DRAFT REPORT

IDENTIFICATION OF SOURCES OF POLLUTANTS TO THE LOWER COLUMBIA RIVER BASIN

Prepared for the Lower Columbia River
Bi-State Program

by
Tom Rosetta and David Borys, DEQ

June 1996

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF APPENDICES

SOURCES OF CURRENTLY UNQUANTIFIABLE POLLUTION

In an effort to locate other potential sources of pollutantion to the Lower Columbia River, environmental clean-up sites, leaking underground storage sites, landfills, contaminated landfills, hazardous waste generators and facilities releasing hazardous and criteria air pollutants were identified in the Oregon Counties of Clackamas, Clatsop, Columbia, Multnomah and Washington. Environmental clean-up sites and facilities releasing hazardous air pollutants were identified in the Washington Counties of Clark, Cowlitz, Lewis, Pacific, Skamania, and Wahkiakum. Spills to the Columbia River were also included. Associated pollutants appearing on the 'Bi-State list of chemicals of concern' were indicated but not quantified in relation to these sources. Other unquantifiable nonpoint sources include rural, agriculture and forest runoff.

DIOXIN/FURANS, PCBS AND DDT

Chlorinated Dioxins/Furans, PCB's and DDT have been identified by the Lower Columbia River Bi-State Program as being 'chemicals of concern' due to their extreme toxicity, wide spread distribution, and persistence in the environment. While DMRs provided some point source data on dioxin/furans, other, unmonitored sources are believed to exist for dioxin/furans, PCBs and DDT. We reviewed and summarized the most recent scientific literature pertaining to these pollutants and their potential point and non-point sources.

TRIBUTARY POLLUTANT LOADING

The pollutant load contributions of the five major tributaries to the Lower Columbia River mainstem (Willamette, Sandy, Cowlitz, Kalama, and Lewis Rivers), P.S. discharges directly to the LCR mainstem, plus the Upper Columbia River pollutant load coming from upstream of the Bonneville dam, are assumed to represent the predominant proportion of PS and NPS pollution to the LCR Basin. Month-specific comparisons among tributaries and main-stem monitoring stations were conducted to determine the relative releases of various metals, pesticides, and other conventional parameters.

POLLUTANT PERCENT LOAD CONTRIBUTIONS

Approximate determinations of PS and urban runoff load contributions were made in relation to the water column toxic metal loads estimated for the Lower Columbia River Basin.

Estimated NPDES point source urban stormwater runoff pollutant loads were subtracted from corresponding water column pollutant loads of the Willamette River tributary. A similar analysis was made at the Beaver Army Terminal monitoring station (R.M. 53.8). This provided percent load contribution estimates of upstream PS, urban NPS, and unidentified source pollution from the Willamette River, and from a site representing the total most downstream Columbia River pollutant load (Beaver Army Terminal).

These mass balance calculations allowed for rough estimates of percent load contributions from the identified and unidentified pollutant source loads to the Lower Columbia River. 'Unidentified' percent load contributions provide information on potential rural NPS pollution, hazardous waste and land-fill sites, sinks, and additional undetermined loads coming from point sources and urban runoff.

To further delineate the sources of pollutants measured in the water column at Beaver Army Terminal, parameter specific loads from the Upper Columbia River (Warrendale Monitoring Station R.M. 141) were included in the mass balance equations. This comparison allowed for unidentified pollutant loads to be roughly attributable to sources in the LCR Basin, by eliminating the Upper Columbia River pollutant loads from the total Columbia River load.

DATA LIMITATIONS AND APPLICABILITY

NPDES point source DMR data averages for wet and dry periods were believed to be accurate representations of the pollutant discharges monitored for those periods. Urban stormwater runoff data was weighted according to monthly precipitation events. These data were considered to be appropriate for making order of magnitude comparisons between PSs, urban stormwater runoff, and tributary loadings.

Tributary loadings were calculated from single day, single sampling regimes (USGS) for each month (in limited cases, two or more values were averaged). Therefore, numbers do not necessarily represent average monthly values, and were considered to be indicators only for pollutant load occurrences during the months of 1994. Judging from the tributary flow and suspended sediments seasonal trends observed in the utilized data, the single day samplings appeared to be in line with corresponding monthly averages calculated by USGS modelers, and were therefore thought to be acceptable indicators for general comparisons.

The ambient water column monitoring was not synoptically scheduled. However, the 1994 sampling dates chosen for the Warrendale, Willamette River, and Beaver Army Terminal Stations were all within three days of one another, except for December (7 day spread), and May (10 day spread). These three stations were considered to be key in making any pollutant load comparisons, and the dates were close enough for the purposes of this report.

1993 NPDES point source waste water data, and 1992 and 1993 urban stormwater data were compared to 1994 ambient water column monitoring data. While it would have been ideal to compare all the 1992, 1993, or 1994 information, this was not possible due to the lack of usable data sets. However, these comparisons were believed to provide reasonable estimates of percent load contributions since the variability of PS data appears to be relatively small from year to year for the time period evaluated (Rosetta, 1995), and urban stormwater runoff loads are expected to be in large part dependent on fairly regular pollutant depositions to impervious surfaces.

The urban stormwater runoff numbers are the least reliable due to their extrapalatory nature, the potential for annual variability due to the magnitude of storm and non-storm events, and atmospheric deposition and runoff related to precipitation. Also, stormwater load estimates for

EXECUTIVE SUMMARY

From its headwaters in Canada, the Columbia River winds its way more than 1200 miles, south through Washington State, picking up the Snake River, and then heading west forming the Washington/Oregon border until it joins the Pacific Ocean. The Lower Columbia River Basin (LCR Basin), the focus of this report, encompasses the Columbia River main-stem and it's tributaries below Bonneville Dam (at river mile 146).

The purpose of this study was to assemble the available information on pollution sources to the Lower Columbia River and Estuary. Data were collected from many different sources, including the Oregon Department of Environmental Quality (ODEQ), the Washington Department of Ecology (Ecology), the U.S. Geological Survey (USGS), Tetra Tech (a consultant to the Bi-State Program), and other agencies and research groups.

One of the primary goals of this project has been to utilize all available data to determine percent load contributions for pollutants entering the LCR Basin. This provides information on important source types or locations where pollution prevention measures might be necessary, as well as source types or locations for which data is absent but needed in order to fully characterize potential pollution problems.

Although a great deal of information exists, it is not always readily accessible, complete, or comparable. This report does not attempt to identify every point and nonpoint input of pollutants to the river; such a task would be impossible. This report does, however, provide a basis for evaluating current conditions and making recommendations for improving data collection and analysis.

THE BI-STATE LIST OF CHEMICALS OF CONCERN

This study has concentrated on, but has not been limited to, gathering and evaluating data regarding approximately 100 pollutants which are believed to represent the greatest threat to the LCR ecosystem and potentially, to human health. These pollutants, referred to as 'Bi-State list of chemicals of concern', were identified by Tetra Tech in respect to 1990-1994 constituent exceedances of water, sediment, and tissue reference values established to protect aquatic life, and exceedances of human health risk-based screening values for consumable fish. The list includes 17 metals (including cyanide), 30 pesticides, 18 dioxin/furans, 23 semi-volatiles, 6 PCBs, and 3 radionuclides, as well as 7 conventional parameters (such as temperature).

POLLUTANT SOURCE IDENTIFICATION

Tracking all the harmful chemicals entering the Lower Columbia River from multiple point and non-point sources was impossible due to pollutant source and instream informational data gaps. Our strategy for producing the most useful body of pollutant source information was to divide the data sources into two categories: first, those sources which provided data from which reliable pollutant load estimates could be ascertained, and second, those sources which provided data from which only qualitative, or 'pollutant identity' information could be obtained.

SOURCES OF QUANTIFIABLE POLLUTANT LOADS

Municipal and industrial point sources (PSs)

Municipal and industrial point sources (PSs) which regularly provide waste water monitoring reports to State agencies (like Ecology and ODEQ) through the National Pollutant Discharge Elimination System (NPDES) were one of two pollutant source types from which useful data could be retrieved for making pollutant load calculations.

We evaluated all of the LCR Basin major and minor Individual NPDES permittees' waste water discharge monitoring reports (DMRs) for 1993, except those minor facilities above Willamette Falls (due to time constraints). General Permittees were not included because they were not assumed to represent proportionately significant contributions of water column pollution when compared to the major and minor facility discharges. All available metals and organics DMR data was evaluated, as well as many conventional parameters such as temperature, pH, total suspended solids, and biochemical oxygen demand (BOD).

