NT	0.26		USEPA, Office of Water, 1989.	Most biosolids land-a western Washington s
			1997		NT	0.43		King, 1998.	
			Average			0.35	**0.35**		
Simpson Kraft Pulp and Paper	Tacoma	Bleach Pulp & Paper	1991		13.7			Heffner, 1992.	[2] Not included in overa discrepencies.
			1991-1997		0.00			McCall, 1997.	[1] (Ave. of 16 results)
			Average		0.00		**0.00**		Average of all results.

Table A-3. Dioxin Loads from Tested Facilities (page 3 of 3)

Facility	Location	Process	Year	Load to (mg TEQ/day): Air	Water	Land	Total	Citation	N
Spokane Municipal Incinerator	Spokane	Municipal Incinerator	1991	0.28		NT		Clean Air Engineering, 1992.	Ash disposed of at th Roosevelt, WA.
			1992	0.0040		NT		Pence, 1992.	
			1992			24.3		Laucks Lab, 1992	Total Ash
			1993	0.0084		NT		Hansen, Guenthoer, Orton, and Blaisdell, 1994a.	
			1994	0.24		NT		Hansen, Guenthoer, Orton, and Blaisdell, 1994b.	
			1995	0.0039		38.0		Hansen, Guenthoer, and Blaisdell, 1995a; Unknown, 1995.	
			1997	0.98		NT		Hansen, Guenthoer, and Blaisdell, 1998.	
			Average	0.25		31.15	**31.4**		
Tacoma City Light	Tacoma	Cogeneration	1990	0.25		NT		Hansen, Orton, and Blaisdell, 1991.	Ash sold to hazardo and storage facilities.
			1991	0.0029		NT		Hansen, Guenthoer and Blaisdell, 1991.	
			1991	0.032		NT		Hansen, Guenthoer, and Blaisdell, 1992a.	
			1991	0.027		NT		Hansen, Guenthoer, and Blaisdell, 1992b.	
			Average	0.078			**0.078**		
VA Hospital	Seattle	Medical Waste Incinerator	1995	0.54		NT	**0.54**	Hansen, Guenthoer and Blaisdell, 1995b.	
Weyerhaeuser Pulp and Paper	Cosmopolis	Bleach Pulp & Paper	1993-1997		0.21			McCall, 1997.	[1] (Ave. of 14 results)
		Bleach Pulp & Paper	1991		0			Golding and Heffner, 1993.	
		Bleach Pulp & Paper	1991		0			Golding and Heffner, 1993.	
			Average		0.20		**0.20**		Average of all results.
Weyerhaeuser Pulp and Paper	Longview	Bleach Pulp & Paper	1991-1997		0.13	1.76		McCall, 1997.	Sludge disposed of in [1] (Ave. of 29 results)
		Hog Fuel Boiler	1990	0.11				Weyerhaeuser, 1991.	("Test #2", Fuel = woo
			Average	0.11	0.13	1.76	**2.00**		

Key:
NT - Not tested
[1] Average of results from NPDES self-reporting data, 1991 to present. TCDD and TCDF only. (Number of results in parentheses).
[2] Department of Ecology compliance monitoring inspection, includes all congeners.

Table A-4. State and Federal Laws Authorizing Data Collection

Regulatory Authority

Ecology's authority to require dioxin and furan testing is limited; this results in limited loading data being available for Washington facilities. This table summarizes Washington and federal regulations authorizing or requiring dioxin data collection.

Air Sources (General)

New Sources

Chapter 173-400 WAC, General Regulations for Air Pollution Sources

Provides mechanisms for requiring dioxin testing under Section 110 (New source review) which can lead to the inclusion of dioxin monitoring requirements in the facility's Notice of Construction.

Existing Sources

Chapter 173-434-210 WAC, Solid Waste Incinerator Facilities
Chapter 173-405-091 WAC, Kraft Pulping Mills
Chapter 173-410-100 WAC, Sulfite Pulping Mills

These regulations allow Ecology to require "special studies relevant to process emissions." Chapter 173-434-210 WAC states "These special studies may include the requirement to conduct studies of dioxin emission and control measures."

Municipal Waste Incinerators

Ash

Chapter 173-306 WAC, Special Incinerator Ash Management Standards

Requires collection and analysis of bottom and fly ash from municipal waste incinerators burning over 12 tons of municipal waste per day. This requirement only applies to ash that designates as a "state only dangerous waste" and is specified in WAC 173-306-200(4)(f).

Wastewater Dischargers

Wastewater

Chapter 173-220 WAC, National Pollutant Discharge Elimination System Permit Program

Allows Ecology to require monitoring including "pollutants which are subject to reduction or elimination under the terms…of the permit" [Section 210(1)(a)(ii)], and "pollutants which the department finds could have a significant impact on surface waters" [Section 210(1)(a)(iii)].

Chapter 173-216 WAC, State Waste Discharge Permit Program

Requires permits to "specify conditions necessary to prevent and control waste discharges to waters in the state, including…any conditions necessary to meet applicable water quality standards for surface waters or to preserve or protect beneficial uses for ground waters" [Section 110(1)(d)] and "any appropriate monitoring, reporting and record keeping requirements as specified by the department…" [Section 110(1)(g)].

Generally, regulatory authority is media-specific. The authority and regulations applied to one medium do not usually apply to other media. The authority to require or authorize dioxin testing is often not explicit, but must be interpreted from the regulations, leading to inconsistencies in the way data are generated. There is no cross-media authority (e.g., a regulation that applies to persistent, bioaccumulative, toxic pollutants across all environmental media) that facilitates collection of comprehensive, consistent data from known or potential sources.

Table A-5. Low, average, and high dioxin loads for bleach pulp and paper mill facilities, period of record (2,3,7,8-TCDD and 2,3,7,8-TCDF only). Loads in mg TEQ/day.

Facility	*# of Samples*	*Low (mg/day)*	*Average (mg/day)*	*High (mg/day)*
James River, Camas - "ASB Effluent"	16	0.00	1.85	23.50
Georgia Pacific - "Effluent"	24	0.62	1.71	4.37
Boise Cascade, Wallula - Secondary and Final Effluent	25	0.00	0.78	3.78
Longview Fibre, Longview - "Final Mill Effluent"	14	0.00	0.76	3.59
Kimberly Clark - Sum of 3 outfalls	11	0.00	0.40	3.34
Weyerhaeuser, Cosmopolis - "Pond D Effluent"	14	0.06	0.21	0.41
Weyerhaeuser, Longview - "Secondary Effluent"	21	0.00	0.13	0.35
Rayonier, Port Angeles - "Final Effluent"	20	0.00	0.10	1.05
Simpson Tacoma Kraft, Tacoma - "Secondary Effluent"	16	0.00	0.00	0.00

Appendix B

Methods

Methods

Data Gathering Strategies

Several strategies were used to gather dioxin data as well as names of organizations and facilities potentially having dioxin data. To locate data and potential sources within Ecology, contacts in each program were established. Data files and databases were searched for both dioxin data and facilities with the potential for dioxin data. These resources included:

- Air Quality Program (AQP) list of potential hospital/medical waste incinerators
- AQP wood waste boiler survey data
- Environmental Investigations and Laboratory Services (EILS) report bibliography
- Hazardous Waste and Toxics Reduction Program (HWTRP) petition and certificate of designation files
- Sediment Section database
- Toxics Cleanup Program (TCP) Facility Site Database
- Water Quality Program (WQP) Wastewater Permit Life Cycle System (WPLCS) database of Daily Monitoring Reports (DMRs)
- Solid Waste and Financial Assistance Program (SWFAP) Municipal Incinerator Annual Reports and ash data.

Ecology's Manchester Laboratory database was searched for contracted dioxin analyses. HWTRP also held a discussion about dioxins and asked attendees for their knowledge of such data or sources.

The Washington State Department of Health was contacted for lists of hospitals and veterinary clinics. Regional air pollution control authorities and USEPA were contacted for dioxin data and potential source names. In a few cases, facilities themselves were contacted for data or clarification of data.

Lists of potential sources were obtained and combined from a variety of sources:

- Hog-fuel (Wood-Waste) Boilers

  The table of hog-fuel (wood-waste) boilers as potential dioxin sources originated from Ecology's Air Quality Program wood-waste boiler survey (Ecology, 1997a). Air pollution control authorities were also contacted for their knowledge of such boilers in their respective regions.

- Medical Waste Incinerators

  The initial list of possible medical waste incinerators was obtained from the AQP. Additional inquiries were made to regional air pollution control authorities. We added county locations and facility status (i.e., active or closed). The Department of Health was contacted for information on veterinary and crematory incinerator sources (Phillips, 1997). Because these facilities typically do *not* routinely burn plastics and since no supporting data were located, veterinary and crematory incinerators were not included in this list.

- USEPA and State MTCA Cleanup Sites
  Staff from Ecology's TCP provided information about clean-up sites, including information from their database as well as verbal and written information. USEPA site managers were also contacted about specific sites.

- Pentachlorophenol Wood Treating Facilities
  Active PCP wood treating facilities were identified by WQP staff. TCP site managers and HWTRP personnel identified the closed sites.

- Oil Refineries
  Ecology's Industrial Section provided reports on dioxin found in catalytic reformer batched wastewaters. Loads were not calculated for these facilities because wastewater volumes were not available.

- Municipal Waste Incinerators
  Data were obtained from AQP, SWFAP, and local air pollution control agencies.

Conventions Used in Processing Quantitative Data

A single cited document may contain more than one sampling event. A single load was calculated for each sampling event reported. In some cases, an individual load may represent a single point in space and time (e.g., loads calculated from a grab sample and an instantaneous wastewater flow). In other cases, the single load may represent multi-day samples collected from several stacks at a single facility and varying stack gas flow rates associated with the several days and samples. A database was designed for this assessment. It includes the items shown in Table B-1.