In an effort to identify potential unmonitored pollutant loads from Oregon and Washington NPDES facilities, comparisons were made to loads based on National Averages (NOAA). This data gap is the result of limited waste water monitoring and reporting requirements which do not necessarily account for cumulative pollution, and do not require facilities to regularly report on all of the contaminants which they may be discharging. Estimates were made for eight metals on the 'Bi-State list of chemicals of concern' and also included Oil and Grease, Suspended Solids, Biological Oxygen Demand and Fecal Coliform Bacteria.

Urban stormwater runoff sources

Urban stormwater runoff sources were the second major type of pollution source to the LCR Basin which presented an opportunity for quantifying pollutant loads. Annual and monthly load estimates for metals and organics were calculated from data provided by the following municipalities: the City of Portland (Metro Area), the City of Gresham (Metro Area), Clackamas County (Metro Area), and the Unified Sewerage Agency (Metro Area plus portions of Washington County). The data originated in all cases from actual measured stormwater sampling results required by NPDES permits.

Urban stormwater runoff pollutant load estimates were also calculated for other cities which are not currently required to submit a NPDES Stormwater Permit to EPA: The Urban Growth Boundaries of St. Helens, Vancouver, Camas, Washougal, and the City of Longview were included. Metal and organic loads were extrapolated from the permitted municipalities data using typical runoff load estimates according to local land use types and areas, and precipitation data.

Eugene, Corvallis, Albany, and Salem were not included in either the Willamette River or Columbia River mass balance equations due to the lack of usable data. All of the major urban areas along the Lower Columbia River above the estuary were included in this evaluation.

FINDINGS

Point Sources:

The greatest pollutant loads from identified waste water discharges of Organics, Conventionals and Metals to the LCR Basin came from the Willamette River point sources. Adsorbable Organic Halides (AOX) were not monitored for regularly by all facilities, but appear to be discharged predominantly to the LCR mainstem.

Based on 1993 inventoried data:
- 52% of the point source waste water discharge volume is coming from sewage treatment plants,
- 39% from paper and allied products
- 5% from chemical and allied products
- 3% from primary metal.

However,
- 71% of the suspended sediment load to the LCR Basin from point sources came from the paper and allied products industry
- 26% from sewage treatment plants
- 1% from the chemical and allied products industry.

The total annual average point source waste water discharge of 500 million gallons per day (MGD) is less than 2% of the discharge from the five largest Lower Columbia tributaries (30,000 MGD) and less than half of a percent of the Upper Columbia River discharge (120,000 MGD).

The lack of waste water load data from minor facilities above Willamette Falls and all facilities above Bonneville Dam and the lack of frequently reported Organic and Metal pollutant data make it difficult to accurately identify all point source contributions to the LCR Basin.

A comparison of Oregon NPDES facility waste water discharges with national averages suggest that there may be a significant load of pollutants being discharged to the LCR basin waterways which is not regularly monitored for, and for which little or no direct information was obtained for this report. These comparisons with national averages involved only twelve specific pollutants (9 metals and three conventional parameters) and grouped facilities into SIC designations which may not provide perfectly matched waste water processes. Therefore, this portion of the study can provide indicators only.

Stormwater Runoff:

Stormwater runoff load estimates were variable within and between urban areas and thus represent only order of magnitude predictions. River segment comparisons showed that the Willamette River contributes the greatest urban stormwater runoff load for nearly every identified pollutant to the LCR Basin. Urban stormwater runoff contributes more of the total load to the LCR Basin than the identified Point Sources for most of the Organics and over half of the Metals (Rural non-point source contributions were not quantified, but for some pollutants rural areas may be the largest source).

Between-Tributary Comparisons:

Metals quantified in suspended sediments as well as the dissolved phase appear to enter the LCR predominantly from the Upper Columbia River (UCR), followed by the Willamette River, followed by the Cowlitz River. The magnitude of the suspended sediment load is strongly dependent on river flow (Q). Both flow and suspended sediment load are powerfully associated with the magnitudes of the metals that they carry. However, metal loading from the UCR and the tributaries is variable, suggesting a variety of sources like metal-rich soils or point sources. Water Column organics was limited to pesticides and Total Organic Halides (TOX). Pesticides were measured more often and detected much more often in the Willamette River than any other tributary or the UCR. TOX inputs appear to originate predominantly from the LCR mainstem industries. A Willamette River Basin inventory indicated that 56 of the 102 Bi-State 'Chemicals of concern' were detected between 1985 and 1995, mostly in smaller streams of the Willamette River Basin. Similar information on other tributaries has not been gathered.

Water Temperatures

The instantaneous water temperatures measured during the three summer months of 1994 were generally similar at the main stem sampling sites and exceeded 20 °C during July and August. Between July and September the Willamette River was generally the warmest tributary entering the LCR with temperatures upward of 24.2 °C. The Lewis and Kalama Rivers were the coldest tributaries entering the LCR with temperatures downwards of 14.3 °C and 15.8 °C respectively.

Dissolved Oxygen

Between 1972 and 1994, when compared to earlier years, the Willamette River at Portland saw an increase in dissolved-oxygen concentration during the three summer months, probably due to the releasing of water from dams during summer navigation and the upgrading to secondary treatment levels of waste water discharges. In general, every month except July through September saw dissolved-oxygen concentrations within 10% of saturation. July through September are low flow months and the water column monitoring data indicated lower dissolved oxygen due to higher temperatures, point and non-point sources placing a biochemical demand on the river, and higher biological respiration due to increased temperature.

Total Dissolved Gas

Total dissolved gas (TDG) saturation in the water column is caused by the spilling of water from dams. The US Army Corps of Engineers has been measuring TDG since 1984 and has historically seen the highest levels between April and July because the stream flow exceeds the capacity of the hydropower turbines and the dams have to spill water. In 1994, between July and

August, higher TDG values were measured above standards due to the spilling of water for out migration of anadromous fish.

Water Quality Standard violations for more than one <u>fecal-indicator</u> test were measured several times in 1994 in the Willamette River near Portland and the Columbia River at Beaver Army Terminal especially during September, January, April, October, November, and December.

<u>Point Source vs Urban Runoff vs Water Column Pollutant Loading</u>

In pollutant load comparisons made for the mainstem Lower Columbia River and its tributaries, a majority of the pollutants were unaccounted for by point sources and urban runoff. Unaccounted source loads would include unmonitored point sources, urban stormwater runoff, combined sewer overflows, in place sources (such as landfills, hazardous waste sites, etc) and other nonpoint sources. Of the total source loads, the Upper Columbia River loads, measured at Warrendale (USGS station), represented the greatest percent pollutant contribution (up to 138%). Eight metals originating from point and urban stormwater runoff sources were measured at greater than 10% of the total tributary and/or LCR mainstem loads on numerous occasions, particularly during dry months. Of these eight metals, four exceeded 100% of the river loads as measured at Beaver Army Terminal, signifying that some pollutant loads are either leaving the watershed system or <u>entering sinks</u> within the LCR basin.

<u>Dioxin/Furans:</u>

147 facilities were identified, using SIC codes identified by BCI (1990), as having the potential of releasing chlorinated Dioxin/Furans into the environment; 49 discharge to the Upper Columbia River (not including Canadian sources), 57 Discharge to the Lower Columbia River (or a tributary other than the Willamette) and 41 discharge to the Willamette River. 14% are either pulp/paper mills or sawmills, 3% are wood treaters, 66% are sewage treatment plants and 17% are other assorted industries. Of the 57 facilities discharging to the Lower Columbia River or one of its tributaries (excluding the Willamette), 65% were located in Washington and 35% were located in Oregon. Facilities located on the Willamette river account for 28% of the identified facilities with the potential to release chlorinated Dioxin/Furans.

<u>PCBs:</u>

55 Environmental cleanup sites in the State of Oregon, and 13 sites in the State of Washington contain PCB contamination in either groundwater, sediment or soil which may have the potential to impact the Lower Columbia River. In general, industries that have large electrical demands are a potential source of PCB contamination. According to Bill Hedgbetch (EPA), the large industries such as the pulp and paper and metal companies have replaced PCB contaminated oils whereas the smaller industries like plywood mills, wood treaters, sawmills and most of the dams on the Columbia River still have electrical equipment that contain the PCB laden oils and pose the current threat of PCB contamination to the Lower Columbia River Basin.