Table B-1. Database Parameters

Major Parameter	Minor Parameter	Description
Citation	Title	Title of citation containing data
	Type	Type of document (e.g., source test, memorandum)
	Author(s)	Name(s) of authors
	Organization	Affiliation of authors
	Date	Publication date
	Publication Number	Publication number
Facility	Name	Name of facility where testing occurred
	County	County where facility is located
	Category	Facility category (e.g., medical waste incinerator, cement kiln)
Process	Type	Type of process tested (e.g., wastewater treatment, wood-fired boiler)
Results	Material Sampled	Material description (e.g., fly ash, wastewater, air emission, etc.)
	Start date	Date when sampling began or occurred
	End date	Date when sampling ended
	Sampling Organization	Affiliation of personnel conducting sampling
	Laboratory	Name of laboratory performing analyses
	Type	Number and type of congeners tested for
	Mass rate notes	How mass rate or load was calculated or detected
	TEQ loads	Milligrams TEQ/day calculated in each of 3 ways (see below)

Non-Detectable Quantities

Sampling and analytical methods for dioxins have a range of detection and quantification limits for individual congeners. Some congeners may be detected and quantified while others remain undetected. Some congener concentrations are qualified as "estimates".

For calculating dioxin loads, we treated estimated concentrations as if they were not qualified (i.e., not flagged as estimates). Dealing with congeners that were not detected is more complex. If one or several 2,3,7,8-substituted congeners are not detected in a sample, the total calculated TEQ may be ambiguous. Researchers approach this problem in different ways:

- If undetected congener concentrations are assumed to be zero, the resulting TEQ is the *minimum* TEQ associated with that sample analysis.
- If congener concentrations are assumed to equal the method detection limit, the resulting TEQ is the *maximum* TEQ associated with that sample analysis.
- If undetected congener concentrations are assumed to equal one half the detection limits, the resulting TEQ is an *average* of the minimum and maximum TEQ for that sample analysis.

This assessment calculates TEQs in each of the three ways described above. The *minimum* TEQ is used to interpret and report results. Appendix C provides a summary of the three calculated loads.

Appendix C

Dioxin Loads Calculated by Three Alternative Methods for Handling Quantities Less than the Detection Limit

Table C-1. Dioxin loads, not including self-reported data associated with National Pollutant Discharge Elimination System (NPDES) permits. Loads in mg TEQ/day.

Facility Name	Process	Material Sampled	Start Date	End Date	Calculated Load (<DL=0)	Calculated Load (<DL=1/2DL)	Calculated Load (<DL=DL)
Ash Grove Cement, Seattle	Cement Kiln	Air Emission	15-Aug-96		0	0.016	0.031
Boise Cascade Pulp and Paper, Wallula	Treatment of Process Wastewater	Wastewater, Treated	07-Apr-92	08-Apr-92	0.32	1.31	2.3
Cameron-Yakima, Yakima	Activated Carbon Regeneration (Multiple Hearth)	Air Emission	01-Dec-94	21-Dec-94	4.68	4.68	4.68
Cameron-Yakima, Yakima	Activated Carbon Regeneration (Rotary Kiln)	Air Emission	06-Dec-94	19-Dec-94	32.7	32.7	32.7
Conrad Industries, Chehalis	Pyrolysis Unit	Air Emission	24-Feb-94	24-Feb-94	0.000405	0.000524	0.000643
Daishowa America Mill, Port Angeles	Hog Fuel Boiler	Ash, Mixed	22-May-96	22-May-96	0.0116	0.059	0.11
Fort James Pulp and Paper, Camas	Hog Fuel Boiler	Ash, Fly	20-Oct-97	20-Oct-97	0.544	0.549	0.555
Fort Lewis Incinerator	Incinerator	Air Emission	15-Jul-97	24-Jul-97	0.0028	0.018	0.034
Fort Lewis Incinerator	Incinerator	Ash, Bottom	01-May-96	01-Sep-96	0	1.73	3.47
Fort Lewis Incinerator	Incinerator	Ash, Fly	01-May-96	01-Sep-96	0.76	0.76	0.76
Georgia-Pacific Pulp and Paper, Bellingham	Treatment of Process Wastewater	Wastewater, Treated	14-Apr-93	15-Apr-93	0	1.81	3.61
Holman Inc., Seattle	Cement Kiln	Cement Kiln	15-May-96	15-May-96	0.0038	0.078	0.15
Holman Inc., Seattle	Cement Kiln	Air Emission	26-Jul-95		2.88	2.96	3.05
Holman Inc., Seattle	Cement Kiln	Air Emission	27-Jul-95		1.09	1.16	1.23
Holman Inc., Seattle	Cement Kiln	Air Emission	08-Jul-96		1.23	1.28	1.33
Holman Inc., Seattle	Cement Kiln	Air Emission	09-Jul-96	10-Jul-96	1	1.08	1.16
Holman Inc., Seattle	Cement Kiln	Air Emission	11-Jul-96		0.64	0.7	0.76
Holman Inc., Seattle	Cement Kiln	Air Emission	26-May-94	27-May-94	0.71	0.76	0.81
Holman Inc., Seattle	Cement Kiln	Cement Kiln	20-Oct-97	20-Oct-97	0.0948	0.191	0.287
Holman Inc., Seattle	Cement Kiln	Cement Kiln	21-Oct-97	21-Oct-97	0.0674	0.137	0.207
Kaiser Aluminum Rolling Mill, Trentwood	Aluminum Remelting	Air Emission	18-Jun-96	19-Jun-97	0.0314	0.0365	0.0416
Kalama Chemical, Kalama	Industrial Boiler/Waste Burner	Air Emission	25-Jun-96	30-Jun-96	0.00029	0.0022	0.004
Longview Fiber, Longview	Treatment of Process Wastewater	Wastewater, Treated	02-Nov-93	03-Nov-93	0.02	1.69	3.35
Northwest Hospital, Seattle	Incinerator	Air Emission	18-Jan-95	20-Jan-95	0.15	0.15	0.15
Olivine Municipal Incinerator, Bellingham	Incinerator	Air Emission	17-Mar-95	18-Mar-95	0.41	0.47	0.54
Olivine Municipal Incinerator, Bellingham	Incinerator	Air Emission	27-Oct-94	28-Oct-94	7.21	7.21	7.21
Rayonier, Inc., Port Angeles	Hog Fuel Boiler	Ash, Fly	13-Sep-93		68.9	Not Available	Not Available
Rayonier, Inc., Port Angeles	Hog Fuel Boiler	Ash, Fly	19-Feb-97	19-Feb-97	6.27	6.31	6.35
Rayonier, Inc., Port Angeles	Hog Fuel Boiler	Air Emission	26-Apr-95	26-Apr-95	0.168	0.186	0.205
Rayonier, Inc., Port Angeles	Hog Fuel Boiler	Ash, Fly	01-Dec-89		12.5	12.5	12.5
Rayonier, Inc., Port Angeles	Hog Fuel Boiler	Ash, Fly	02-Dec-89		1.23	1.23	1.23
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Dec-89		12.3	Not Available	Not Available
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Feb-90		15.3	Not Available	Not Available
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Jun-90		0.19	Not Available	Not Available
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Dec-91		51.9	Not Available	Not Available
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Apr-92		27.1	Not Available	Not Available
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Jun-92		20.7	Not Available	Not Available
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Sep-92		10	Not Available	Not Available