DDT:

USGS detected and quantified DDE and DDT at Willamette R.M. 9.1 in 1977, with highest levels of many of the same first generation pesticides detected in 1982 at R.M. 7.1 (Doane Lake). A high concentration of DDT (2700 ug/kg) at Willamette R.M. 7.1 as well as a high proportion of DDT, compared to its associated analogues, suggested a recent movement of DDT into the harbor. (Rosetta, 1993) In 1988 the U.S. Geological Survey in the process of completing the National Water-Quality Assessment Study, detected DDT in 72 percent of the sites sampled in the Yakima River or one of its major Tributaries. (USGS Geological Survey Circular 1090) The authors of a 1988 USGS report noted that DDT and metabolite concentrations measured in Johnson Creek exceeded those documented for one of the most agriculturally affected areas in the U.S.: Yakima River Basin, Washington.

Even though DDT has been banned since 1972, the Washington Coalition believe it is being illegally used in several areas within the Lower Columbia River Basin. In three Oregon Voluntary Agriculture Pesticide Waste Collection events (1991, 1993 and 1995), a total of 21, 546 lbs of DDT (including mixtures) were collected.

Sources of Unquantifiable Pollution

Oregon and Washington Environmental Clean-up sites

336 Environmental Clean-up sites were identified in the Oregon counties of Clackamas, Clatsop, Columbia, Multnomah and Washington. 40 Sites have surface water contamination, 18 have sediment contamination and 148 have ground water contamination. A list of 185 pollutants were compiled from these sites, 66 of which are on 'Bi-State List of Chemicals of Concern'. The mediums where pollution was found (and the corresponding number of chemicals identified in each) includes: Air (4), Groundwater (10), Leachate (3), Sediment (53), Soil (152), Surface Water (51), other (34). Note: sampling was only completed within property boundary.

Within the Washington counties of Clark, Cowlitz, Lewis, Pacific, Skamania, and Wahkiakum, 112 Environmental Clean-up sites were identified. 29 have drinking water pollution, 91 have groundwater pollution, 39 have surface water pollution and 11 have sediment pollution. Pollution was also found in the air and soil. Specific identification of the pollutants found was not possible from the Washington database because the pollutants were grouped into categories. The categories where pollutants were found include: Base/Neutral/Acid Organic, Halogenated Organic Compounds, EPA Priority Metals and Cyanide, other-Metals, PCBs, Pesticides, Petroleum Products, Phenolic Compounds, Non-Halogenated Solvents, Dioxin, Polynuclear Aromatic Hydrocarbons (PAH), Reactive Wastes, Corrosive Wastes, Conventional Organic and Inorganic Contaminants and Asbestos.

Oregon Landfills

Six landfills in the identified Oregon counties were identified with pollution. A total of 25 contaminants were found of which 11 were identified on Bi-State List of 'Chemicals of Concern'. The mediums where pollution was found (and the corresponding number of chemicals identified in each) includes: Groundwater (17), Leachate (3), Sediment (4), Soil (2), Surface Water (6), other (8).

In Oregon, 17 operating municipal or industrial solid waste landfills (including pulp/paper and demolition) were identified in the above counties.

Twelve Washington Landfills were identified by Tetra Tech in 1992. Additional work is under way to compile a more recent list of Washington landfills with the potential of polluting the LCR Basin, but is not available at this time.

Oregon Underground Storage Tanks

2410 Underground Storage Tanks (UST) incidences occurred within the identified Oregon counties between 1980 and 1993 with 792 directly impacting drinking water, ground water or surface water. 1618 of the total UST incidences have been either cleaned-up or are under control. The remaining 792 incidences are ongoing or their status is unknown. 13 material mixture spills were reported and include: bunker oil, diesel, fuel oil, heating oil, leaded gasoline, unleaded gasoline, misc. gasoline, other petroleum products, waste oil, lubricant, chemical and other. The impacted categories include: drinking water, ground water, surface water, soil, facility vapor and unknown.

Oregon Criteria Air Polluters

For 1993, 104 facilities were identified in DEQ's_Air Contaminant Source Identification System (ACSIS), releasing either particulate, carbon monoxide, sulfur dioxide, nitrogen dioxide, volatile organic compounds or lead in the Oregon Counties of Clackamas, Columbia, Multnomah and Washington (81 facilities release Volatile Organic Compounds). Facilities located in Portland, St. Helens, West Linn and Forest Grove contribute a large portion of the criteria pollutants to the area.

Oregon and Washington Toxic Air Polluters

In 1993, a total of 139 Oregon and Washington facilities reported to EPA's Toxic Release Inventory (TRI). 89 facilities reported releasing a combined total of 69 pollutants (11 identified on 'Bi-State Chemicals of Concern') to the atmosphere in the 5 identified Oregon counties. 50 facilities reported releasing a combined total of 47 pollutants (10 identified on the 'Bi-State List of Chemicals of Concern') in the 3 identified Washington counties.

Between the years of 1992 and 1995 the U.S. Coast Guard reported 343 individual spill incidents in the LCR in which 39 pollutants were identified. For the same years 298 spill incidents occurred in the Willamette River in which 47 substances were identified. In a majority of the spills the identified substances were complex mixtures such as gasoline or diesel oil.

Oregon Hazardous Waste Generators

In 1993, 83 Hazardous Waste Generators were identified in Oregon and contained a combined total of 22 toxic pollutants (8 were identified on the 'Bi-State List of Chemicals of Concern').

RURAL NONPOINT SOURCE MODELING

Global Information System (GIS) based modeling is being undertaken to better estimate pollutant loads originating from non-point sources. SWAT (Soil and Water Assessment Tool), a basin scale water quality model developed and used by the National Oceanic and Atmosphere Association (NOAA) throughout the coastal areas of the U.S., has been chosen and initial data conversion has begun. The model utilizes inputs such as soil type, elevation contours, vegetation cover, land use, weather conditions, and stream reach and flow. The Willamette River Basin has been selected as the Pilot and upon successful completion the remaining Lower Columbia River Basin will be modeled.

INTRODUCTION

Just beyond the Columbia River Estuary, approximately 60 to 160 billion gallons of water poured into the sea every day out of the Columbia River over the course of 1994. And this was considered to be a 'low-flow' year, relatively.

From its headwaters in Canada, the Columbia River winds its way more than 1200 miles, south through Washington State, picking up the Snake River, and then heading west forming the Washington/Oregon border until it joins the Pacific Ocean. And each gallon, of the billions of gallons of water which arrive at the estuary daily, represents a composite (or mixture) of water from the entire length of the Columbia watershed system. In other words, each sample of water contains discharged chemicals from all of the major and minor point sources, as well as additions of non-point source pollution, either from urban, agricultural, or forested areas, or from atmospheric deposition.

It is now of paramount importance to better understand the sources of pollution to the LCR Basin and estuary, and where possible, to reduce pollutant loads which are regularly entering the watershed and posing danger to organisims. Evidence exists that upper food-chain animals including the American Bald Eagle, and some species of mink and river otter are being adversly affected by water contaminants in the Lower Columbia River Basin (LCR Basin). Many species of fish, including salmon, are showing detectable levels of dioxin/furans, PCBs, various pesticides, and other organic pollutants. Nearly 70 individual Salmon stocks are permanently gone, with about that same number in jeopardy.

Tracking all of the harmful pollutants entering the Lower Columbia River from innumerable point and non-point sources is realistically impossible at this time due to pollutant source and instream informational data gaps. And, due to its size and complexity, it is difficult to obtain a reliable and meaningful picture of the presence and impacts of toxics in the Basin. Characteristics of terrain, geology, hydrology, and ecology, are all highly variable throughout the region, along with seasonal and daily fluctuations of flow volume, suspended sediments, and other measurable parameters which may affect or contribute to toxicity of pollutants.

Research has conquered a lot of the chemistry associated with identifying industrial and municipal discharges, but full knowledge of waste water effluent characteristics on a day to day basis is limited. Further more, quantities of many chemicals are assumed to be much greater coming from non-point sources originating from urban or rural landuse practices. Little data is available at this time to accurately estimate percent load contribution breakdowns amongst various pollutant sources. Modeling options have been researched, and non-point source pesticide discharge modeling is currently underway in order to fill some of the important data gaps.

Our knowledge of ambient (in-stream) toxic impacts is even less solid and more debatable, particularly when trying to define the multi-chemical additive and cummulative effects potentially experienced by organisms in the LCR Basin. This is an area which requires further consolidation of the information we do possess, and important additional research.