Facility Name	Process	Material Sampled	Start Date	End Date	Calculated Load (<DL=0)	Calculated Load (<DL=1/2DL)	Calculated Load (<DL=DL)
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Dec-92		3.5	Not Available	Not Available
Rayonier, Inc., Port Angeles	Treatment of Process Wastewater	Wastewater, Treated	01-Feb-94		0	Not Available	Not Available
Recomp (Thermal Reduction Company),	Incinerator	Air Emission	14-Dec-88	14-Dec-88	4	4	4
Recomp (Thermal Reduction Company),	Incinerator	Ash, Mixed	01-Jan-96	31-Dec-96	2.17	2.32	2.48
Recomp (Thermal Reduction Company),	Incinerator	Ash, Mixed	01-Jan-94	31-Dec-94	0.617	0.683	0.75
Recomp (Thermal Reduction Company),	Incinerator	Ash, Mixed	01-Jan-95	31-Dec-95	0.622	0.672	0.722
Renton Wastewater Treatment Plant, Renton	Treatment of Municipal Wastewater	Sludge from Wasterwater Treatment	01-Jan-89		0.262	1.18	2.1
Renton Wastewater Treatment Plant, Renton	Treatment of Municipal Wastewater	Sludge from Wasterwater Treatment	08-Sep-97	08-Sep-97	0.432	Not Available	Not Available
Simpson Tacoma Kraft Company	Treatment of Process Wastewater	Wastewater, Treated	12-Feb-91	13-Feb-91	13.73	13.75	13.77
Spokane Municipal Incinerator, Spokane	Incinerator	Ash, Mixed	13-Dec-95		38.0	38.0	38.0
Spokane Municipal Incinerator, Spokane	Incinerator	Air Emission	22-Sep-92	25-Sep-92	0.00398	0.0234	0.0428
Spokane Municipal Incinerator, Spokane	Incinerator	Air Emission	30-Sep-93		0.0084	0.07	0.13
Spokane Municipal Incinerator, Spokane	Incinerator	Air Emission	09-Jun-94	10-Jun-94	0.24	0.27	0.3
Spokane Municipal Incinerator, Spokane	Incinerator	Air Emission	11-May-95	12-May-95	0.0039	0.16	0.31
Spokane Municipal Incinerator, Spokane	Incinerator	Air Emission	01-Nov-91	01-Nov-91	0.28	0.29	0.3
Spokane Municipal Incinerator, Spokane	Incinerator	Ash, Bottom	27-Jan-92	02-Feb-92	0.02	Not Available	Not Available
Spokane Municipal Incinerator, Spokane	Incinerator	Ash, Fly	27-Jan-92	02-Feb-92	24.3	Not Available	Not Available
Spokane Municipal Incinerator, Spokane	Incinerator	Ash, Fly	23-Sep-97	02-Oct-97	0.984	0.993	1.003
Tacoma City Light, Steam Plant #2, Tacoma	Steam Plant/Incinerator	Air Emission	02-Aug-91	02-Aug-91	0.00293	0.01	0.017
Tacoma City Light, Steam Plant #2, Tacoma	Steam Plant/Incinerator	Air Emission	11-Dec-91	12-Dec-91	0.0318	0.068	0.103
Tacoma City Light, Steam Plant #2, Tacoma	Steam Plant/Incinerator	Air Emission	20-Mar-92	23-Mar-92	0.0267	0.047	0.067
Tacoma City Light, Steam Plant #2, Tacoma	Steam Plant/Incinerator	Air Emission	08-Oct-90	09-Oct-90	0.252	0.26	0.269
Veteran's Administration Medical Center, Seattle	Incinerator	Air Emission	23-Jan-95	25-Jan-95	0.54	0.54	0.54
Weyerhaeuser Paper Co., Cosmopolis	Other	Wastewater, Other	29-May-91	30-May-91	0	0.049	0.098
Weyerhaeuser Paper Co., Cosmopolis	Treatment of Process Wastewater	Wastewater, Treated	29-May-91	30-May-91	0	0.34	0.67
Weyerhaeuser Pulp and Paper, Longview	Hog Fuel Boiler	Air Emission	25-Jul-90	25-Jul-90	0.11	0.12	0.13