Nonetheless, understanding locations and quantities of pollutant inputs, as well as the watershed dynamics which mold their fate, and the health of the organisms which may be affected, will be the key to resolving and continuing to resolve the human-induced pollution problems of the LCR Basin.

Objectives

Information gathering and evaluations conducted for this project were built on previous work done by Tetra Tech, U.S. Geological Survey (USGS), and other agencies and research groups. All available water column data was utilized for calculations and in-place sources listed, while other Bi-State monitoring data from sediment and fish tissue, though available, was only used for reference purposes in this report.

The main objectives include:

1. To quantify recent pollutant loads (or levels of parameters of concern) to the LCR (below Bonneville Dam). Approximately 100 chemicals of concern (metals, organics, and conventionals; see Table 1.) were prioritized to be inventoried for this review.

   This 'Bi-State list of chemicals of concern' was identified by Tetra Tech in respect to constituent exceedances of water, sediment, and/or tissue reference values established to protect aquatic life, and/or in respect to exceedances of human health risk-based screening values for consumable fish.

   The following conventional parameters were also inventoried: loads for Enterococcus bacteria, fecal coliform bacteria, B.O.D. (Biochemical Oxygen Demand), TSS (Total Suspended Solids), and TDG (Total Dissolved Gas), and levels for, D.O. (dissolved oxygen) concentration, Ph, and temperature.

2. To present as much of the collected information as possible in a format which identifies source types and locations, pollutants of interest, load quantities where feasible, and load contributions (%) of the total load for the specified metals, organics, and selected conventional parameters.

3. To identify the metal and organic chemicals (from the 'Bi-State list of chemicals of concern') from sources for which data was insufficient to calculate loads.

4. Describe data gaps.

5. To provide a usable data base of source information pertaining to toxics and related chemical parameters.

Scope of Work

This report is divided into five Sections:

1. NPDES point source (PS) waste water discharge identification and quantification;
2. Urban stormwater runoff quantification;
3. Tributary water column loading comparisons, including between-tributary comparisons, and percent load contribution comparisons between PS, urban stormwater runoff, and unidentified sources;
4. Investigative studies on potential sources of dioxin/furans, PCBs and DDT; and
5. 'Other' in place sources of identified pollutants, with information retrieved from several data bases, including the Environmental Cleanup Site Information System (ECSI), the Toxics Release Inventory (TRI), the Underground Storage Tank Information System (UST), DEQ's Solid Waste Information System (SWMS), and the Air Contaminant Source Identification System (ACSIS).

Each section is self-explanatory, and each addresses pollutant sources from a different perspective, providing some of the pieces of the LCR pollution puzzle, utilyzing available data. A breakdown of potential pollution source types, arranged in association with each of the five major tributaries and the LCR main-stem stations for which they may provide upstream pollutant discharges, is presented as a mass balance scheme in Figure 1.

Recommendations for policy changes or additional research needs are also addressed in accordance with these evaluations for each Section.

SECTION 1.1 Point Source Discharge Identification and Quantification

Overview

Discharge Monitoring Report (DMR) waste water discharge data was obtained for all Major and Minor NPDES facilities discharging to the Lower Columbia River mainstem and it's tributaries below Bonneville Dam, for the following counties: Pacific, Wahkiakum, Cowlitz, Lewis, Skamania, Clatsop, Columbia, and Multnomah. All other Major NPDES dischargers to the Willamette River Basin were also included in this inventory.

Compiled waste water sampling data includes conventional parameters (excluding nutrients), and also all available metals and organics data. Parameters with an asterick in Table 2 are the 50± that Tetra Tech identified as known or suspected to be present in water, sediment, or fish tissue that may be impacting fish, wildlife or human health in LCR.

1993 DMR waste water flow and pollutant concentration data for NPDES dischargers to the Lower Columbia River Basin (LCR Basin) were retrieved from Washington State DOE's WPLCS (Water 'quality' Permit Life Cycle System) data base. Similar 1993 DMR pollutant data for the Oregon side of the Columbia River was retrieved from DEQ's source files in order to calculate pollutant loads.

Dioxin and furan waste water data reported by three pulp and paper industries on the Washington side of the LCR was retrieved from the Washington Industrial Region office. This data represents monitoring measurements taken between 1992 and 1995.

Relevant 1993 toxics scans (Form 2-C) of effluent wastewater were also retrieved from both Oregon and Washington State source files for the inclusion of available reporting of irregularly monitored parameters.

All of the data was arranged in MS ACCESS, and was set up to allow quick and accurate delineations of parameter loads according to location (River segments as established by Tetra Tech by the Bi-State Program), Industrial type (using designated SIC codes), size (Major vs Minor), and other classifications.

Treatment of Data

Loads (Lbs/day) were calculated using discharge flow volumes and waste water pollutant concentration values for each facility (if loads were not already listed in DMRs). 1/2 the detection limit was used in calculations where non-detects and detects were identified. If no detections of a particular pollutant was reported during the investigated time period at all, then a value of zero was assigned for the concentration and load. This is consistent with Tetra Tech's method. Dioxin and Furan loads were calculated using 1/2 the detection limit for all cases due to limited monitoring data availability.

Data Limitations and QA/QC

DMR's are completed according to each facility's permit requirements. Therefore, if a facility did not report a specific parameter in its DMR, this does not necessarily mean it was not releasing that compound.

Samples of the WPLCS DMR data have been checked against the original paper files at Lacey, WA. Several minor inputting errors have been corrected. The biggest problem encountered has been that some entire groups of data were left out of the WPLCS system. This has been remedied.

OR DMR data input into our database was randomly checked against the paper file entries where it originated. Data reliability was also checked when certain queries were built. If a particular parameter was extremely high or low the source files were checked for clarification.

Specific Facility information, including: ID#, Name, Location, Latitude and Longitude, Type (Industrial or Domestic), Size (major or minor), River Segment code representing where discharged pollutants enter the Columbia River, and specific receiving stream code are presented in Appendix A.

Results and Conclusions

Of the 119 facilities inventoried for this report, 76 were located in Oregon and 43 were located in Washington (Table 2). 50 discharge to the Willamette River or one of its tributaries, 28 of these 50 are major facilities located above Willamette Falls (Table 3). 41 facilities discharge directly into the Lower Columbia River and the remaining 28 discharge into one of the four inventoried tributaries. NPDES facilities inventoried for this study collectively measured for a total of 107 different types of pollutants: 23 metals, 71 organics and 13 conventional parameters (Table 4).

Further designations were made by breaking the Lower Columbia River mainstem into 10 segments, as designated by Tetra Tech, in order to better locate the sources of pollutants Table 5 and Figure 1a). Table 6 lists the total number of facilities from Oregon and Washington discharging into each segment. River Segment 3B was influenced by 50 facilities, all of them located on the Willamette River. River Segments 2C and 4A were next with 18 and 19 facilities respectively. Table 7 lists the number of facilities discharging to the Lower Columbia River and its Tributaries.

One further designation was made to determine which types of industry are most abundant in the Lower Columbia River Basin (Table 8). There are 17 different industry types inventoried impacting the Lower Columbia River . 65 dischargers are designated electric and sanitary services (3 Electric Services and 62 Sanitary Services), 13 paper and allied products and 10 primary metal industries. These three general industry types account for 74% of the facilities inventoried. Of the 65 electric and sanitary services, 23 discharging to segment 3B, 12 discharging to segment 2C and 8 discharging to segment 3A. 7 of the 13 paper and allied products and 6 of the primary metal industries are discharging to river segment 3B. This inventory clearly shows that the Willamette River has a great point source influence on the Lower Columbia River.

Pollutant load contributions were summed from average annual daily waste water loads (lbs/day) for all facilities, and grouped initially into four separate pollutant type categories: 1) Organics, 2) General Organics, 3) Metals, and 4) Conventionals (see Table 4.). A summary of percent load contributions by river segment is presented in Table 9.

Tables 10, 11, 12, and 13 present pollutant loads (Lbs/day) by river segment for organics, general organics, metals, and conventional parameters, respectively. Percent totals by river segment (bottom row of each Table) are also graphically depicted in figures 2, 3, 4, and 5, respectively. Corresponding tables 10a, 11a, 12a, and 13a exhibit percent loadings across river segments for each specific pollutant.

Organics (Table 10), Metals (Table 12) and Conventionals (Table 13) contributed the greatest load to river segment 3B while General Organics (Table 11) contributed the greatest load to river segment 3A (as shown in Table 9). Since these **categories** consist of several pollutants, it is important to look at each categories load and percent load tables to see which pollutant is contributing the greatest weight to the overall river segment load. For example in Table 10, which lists the load of individual pollutants in the Organic category, Bis(2-ethylhexyl)phthalate contributes 1147 lbs/day to the 2723 lbs/day total load to river segment 3B (42% from table 10a). Chloroform contributes 34%, and Toluene contributes 17% to the total load to river segment 3B. For Conventionals, Total Dissolved solids contribute 61% and Total Suspended Solids contribute 23% to the total category load to river segment 3B. Total Fluoride contributes 42%, Total Zinc contributes 18% and both Total Boron and Dissolved Zinc contribute 9% each to the total Metal Load to river segment 3B. For General Organics Total Toxic Organics contribute 62%, Oil & Grease contribute 20% and Absorbable Organic Halides contribute 18% to the total category load to river Segment 3A.

The greatest contributing river segment for each category is not always the same as the individual pollutant within the category. Looking at the percent pollutant for each Category by river segment gives an idea of which segment is being significantly affected by which pollutant. For example, 41% of 2,3,7,8 TCDF total load is discharged into river segment 3A and only 3% discharged into river segment 3B. Other pollutants where the greatest discharge to a river segment is different then their corresponding Organic categories include: Benzo(a)pyrene, Di-n-butyl Phthalate, 2,3,7,8 TCDD, Phenanthrene, Phenol and Total Phenolics. Absorbable Organic Halide is the only General Organic that discharges a greater amount to a river segment other than 3B. For, Metals Total Aluminum, Total Cobalt, Total Copper, Total Lead and Total Magnesium contribute a greater load in a designated river segment other than 3B. Biological Oxygen Demand is the only Conventional parameter that contributes a greater load to a river segment other than 3B.

Tables 14, 15, 16, and 17 provide percent load breakdowns for each pollutant type category, respectively, by facility type (SIC designations) and by river segment. The far right column of each table (Grand Total) lists the percent pollutant load contribution to the total load from all industry type categories. Appendix A contains a break down of each facility by SIC General

Code definition. Specific SIC code numbers are also included for a more exact identification of each industries primary activities. Tables 14(a) through 17(l) correspond to Tables 14 through 17 in respect to Pollutant Type categories, with suffix 'small letter' designations for each industrial type (by SIC), and present loads (Lbs/day) for specific pollutants across river segment designations. For example, Tables 14(a) through 14(g) present specific 'organic' pollutant loadings by river segment for individual facility types.

In the pollutant category by Facility Type comparison the Electric and Sanitary Services contributed the greatest Load to the Organic (Table 14) and Metal Categories (Table 16). Paper and Allied Products industry contributed the greatest Load to the General Organic (Table 15) and Conventional Categories (Table 17). 52% of the inventoried point sources' waste water discharge flow volume is coming from sewage treatment plants, 39% from paper and allied products, 5% from chemical and allied products and 3% from primary metal industry (Figure 5a). However, 71% of the suspended sediment load to the Lower Columbia Basin from point sources came from the paper and allied products industry, 26% from sewage treatment plants and 1% from the chemical and allied products industry (Figure 5b). There is a clear distinction between which facility type is having the greatest impact on a particular river segment for each of the four categories. Once again each category consists of several pollutants of which one may be contributing a greater weight than the others. Thus, it is essential that the break down by industry type tables are consulted.

The above comparisons were completed to get an idea of where the pollution to the Lower Columbia River is coming from and to identify which sections of the river are receiving the greatest industrial influence. Looking at the larger picture of the overall report, the point source load estimates will be used in Section III for mass balance calculations.

Findings

The greatest loads of Organics, Conventionals and Metals to the LCR came from the Willamette River. Lack of load data from minor facilities above Willamette falls and all facilities above Bonneville Dam make it impossible to accurately identify all point source contribution to the LCR. Also, Organic and Metal pollutants data were not frequently reported, depending on permit requirements, but Conventional pollutants were regularly reported. This severely limits the quality of the Organic and Metal data used in the annual load calculations and makes it impossible to determine loading for all 100+ chemicals identified in the Tetra Tech report. Conventional parameter load data can be viewed as accurate.

Recommendations

1. Calculate loads for all minor facilities above Willamette Falls and all facilities located above Bonneville Dam.

2. Compare point source load results with Tetra-Tech's fish tissue and sediment sampling data to determine if contaminated fish or sediment locations correspond to point source hot spots.

3. Use available documentation pertaining to potential sources of chlorinated dioxins and furans in order to design and implement a monitoring program for improved tracking of these pollutants in the Lower Columbia River Basin.

4. DEQ and Ecology should gather and review all relevant water column monitoring data (i.e., mixing zone studies, dilution studies, or other special ambient monitoring studies required by permits) submitted by NPDES permittees. In cases where such data has not been collected, DEQ and Ecology, in cooperation with all municipal and industrial permit holders should require periodic ambient measurements of those pollutants found in the permittee's discharge upstream and downstream from the permittee's outfall to better determine the fate and transport of those pollutants in receiving waters in relation to background levels. This could be accomplished as a permit renewal requirement.

5. Establish a system to expand monitoring of permitted point source dischargers, as required, to include a "beneficial uses impact analysis" and to identify the concentrations and loading contribution of all possible pollutants discharged (conduct full-scan analysis of effluent). This would be required at least once for all permittees and periodically for the Major permittees.

6. DEQ and Ecology should assess the cumulative impacts of General Permitting discharges on receiving water. General permittees were excluded from the 1993 inventory (which included Major and Minor permittees). Most General permittees do not report their discharge volume making load estimates impossible using traditional means (Concentration of pollutant times discharge volume).

7. Substitute 'toxic equivalent' values for pollutant loads (Lbs/day) in making comparisons of potential NPDES discharge impacts in respect to river segments and industry types.

8. NPDES DMR Data reporting requires:

   - Uniformity and clarity in titling monitored pollutants. Data bases are being developed to handle large fields of point-source data and they will need precise constituent identities for entry and retrieval purposes.

   - Inclusion of detection limits in DMRs. This will be important for load calculations (useful in TMDL analysis) which are based on detection limits in cases where pollutants are not detected.

   - Full use of NPDES discharge monitoring report (DMR) data requires uniform and accurate use of '<' (and'>') signs in Discharge monitoring reports. These designations can greatly influence load calculations which are usually estimated using the detection limits in the case of non-detected parameters. These reports should also include a regularly administered QA/QC program.

- Computer disk DMR reporting for easy entry of monitoring data into data bases such as DMS (Discharge Monitoring System). This would enable automatic flagging of permit limit exceedences, more immediate access to data, timely permittee notification of necessary compliance actions, comparative analysis of monitoring results, facility performance tracking, and other efficient data audits, surveys and reviews. An <u>annual summary</u> could be submitted on paper to reduce filing.

SECTION 1.2 NOAA (National Oceanic and Atmospheric Association) Comparisons.

Overview

Measured LCR Basin point source loadings for 12 monitored conventional and heavy metal pollutants were compared to 'potential' loadings for the same set of facilities [evaluated pollutants included: Oil & Grease, Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Mercury (Hg), L:ead (Pb), Zinc (Zn), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and Fecal Coliform Bacteria (FCB) [excluded parameters: Total Phosporous and Total Nitrogen]. Potential loadings were calculated from 'typical' pollutant concentration estimates obtained from NOAA's 1991 National Coastal Pollutant Discharge Inventory (NCPDI).

The two objectives of this exercise were: 1) To make comparisons and estimate the relationships between monitored waste water pollutant loads and typical waste water pollutant loads for facility types (by SIC code designation); and, 2) Identify and estimate quantities of pollutants which may be discharged but for which monitoring is not done. These comparisons are only intended to provide indicators of possible additional NPDES point source pollution.

The rationale for using 'typical' pollutant values for comparative purposes stems from the assumption that different facility types (by SIC code) release predictable types and amounts of pollutants in their waste water discharges. For example, NOAA estimated that a typical pulp and paper facility (SIC code: 2621) released a 28.4 mg/L concentration of Total Suspended Solids (TSS) and a 0.03 ug/L concentration of chromium (Cr); sewage treatment plants (SIC code: 4952) typically released a 22.1 mg/L concentration of TSS and a 0.043 ug/L concentration of Cr (amongst other pollutants).

NOAA's inventory included effluent discharge information for NPDES facilities (year 1991) from 735 counties in 29 coastal and Great Lakes States (both coasts). Typical pollutant concentrations for different facility types were calculated utilizing data from discharge monitoring reports (DMRs) retrieved from the Permit Compliance System data base, permit limits, permit application and renewal information on 168 pollutants, and EPA development documents.