Table C-2. Dioxin loads from bleached pulp and paper mill treated wastewater.
(2,3,7,8-TCDD and 2,3,7,8-TCDF only).
Source: self-reported data associated with National Pollutant
Discharge Elimination (NPDES) permits
(DL = Detection Limit)

Date	TEQ Load (mg/day) <DL= 0	1/2 DL	DL
Fort James, Camas - "ASB Effluent"			
2/23/94	23.50	23.50	23.50
2/18/94	0.00	0.37	0.74
2/23/94	23.50	23.50	23.50
2/28/94	3.09	3.09	3.09
5/4/94	0.00	0.44	0.88
7/27/94	2.68	2.68	2.68
9/9/94	0.00	0.67	1.33
10/12/94	0.00	0.35	0.70
1/30/95	0.00	0.33	0.66
5/1/95	0.00	0.19	0.37
1/31/96	0.08	0.46	0.84
4/17/96	0.09	0.51	0.94
7/31/96	0.07	0.41	0.75
10/23/96	0.10	0.58	1.06
12/11/96	0.06	0.37	0.68
2/19/97	0.00	0.27	0.54
4/23/97	0.00	0.18	0.35
Georgia Pacific - "Effluent"			
11/25/91	0.6	1.2	1.9
2/19/92	1.1	1.7	2.3
5/20/92	1.5	2.9	4.2
8/19/92	0.7	1.3	2.0
11/18/92	0.8	1.4	2.1
2/17/93	1.0	1.6	2.2
5/19/93	0.8	1.5	2.1
8/25/93	1.2	1.9	2.7
11/18/93	1.7	2.3	2.8
2/23/94	1.1	1.7	2.4
5/19/94	1.4	2.1	2.9
8/25/94	2.2	2.9	3.5
11/16/94	1.8	2.6	3.4
2/22/95	2.7	3.2	3.7
5/24/95	2.2	2.8	3.4
8/23/95	2.3	3.1	3.8
11/15/95	4.4	5.1	5.9
1/17/96	2.4	3.2	3.9
4/17/96	1.9	1.9	1.9
7/17/96	1.4	2.0	2.6
10/23/96	1.3	2.0	2.8
1/15/97	1.7	2.3	2.9
4/16/97	0.9	1.6	2.3
7/16/97	4.2	4.9	5.7
Boise Cascade, Wallula - Final Mill Effluent			
2/20/92	1.79	1.79	1.79

2/20/92	2.04	2.04	2.04
2/27/92	2.88	2.88	2.88
4/15/92	0.22	0.45	0.67
8/4/92	2.04	2.04	2.04
12/9/92	0.40	0.91	1.41
2/24/93	0.36	0.54	0.73

Boise Cascade, Wallula - Secondary and Final Effluent
note: secondary effluent is major portion of final effluent (75-80%)

9/16/91	3.78	3.78	3.78
6/10/93	0.49	0.70	0.92
9/2/93	0.21	0.33	0.45
12/2/93	0.20	0.52	0.83
3/19/94	0.11	0.20	0.30
6/1/94	0.15	0.48	0.80
8/11/94	0.11	0.23	0.35
12/8/94	0.00	0.18	0.36
3/12/95	0.16	0.50	0.84
6/8/95	0.15	0.40	0.65
9/10/95	0.38	0.49	0.60
3/13/96	1.10	1.10	1.10
11/18/95	1.20	1.20	1.20
4/6/96	0.49	0.74	0.98
7/20/96	0.16	0.21	0.26
10/19/96	0.61	0.61	0.61
1/31/97	0.19	0.36	0.52
5/2/97	0.23	0.34	0.46

Longview Fibre, Longview - "Final Mill Effluent"

7/26/91	2.84	2.84	2.84
7/26/91	3.59	3.59	3.59
10/14/91	2.46	2.46	2.46
2/17/92	0.30	1.46	2.62
5/13/92	0.89	1.42	1.94
8/14/92	0.26	0.70	1.13
12/16/92	0.00	0.40	0.81
3/26/93	0.14	0.43	0.72
7/27/93	0.00	0.20	0.39
11/16/93	0.00	0.42	0.84
12/19/94	0.00	0.52	1.04
11/21/94	0.00	0.22	0.44
2/27/95	0.14	0.44	0.74
5/3/95	0.00	0.21	0.42

Kimberly Clark - Sum of 3 outfalls

9/5/91	0.15	0.41	0.68
12/9/91	0.00	0.63	1.26
6/26/92	0.11	0.31	0.50
9/12/92	0.00	0.20	0.39
12/19/92	0.03	0.20	0.36
9/21/93	0.00	0.21	0.41
1/17/94	0.03	0.22	0.42
2/21/95	0.04	0.31	0.58
5/21/96	3.34	3.44	3.53
6/20/96	0.65	0.71	0.78
7/23/96	0.09	0.36	0.63