All of the NOAA estimates for heavy metals resulted from the analysis of the 'total' metal in each case. In a few cases where LCR Basin facilities measured for 'total recoverable' instead of 'total', 'total recoverable' values were substituted for comparisons to NOAA values, providing a conservative (or lower than expected) estimate of the 'total' metal for comparison to NOAA data.

Treatment of Data

Waste water pollutant loads were calculated in accordance with the equation: Load = Pollutant Concentration X Flow ; where Load = Lbs/day, Pollutant Concentration = mg or ug/L, and Flow = Million Gallons /Day (MGD). For the NOAA load estimates, the actual Oregon or Washington facility waste water discharge flows were plugged into the equation along with the corresponding NOAA pollutant concentration estimates (by SIC code) for each facility. This allowed for the direct comparisons of actual pollutant loadings calculated from measured concentrations (DMR loads) to predicted pollutant loadings calculated from 'typical' concentrations (NOAA loads). P-factors (pipe-factors) were used where appropriate to modify the data in order to account for multiple outfall discharges.

A NOAA waste water pollutant load for a parameter specifically monitored for by a LCR Basin facility was defined as a 'matched' load. For example, a facility with the SIC code 2231 monitored for chromium and measured an average annual load of 0.26 lbs/day. Using the NOAA typical chromium concentration of 0.4 ug/L for SIC code 2231 resulted in a 'matched' load of 1.12 lbs/day. These two values composed as a ratio (DMR load/matched load) equal 0.23, and give an indication of how well the two numbers agree; a value of '1' would show absolute agreement, < 1 could mean better than average treatment by LCR Basin facilities with SIC code 2231, and > 1 could signify the opposite.

A NOAA waste water pollutant load for a parameter not specifically monitored for (or never measured at above detection limits) by a LCR Basin facility was defined as an 'unmatched' load. For example, NOAA estimated that 0.06 Lbs/day of copper would be discharged by a specific facility with SIC code 2231, using that facilities effluent discharge value. Since copper was not monitored for by this facility for (or never measured at above detection limits), this load is 'unmatched', and represents potentially, an additional load to the LCR Basin.

Data Limitations and QA/QC

The NOAA estimates for typical waste water pollutant loading originated from a massive amount of data gathered from several sources, as described. The entire data set was designed to provide comprehensive information on effluent discharges, with attention paid to removing data gaps. Error could have resulted from initial analysis or reporting mistakes, data transfer, and/or data calculation errors. NOAA performed fairly extensive QA/QC on pollutant numbers. Sets of data were checked for anomalies, utilizing coefficients of variation to remove numbers which appeared outside normal ranges. At best, the numbers provided by NOAA represent typical or average values and should be used as indicators only but could also point out Oregon and Washington facilities that are discharging pollutants under national averages.

DMR data QA/QC is described in the Point Source Section of this document; data is expected to be good. The same types of errors that could impact on the NOAA numbers could be seen here as well, since both data sets have their roots in DMRs.

Comparing the DMR data collected for the LCR Basin to the NOAA estimates presents inherent problems which can only be resolved by verification monitoring. Continual progress is being made in detoxifying effluent discharges: we are comparing 1991 NOAA data to measured 1993 DMR data, a two year time lag. Same facility-type industrial processes can also vary significantly between separate factories. This can occur due to regional practices and limitations, and individual progress in the latest and cleanest manufacturing processes. The quality of the influent water used by facilities can also vary. This could affect the compliance monitoring requirements, and effluent pollutant concentrations.

Results and Conclusions

A comparison between the NOAA and actual DMR waste water pollutant loads is presented in Table 18. Where several facilities shared the same SIC code, their individual pollutant loads and corresponding NOAA matched and unmatched load estimates were summed. The last five lines of Table 18 exhibit the sum 'Totals' across all SIC code designations.

In general, total 'DMR load/matched load' ratios were less than '1' for the heavy metals; excluding mercury (total ratio = 3.07) for which data was extremely limited. This indicates that these monitored pollutants are probably being discharged at below the national average rates. East Coast discharges, which are expected to contain higher than West Coast pollutant concentrations, may be the cause of this.

The variability observed in NOAA/DMR load ratios suggests that these numbers are metal- and industry-type-specific comparisons, and will require verification. The total ratios are close to '1' for BOD and TSS. This is not suprising since these two parameters are the most monitored for, and thus possess the most reliable data for comparisons. Fecal Coliform Bacteria (FCB) displayed a total ratio of 14.54. This may or may not indicate that FCB is being discharged at more than ten times the national average.

The greatest proportion of unmatched loads, representing potential pollutant discharges not monitored for, appear to come from sewage treatment plants (SIC code: 4952), the pulp and paper industry (SIC code: 2621), the electronics industry (SIC code: 3674), and Electricity providers (SIC code: 4911).

Total unmatched loads are adjusted in the last line of Table 18 by factoring them against the total DMR/Matched ratio for each specific parameter. This was done on the assumption that the ratio relationship observed between the DMR and matched loads would likely carry across to unmonitored NOAA estimates. This remains to be proven and will require verification by monitoring.

Total unmatched loads (2nd line from bottom of Table 18) suggests that potential unmonitored loads for As, Cd, Cr, Cu, Fe, oil and grease, Pb, and Zn may far exceed the loads actually being monitored for. Total 'adjusted' unmatched loads greatly decrease this expectation, but still indicate that the actual point source loading of many pollutants could be twice as much (or more) than what is being measured for. Again, this will require verification.

Several facility types had no monitoring of any of the 12 evaluated pollutants. Their calculated unmatched waste water loads provide the only information available on their potential discharges. These facilities come under the following SIC code designations: 2671, 2819, 2899, 3273, 3317, 3369, 3537, 3624, and 3728.

Findings

Comparison of Oregon NPDES facility waste water discharges with National averages suggest that there may be a significant load of pollutants being discharged to the LCR basin waterways which is not regularly monitored for, and for which little or no direct information was obtained for this report. These comparisons with national averages involved only twelve pollutant parameters (9 metals and three conventional parameters) and grouped facilities into SIC designations which may not provide perfectly matched wastewater processes. However, comparisons between the most frequently monitored pollutants, such as TSS and BOD were exact and thus gives more credibility to the NOAA averages. This study can provide indicators only.

Recommendations

1. DEQ and Ecology, in cooperation with permit holders, should gather the most up-to-date waste water monitoring data for each major and minor NPDES permittee pertaining to the presence and concentrations of the 168 "priority pollutants". This data could include analytical data reported as a part of the permit renewal process (Form C), routine monitoring data, or other data collected as specified by each discharger's NPDES permit, such as special studies required as a condition of a permit. The data should be systematically reviewed keeping in mind that trace concentrations of persistent pollutants from several dischargers might cumulatively account for the presence in the Lower Columbia River of chemicals of concern to the Bi-State Program. Analytical methodology and detection levels should be specified.

2. Provide a central location for NPDES permit application/renewal scans, ideally in an electronic data base. Scans of this nature are the best source of comprehensive wastewater effluent information.

SECTION 2 Urban Storm Water Runoff Identification and Quantification

Overview

Urban runoff pollution results from numerous sources. It is the result of rainfall and snow melt that becomes contaminated as it travels through the atmosphere, along the land surface and makes its way to a water body. Water entering streams can come from storm water outfalls, combined sewer overflows or an unidentifiable source. Regardless of the point of entry, storm water carries many pollutants that can have a detrimental effect on the receiving waters. This effect becomes worse as urbanization increases due to the greater amount of impervious land which means greater quantities of urban run-off.

In an effort to quantify urban non-point source pollutant loadings to the Lower Columbia River the most recent investigative studies pertaining to Storm water pollution impacts were evaluated for the following municipalities including: City of Portland (Metro Area), City of Gresham (Metro Area), Clackamas County (Metro Area) and Unified Sewerage Agency (Metro Area plus portions of Washington County). Under regulation 40 CFR 122.26(d)(2)(iii) municipalities exceeding a population of 100,000 are required to collect quantitative data at between 5 to 10 storm water outfalls during three storm events at least one month apart. Sampled parameters include: Biological Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), Fecal Coliform Bacteria (FCB), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), metals, and organics. Storm Water Runoff Load Estimates were also included for other cities which were not required to submit an NPDES Storm Water Permit to EPA at this time. The Urban Growth Boundaries of St. Helens, Vancouver, Camas, Washougal, and the City of Longview were included. For each area of interest the quantity of acres by land use type and the impacted river segment is listed in Table 19.