Weyerhaeuser, Cosmopolis - "Pond D Effluent"

3/22/93	0.13	0.18	0.22
5/3/93	0.06	0.20	0.33

10/12/93	0.21	0.26	0.31
12/21/94	0.15	0.20	0.24
3/23/94	0.15	0.24	0.33
5/24/94	0.13	0.22	0.30
8/23/94	0.24	0.53	0.82
1/24/95	0.08	0.12	0.17
5/30/95	0.31	0.40	0.49
12/12/95	0.27	0.32	0.37
2/21/96	0.36	0.41	0.45
6/27/96	0.41	0.54	0.68
9/24/96	0.31	0.42	0.54
1/7/97	0.14	0.19	0.24

Weyerhaeuser, Longview - "Secondary effluent"

12/12/91	0.32	0.66	1.00
3/5/92	0.00	0.37	0.74
5/19/92	0.30	0.72	1.15
9/8/92	0.00	0.13	0.25
11/30/92	0.00	0.36	0.73
1/25/93	0.35	0.48	0.60
3/14/93	0.00	0.13	0.26
5/14/93	0.05	0.18	0.30
8/24/93	0.10	0.23	0.36
10/19/93	0.17	0.29	0.41
6/7/94	0.12	0.70	1.28
8/19/94	0.15	0.52	0.89
11/26/94	0.22	0.71	1.21
2/15/95	0.30	0.91	1.53
2/15/95	0.32	0.81	1.30
2/15/95	0.31	0.86	1.41
3/14/95	0.0369	0.28	0.53
3/14/95	0.00	0.54	1.08
3/14/95	0.02	0.41	0.81
4/19/95	0.26	0.52	0.78
4/19/95	0.24	0.63	1.02
4/19/95	0.25	0.57	0.90
9/30/95	0.14	0.50	0.86
9/30/95	0.09	0.45	0.80
9/30/95	0.12	0.47	0.83
3/6/96	0.03	0.20	0.37
3/6/96	0.05	0.22	0.39
3/6/96	0.04	0.21	0.38
4/24/96	0.10	0.19	0.28
4/24/96	0.10	0.19	0.28
4/24/96	0.10	0.19	0.28
8/13/96	0.13	0.49	0.85
8/13/96	0.13	0.31	0.49
8/13/96	0.13	0.40	0.67
11/13/96	0.07	0.24	0.42
11/13/96	0.10	0.28	0.45
11/13/96	0.09	0.26	0.44

Rayoneir, Port Angeles - "Final effluent"

1/25/93	0.00	0.34	0.69
1/26/93	0.19	0.91	1.63
1/27/93	0.00	0.65	1.29
1/28/93	0.00	0.36	0.71

1/29/93	0.00	0.53	1.05
6/4/93	0.23	0.96	1.69
7/20/93	1.05	1.05	1.05
10/12/93	0.21	0.62	1.02
3/8/94	0.00	0.56	1.12
5/30/94	0.00	0.34	0.67
8/31/94	0.00	0.19	0.38
12/12/94	0.14	0.40	0.67
3/21/95	0.00	0.05	0.10
5/10/95	0.00	0.33	0.66
9/6/95	0.00	0.29	0.58
12/20/95	0.00	0.12	0.25
3/6/96	0.00	0.17	0.34
5/1/96	0.00	0.18	0.37
8/6/96	0.09	0.17	0.25
11/21/96	0.12	0.41	0.70

Simpson Tacoma Kraft, Tacoma - "Secondary Effluent"

11/18/91	0.00	0.45	0.90
3/30/92	0.00	0.11	0.23
7/31/92	0.00	0.21	0.43
11/30/92	0.00	0.12	0.24
6/15/93	0.00	0.17	0.34
3/30/94	0.00	0.12	0.25
6/27/94	0.00	0.40	0.80
9/20/94	0.00	0.11	0.21
12/6/94	0.00	0.22	0.44
3/30/95	0.00	0.13	0.26
6/20/95	0.00	0.06	0.12
10/2/95	0.00	0.06	0.13
12/11/95	0.00	0.48	0.97
3/28/96	0.00	0.06	0.13
9/27/96	0.00	0.20	0.40
2/6/97	0.00	0.17	0.34

Table C-3. Dioxin loads from bleached pulp and paper mill wastewater sludge.