Treatment of data

For the municipalities (Permitted cities), each outfall evaluated represents a specific land use type designation (depending on permit requirements). For example, USA classified an outfall as residential based on the major contributing land use type. Sampling was performed at each designated land use type outfall for the selected storm events and pollutant concentrations obtained. For purposes of the storm water estimate needed for this report, average concentrations were calculated from the data for each land use type.

Pollutant Loads were calculated in accordance with the equation: Load = Concentration x Flow; Load = lbs/year; Concentration (mg/l or ug/l) = the average concentration calculated for a pollutant detected by each municipality; Flow (mgd) = Run-off Coefficient x Acres Land Use Type x Average Annual Rainfall Amount/Storm x # Storm Events/Year. Runoff Coefficients are defined as the overall ratio of runoff to rainfall and are used to convert rainfall data to estimates of runoff volume by land use type. These coefficients are strongly related to the percent impervious land. The average annual rainfall/Storm amount is based only on those storm events that meet the minimum qualifications of greater than 0.1 inches in an inter-event time of 6 hours.

For the non-permitted urban areas, loads were calculated for each land use type using concentration/area estimates. Concentration/area estimates were obtained for city of Portland, Unified Sewerage Agency and Clackamas County by dividing each detected pollutants load by the area (for each land use type) and average rainfall amount. If a municipality did not detect or did not monitor for a constituent that was detected by another municipality, 1/2 the detection limit was used to obtain the concentration/area estimate. For example, if the City of Portland detected Mercury at 5 ug/l but Clackamas County did not, the 5 ug/l was averaged with 1/2 the detection limit of Mercury from the test performed by Clackamas County. For the four municipalities listed above, an average was taken to obtain concentration/area estimates by land use types which was used to calculate loads for the cities which did not have to file for a NPDES Storm Water Permit. Average Concentration/area estimates were used because they are thought to be representative of this area.

The Pollutant loads for the non-permitted cities was calculated by the formula : LOAD (lbs/year) = Land Use Area x Concentration/Area Estimate x Average Annual Rainfall/Storm x # of Storms. The average rainfall data gathered for each non-permitted city was not sufficient for determining storm statistics so a rain gauge having historical hourly rainfall data in Portland was selected to determine the monthly average number of representative storm events. Due to Geographical variations in rainfall amount per storm a regression was performed to adjust the difference between the Portland data and the study area. The underlying assumption is if a storm moved through Portland it was assumed the same storm also moved through the other areas. Table 20 lists the non-permitted cities rainfall statistics. The high R-square signifies good correlation between Portland and all the non-permitted cities monthly rainfall. The average rainfall/storm was greater than Portland's for every non-permitted city except Vancouver.

In an effort to establish the impact that Storm Water Runoff is having on the Lower Columbia River, comparisons were made between the Storm Water Runoff and Point Source Loads (excluding major facilities above Oregon City) identified later in the report.

Data Limitations and QA/QC

The Sampling techniques employed by each municipality were in accordance with standard EPA protocol and a strict QA/QC program was followed.

The Municipality Storm Water Runoff concentrations used to estimate pollutant loads are an average calculated for each parameter for several sampling episodes. Several compounds, for example Mercury, were not detected in every sampling episode. This type of spotty detection happened for several compounds. When this occurred, 1/2 the detection limit was used for every non-detected occurrence of the pollutant for calculating an overall average concentration. Appendix B contains the qualified concentration data for each municipality.

For the non-permitted city storm water runoff load estimates, the same data limitations apply as above, since the municipality pollutant data was used in the load calculations. One additional limitation occurs because for each pollutant an average concentration/area estimate was calculated. If a municipality detected a compound but another one did not, 1/2 the detection limit was used as an estimate in the pollutant average concentration/area estimate. The additional qualifiers to the non-permitted city storm water runoff load estimates are indicated in Tables 36 and Table 37 by bold type.

Storm water runoff estimates were not calculated for the Middle and Upper Willamette River, like Salem and Eugene, or cities above Bonneville Dam. The total storm water load estimates that will be shown later in the report should be viewed not as the total storm water contribution to the Lower Columbia River but only as the load from the areas identified.

Results and Conclusions

Presented in Table 21 is a summary of the Municipalities Total Storm Water Runoff Load (lbs/year) estimates and major contributing land use type by individual parameter and municipality. The text and tables (22-35) following include a short description of the areas included in each permitted municipality jurisdiction and their corresponding loads.

The variability in the permitted municipality storm water run-off loads can be attributed to designation of areas by land use type and sampling of a representative land use type during storm events of differing intensity. Designation of Municipalities by land use type was good for consistency purpose but adds a layer of uncertainty to the load estimates. For example a light residential area located in Gresham has different characteristics than a light residential area in Portland. The variability of residential areas located within each municipality is significant. Each Municipality picked a representative area of each land use type for sampling. Specific storm events, different for each municipality, were chosen for each sampling episode. The difference between these representative sampling areas and storm events is enough to explain the variability in Table 19 that exists in the urban stormwater load estimates between municipalities. In some cases, such as BOD, Cr and Zn, the largest municipality area, USA, contributes a greater load than the smaller municipalities. In other cases, like for Cu, Cd and TDS, Portland contributes a greater load than USA. One additional explanation for the variability arises when trying to get a representative storm water run-off grab sample for an entire run-off episode from one instant in time. The pollutant concentrations in a runoff-episode are time dependent so it is impossible to get a representative sample from just a few samples. These Load calculations should only be viewed as order of magnitude estimates and should not be taken as definitive. Better estimates of rural and possibly urban nonpoint sources will be obtained when more sophisticated nonpoint source modeling techniques are completed as the next phase of this project.

The non-permitted cities annual load (lbs/year) estimates to the Lower Columbia River are presented in Table 36 along with the river segments impacted by each. Table 37 Lists the dissolved annual loads (lbs/year) to the LCR.

A comparison of the annual storm water runoff and point source loads shows that a significant portion of the pollution common among both sources is coming from urban stormwater runoff (Table 38). This is identified in Table 38 by a positive difference. Urban stormwater runoff is contributing more load to the LCR than the point sources for every matched pollutant except : BOD, Total Arsenic, Total Cadmium, Total Copper, Total Cyanide, Chloroform and Toluene. 80% of the listed matched pollutants are dominated by urban stormwater runoff (27 of 34). This data suggests non-point sources, when considering urban only and not including agricultural or forestry areas, are contributing most of the organic load to the Lower Columbia River.

Note: The cities of Salem, Eugene and Springfield are not included in the above comparison, but it is estimated that combined they contribute about the same load from storm water run-off as Portland. If these cities were included in the total urban stormwater runoff load estimate, their presence would not be insignificant. Also, no estimates have been made on the impact of urban stormwater runoff from cities above Bonneville dam at this time.

Making the urban storm water runoff load estimates, though often variable between areas and thus only order of magnitude predictions, has enabled the Bi-State Program to get one step closer in identifying the source of those pollutants that are present in the Lower Columbia River and suspected of having detrimental effects on both the ecological and human populations. These Load estimates will be used in section III in the report for mass balance calculations.

Findings

Urban storm water runoff load estimates were variable within and between areas and thus only represent order of magnitude predictions which are appropriate and useful in a study such as this in identifying sources of pollutants on a basin wide scale. River segment comparisons showed that the Willamette River (Columbia River Segment 3B) contributes the greatest urban storm water runoff load for nearly every identified parameter to the Lower Columbia River. Urban storm water run-off contributes more of the total load to the Lower Columbia River than the identified point sources for most of the organics and for over half of the metals. Rural nonpoint source contributions were not quantified, but for some pollutants may be the primary and largest source.

Recommendations

1. Calculate urban stormwater runoff load estimates for cites upstream on the Willamette River, such as Albany, Corvallis, Salem and Eugene.

2. Existing stormwater monitoring data by land use type should be used in characterizing basin wide pollutant loading, and municipalities should be allowed to develop more cost-effective monitoring schemes that better reflect actual water quality impacts from runoff.

3. Ecology and DEQ should coordinate with municipalities in order to assure comparable analysis of pollutants and should use an analysis method with the lowest practical detection limit to ensure accurate identification of compounds and compatibility in urban stormwater samples from the different municipalities throughout the LCR Basin.

4. Develop and use more sophisticated basin wide non-point source modeling techniques that would take into account such factors as soil type, vegetation cover and slope. Non-point source modeling would greatly increase the confidence in the load attributed to urban storm water run-off from non-permitted cities and allow load estimates to be made for agricultural and forested areas.