	2,3,7,8-TCDD				2,3,7,8-TCDF				2,3,7,8-TCDD/TCDF		
	TEF = 1				TEF = 0.1						
Date	Value (ppt)		TEQ (ppt) <DL = 0	DL	Value (ppt)		TEQ (ppt) <DL = 0	DL	Total TEQ (ppt) <DL = 0	1/2 DL	DL
Boise Cascade, Wallula - "Clarifer Sludge"											
9/16/91	**9.1**		9.1	9.1	**17**		1.7	1.7	10.8		10.8
3/31/92	**1.3**		1.3	1.3	**11**		1.1	1.1	2.4		2.4
4/15/92	**0.45**		0.45	0.45	**1.6**		0.16	0.16	0.61		0.61
8/4/92	**1.3**		1.3	1.3	**3.7**		0.37	0.37	1.67		1.67
12/11/92	**1.1**		1.1	1.1	**2.3**		0.23	0.23	1.33		1.33
2/24/93	0.28	U	0	0.28	**1.9**		0.19	0.19	0.19		0.47
6/10/93	0.31	U	0	0.31	**1.7**		0.17	0.17	0.17		0.48
9/2/93	**1.6**		1.6	1.6	**3.8**		0.38	0.38	1.98		1.98
12/2/93	1	U	0	1	**2.4**		0.24	0.24	0.24		1.24
3/19/94	1	U	0	1	**3.3**		0.33	0.33	0.33		1.33
8/11/94	0.37	U	0	0.37	**1.6**		0.16	0.16	0.16		0.53
12/8/94	1	U	0	1	**1.7**		0.17	0.17	0.17		1.17
3/12/95	1	U	0	1	**2.7**		0.27	0.27	0.27		1.27
6/8/95	0.55	U	0	0.55	**2.4**		0.24	0.24	0.24		0.79
9/10/95	**1**		1	1	**20**		2	2	3		3
3/13/96	**0.47**		0.47	0.47	**2.5**		0.25	0.25	0.72		0.72
11/18/95	**14**		14	14	**222**		22.2	22.2	36.2		36.2
4/6/96	0.65	U	0	0.65	**2.8**		0.28	0.28	0.28		0.93
7/20/96	**0.6**		0.6	0.6	**1.7**		0.17	0.17	0.77		0.77
10/22/96	**0.28**		0.28	0.28	**0.91**		0.091	0.091	0.371		0.371
1/31/97	0.33	U	0	0.33	**0.77**		0.077	0.077	0.077		0.407
Mean TEQ (ppt)									2.95		3.26
Production rate (tons/year dry weight)									11,000		11,000
TEQ load (mg/day)									0.081	0.085	0.089

	2,3,7,8-TCDD				2,3,7,8-TCDF				2,3,7,8-TCDD/TCDF		
	TEF = 1				TEF = 0.1						
Date	Value (ppt)		TEQ (ppt) <DL = 0	DL	Value (ppt)		TEQ (ppt) <DL = 0	DL	Total TEQ (ppt) <DL = 0	1/2 DL	DL
Weyerhaeuser, Longview - "Combined Effluent Sludge"											
12/12/91	**50**		50	50	**92**		9.2	9.2	59.2		59.2
3/5/92	22	U	0	22	**86**		8.6	8.6	8.6		30.6
5/19/92	5.3	U	0	5.3	**140**		14	14	14		19.3
9/8/92	2.7	U	0	2.7	**24.1**		2.41	2.41	2.41		5.11
11/30/92	2.4	U	0	2.4	**38**		3.8	3.8	3.8		6.2
3/14/93	**8.74**		8.74	8.74	**64.3**		6.43	6.43	15.17		15.17
5/14/93	0.6	U	0	0.6	**45.2**		4.52	4.52	4.52		5.12
8/24/93	0.67	U	0	0.67	**43.4**		4.34	4.34	4.34		5.01
10/19/93	0.49	U	0	0.49	**27.3**		2.73	2.73	2.73		3.22
6/7/94	5.1	U	0	5.1	3.5	U	0	0.35	0		5.45
8/19/94	4.83	U	0	4.83	**52**		5.2	5.2	5.2		10.03
11/26/94	**22.4**		22.4	22.4	**54.6**		5.46	5.46	27.86		27.86
2/15/95	8	U	0	8	**65.7**		6.57	6.57	6.57		14.57
3/14/95	**23.4**		23.4	23.4	**55.3**		5.53	5.53	28.93		28.93
4/19/95	**9.32**		9.32	9.32	**42.7**		4.27	4.27	13.59		13.59
9/30/95	4.8	U	0	4.8	**114**		11.4	11.4	11.4		16.2
3/6/96	3.9	U	0	3.9	**55.5**		5.55	5.55	5.55		9.45
4/24/96	2	U	0	2	**47.4**		4.74	4.74	4.74		6.74
8/13/96	3	U	0	3	**102**		10.2	10.2	10.2		13.2
11/13/96	4.37	U	0	4.37	**53.4**		5.34	5.34	5.34		9.71
Mean TEQ (ppt)									11.71		15.23
Production Rate (Oven-dried tons/day)									165		165
TEQ load (mg/day)									1.76	2.02	2.28

Citation for mass rate:
Weyerhaeuser Co., 1991. Supplemental Environmental checklist for the Weyerhaeuser Longview

Date	2,3,7,8-TCDD TEF = 1			2,3,7,8-TCDF TEF = 0.1			2,3,7,8-TCDD/TCDF		
	Value (ppt)	TEQ (ppt) <DL =		Value (ppt)	TEQ (ppt) <DL =		Total TEQ (ppt) <DL =		
		0	DL		0	DL	0	1/2 DL	DL

Kraft Mill Modernization Project, November 1991. The mass rate number is a predicted estimate.

Table C-3. Dioxin loads from bleached pulp and paper mill wastewater sludge.

Date	2,3,7,8-TCDD TEF = 1 Value (ppt)	TEQ (ppt) <DL = 0	TEQ (ppt) <DL = DL	2,3,7,8-TCDF TEF = 0.1 Value (ppt)	TEQ (ppt) <DL = 0	TEQ (ppt) <DL = DL	2,3,7,8-TCDD/TCDF Total TEQ (ppt) <DL = 0	Total TEQ (ppt) <DL = 1/2 DL	Total TEQ (ppt) <DL = DL
Boise Cascade, Wallula - "Clarifer Sludge"									
9/16/91	**9.1**	9.1	9.1	**17**	1.7	1.7	10.8		10.8
3/31/92	**1.3**	1.3	1.3	**11**	1.1	1.1	2.4		2.4
4/15/92	**0.45**	0.45	0.45	**1.6**	0.16	0.16	0.61		0.61
8/4/92	**1.3**	1.3	1.3	**3.7**	0.37	0.37	1.67		1.67
12/11/92	**1.1**	1.1	1.1	**2.3**	0.23	0.23	1.33		1.33
2/24/93	0.28 U	0	0.28	**1.9**	0.19	0.19	0.19		0.47
6/10/93	0.31 U	0	0.31	**1.7**	0.17	0.17	0.17		0.48
9/2/93	**1.6**	1.6	1.6	**3.8**	0.38	0.38	1.98		1.98
12/2/93	1 U	0	1	**2.4**	0.24	0.24	0.24		1.24
3/19/94	1 U	0	1	**3.3**	0.33	0.33	0.33		1.33
8/11/94	0.37 U	0	0.37	**1.6**	0.16	0.16	0.16		0.53
12/8/94	1 U	0	1	**1.7**	0.17	0.17	0.17		1.17
3/12/95	1 U	0	1	**2.7**	0.27	0.27	0.27		1.27
6/8/95	0.55 U	0	0.55	**2.4**	0.24	0.24	0.24		0.79
9/10/95	**1**	1	1	**20**	2	2	3		3
3/13/96	**0.47**	0.47	0.47	**2.5**	0.25	0.25	0.72		0.72
11/18/95	**14**	14	14	**222**	22.2	22.2	36.2		36.2
4/6/96	0.65 U	0	0.65	**2.8**	0.28	0.28	0.28		0.93
7/20/96	**0.6**	0.6	0.6	**1.7**	0.17	0.17	0.77		0.77
10/22/96	**0.28**	0.28	0.28	**0.91**	0.091	0.091	0.371		0.371
1/31/97	0.33 U	0	0.33	**0.77**	0.077	0.077	0.077		0.407
Mean TEQ (ppt)							2.95		3.26
Production rate (tons/year dry weight)							11,000		11,000
TEQ load (mg/day)							0.081	0.085	0.089

Date	2,3,7,8-TCDD TEF = 1 Value (ppt)	TEQ (ppt) <DL = 0	TEQ (ppt) <DL = DL	2,3,7,8-TCDF TEF = 0.1 Value (ppt)	TEQ (ppt) <DL = 0	TEQ (ppt) <DL = DL	2,3,7,8-TCDD/TCDF Total TEQ (ppt) <DL = 0	Total TEQ (ppt) <DL = 1/2 DL	Total TEQ (ppt) <DL = DL
Weyerhaeuser, Longview - "Combined Effluent Sludge"									
12/12/91	**50**	0	0	**92**	0	0	0		0
3/5/92	22 U	0	0	**86**	0	0	0		0
5/19/92	5.3 U	0	0	**140**	0	0	0		0
9/8/92	2.7 U	0	0	**24.1**	0	0	0		0
11/30/92	2.4 U	0	0	**38**	0	0	0		0
3/14/93	**8.74**	0	0	**64.3**	0	0	0		0
5/14/93	0.6 U	0	0	**45.2**	0	0	0		0
8/24/93	0.67 U	0	0	**43.4**	0	0	0		0
10/19/93	0.49 U	0	0	**27.3**	0	0	0		0
6/7/94	5.1 U	0	0	3.5 U	0	0	0		0
8/19/94	4.83 U	0	0	**52**	0	0	0		0
11/26/94	**22.4**	0	0	**54.6**	0	0	0		0
2/15/95	8 U	0	0	**65.7**	0	0	0		0
3/14/95	**23.4**	0	0	**55.3**	0	0	0		0
4/19/95	**9.32**	0	0	**42.7**	0	0	0		0
9/30/95	4.8 U	0	0	**114**	0	0	0		0
3/6/96	3.9 U	0	0	**55.5**	0	0	0		0
4/24/96	2 U	0	0	**47.4**	0	0	0		0
8/13/96	3 U	0	0	**102**	0	0	0		0
11/13/96	4.37 U	0	0	**53.4**	0	0	0		0
Mean TEQ (ppt)							3.20		0.00
Production Rate (Oven-dried tons/day)							165		165
TEQ load (mg/day)							0.48	0.24	0.00

Citation for mass rate:
Weyerhaeuser Co., 1991. Supplemental Environmental checklist for the Weyerhaeuser Longview Kraft Mill Modernization Project, November 1991. The mass rate number is a predicted estimate.

Appendix D

Dioxin TEQ Load Calculations

Appendix D is printed as a separate report, Publication No. 98-321.