SECTION 3 Tributary Pollutant Load Comparisons

Overview

Data evaluations in this section were conducted in order to begin answering two fundamental questions regarding the pollutant loading to the Lower Columbia River Basin (LCR Basin): 1) what is the relative importance of the various tributaries as conduits of specific contaminants of concern to the LCR; and 2) what are the relative percent load contributions of specific pollutants from point sources (PS) vs. non-point sources (NPS) pertaining to individual tributaries, as well as to the estuary located near the mouth of the LCR?

While these questions could not be answered completely or definitively in this report due to data constraints, approximations were considered valid for the purposes of indicating potential source contributions, and for identifying data gaps and needs to be utilized in future studies.

The information gathered from this analysis will help the two environmental agencies, Ecology and DEQ, determine where their time and money can best be spent concerning the major sources of pollutants to the Lower Columbia River and Estuary.

The pollutant load contributions of the five major tributaries to the Lower Columbia River mainstem, pollutant discharges to the LCR mainstem itself, plus the pollutant load coming from upstream of the Bonneville dam (see Table 39), are assumed to represent the predominant proportion of PS and NPS pollution to the LCR Basin. Although, specific in-place sources, such as hazardous waste sites, landfills, and hot spots in the river may also contribute a major portion of certain pollutants. Most of the atmospheric deposition, as well, is expected to run off and find its way into the tributaries.

Comparisons between tributaries were conducted to determine the relative releases of various metals, pesticides, or other conventional parameters. Data was not considered sufficient to provide more than rough approximations of mass balance loading numbers for most parameters due to sampling date mismatches. Month-specific comparisons were made in order to provide indicators of potential high tributary pollutant discharges.

A second type of comparison was made in order to further delineate pollutant loading sources. Approximate determinations of PS and urban runoff percent load contributions (utilizing data described in Sections 1.1 and 2, respectively) were made in relation to the pollutant loads estimated for the Lower Columbia River Basin.

Estimated upstream NPDES PS and urban stormwater runoff pollutant loads were subtracted from corresponding water column pollutant loads of the Willamette River tributary. A similar comparison was made at the Beaver Army Terminal monitoring station (R.M. 53.8). This provided percent load contribution estimates of upstream PS, urban NPS, and unidentified source pollution from the dominant LCR tributary (The Willamette River), and from a site representing the total most downstream Columbia River instream pollutant load (Beaver Army Terminal).

These mass balance calculations allow for rough estimates of percent load contributions from the identified and unidentified pollutant sources to the Lower Columbia River. 'Unidentified' percent load contributions provide information on potential rural NPS pollution, hazardous waste and land-fill sites, sinks, and additional undetermined loads coming from point sources and urban runoff.

To further delineate the sources of pollutants seen at Beaver Army Terminal, parameter loads from the Upper Columbia River (Warrendale Monitoring Station R.M. 141) were included in the mass balance equations (see Figure 6). This comparison allowed for unidentified loads to be roughly attributable to sources in the LCR Basin, by eliminating the Upper Columbia River pollutant loads from the total Columbia River load.

Four other rivers considered to be 'major' tributaries to the LCR were also evaluated individually for percent loading of pollutants from upstream PSs (the Sandy, Cowlitz, Kalama, and Lewis Rivers). The only parameters which matched for comparison for any of these streams were discharge (Q) and suspended sediments (see Table 45). No upstream urban runoff values were available for comparisons.

For the purpose of brevity, information regarding the two types of pollutant load comparisons described above will be combined in the following sections, except for separate results evaluations prepared in the Results Section.

Monitoring Station Selection

Seven LCR Basin water column monitoring stations were selected for this evaluation (Figure 7 and Table 39). The sites were chosen because they were located near the mouths of the tributaries or near the upstream or downstream boundaries of the LCR mainstem. This theoretically provided load measurements at the highest collection points of upstream water flow and waste discharges from point and non-point sources.

The Warrendale sampling station is assumed to represent the load coming from the Upper Columbia river. The Sandy, Willamette, Lewis, Kalama and the Cowlitz monitoring stations are assumed to represent the major tributary loads to the LCR main-stem. And, the Beaver Army Terminal monitoring station is assumed to be representative of the total Columbia River pollutant load. Theoretically, the sum of the tributary loads plus the Upper Columbia River load equals the load passing the Beaver Army Terminal monitoring station.

These sites also conveniently exhibited extensive multi-constituent monitoring done by USGS in 1993 and 1994. A STORET retrieval of USGS data for all of the measured pollutants measured at all of the stations of the study area confirmed that these were the best stations for evaluation. Tributary and LCR mainstem flow discharge numbers (Q) were also available or estimable for each station.

Parameters of interest

Physical and chemical parameters evaluated for between tributary comparisons included: discharge (Q); suspended sediments; trace elements and metals (dissolved and in suspended sediments); pesticides (water column); total organic halides; and radionuclides; [See USGS (1995) for comprehensive information regarding parameter sampling, monitoring stations, and raw data.]

Information from the USGS Report (1995) pertaining to dissolved oxygen, dissolved gas, organic carbon (dissolved and suspended), chlorophyll a, Fecal Coliform bacteria, temperature, and pH, is also summarized in this section.

[Investigative study results involving potential sources of PCBs and dioxin/furans are included in the next section.]

'Suspended sediments' passing through a 63 um filter (typical method for ambient monitoring purposes) were compared to 'suspended solids' passing through a 45 um filter (typical method for PS monitoring). Consultation with USGS personnel led to the assumption that while these two methods were slightly different, the resulting loads were comparable for our purpose of obtaining percent load contributions. Obviously, the 'suspended solids' estimates would exhibit slightly conservative (or lower) values than expected in comparisons to 'suspended sediments'.

Parameters detected at least once during 1993 or 1994 were included for load calculations. Appendix C presents the complete list of measured and detected toxics parameters for each tributary or main-stem monitoring station for 1994.

Tributary comparisons to upstream NPDES point source and urban stormwater runoff pollutant loads were limited to matching parameters and included evaluations of discharge, suspended sediments (or solids), and metals (dissolved, total, and total recoverable).

Monitoring Dates

1994 USGS monitoring station sampling dates are presented in Table 40.

Some 1993 data was also evaluated, but its use was limited to individual tributary comparisons to upstream PS and NPS pollutant loading: for the Willamette Station: 1/25, 3/15, 4/15, 4/28, 5/27, 6/23, 7/15, 8/5, 9/1, 10/8, 11/4, and 12/9; for the Beaver Army Terminal Station: 1/27, 3/16, 4/27, 5/3, 5/10, 5/17, 5/24, 6/1, 6/7, 6/24, 8/6, and 11/5.

Discharge Estimates

All of the tributary and main stem flow discharge estimates (Q) used in load calculations represent 'mean daily average values', excluding the Sandy River and Kalama River stations for which only 'instant discharge values' were available. Utilized Q value dates match constituent sampling dates.

Discharge estimates for the Willamette River station at Portland and the Columbia River Beaver Army Terminal station were obtained by the USGS using continuous gage monitoring located at the monitoring sites.

Discharge estimates for the Columbia River Warrendale station were obtained from upstream Bonneville Dam discharge release measurements provided by the U.S. Army Corps of Engineers.

Discharge estimates for the Sandy River station and the Kalama River station were provided by the USGS.

Discharge estimates for the USGS Cowlitz River station (14244200) were calculated, comparing Q values from three other stations: Ecology Station 26B070 on the Cowlitz River (also near Kelso, and assumed comparable in discharge volume to the USGS Cowlitz River station), and two USGS gauging stations upstream, for which Q's were summed: Station 14238000 on the Cowlitz River below Mayfield Dam (R.M. 50.6); and Station 14142580, at R.M. 6.5 on the Toutle River, a tributary entering the Cowlitz River at R.M. 20.0. The Ecology station had 12 discharge measurements corresponding to the year and months of the constituent sampling period for the USGS Cowlitz Station but on different days. A regression equation was designed to calculate Cowlitz Q's to the Columbia River for any day of the sampling period. The twelve Ecology measurements (y), were regressed against same day Cowlitz River below Mayfield Dam + Toutle River discharge measurements (x); log(y)=1.106833(log(x)-0.3642, adjusted R2 = 0.989633. Cowlitz River below Mayfield Dam + Toutle River discharge numbers corresponding to constituent sampling days of the USGS Cowlitz at Kelso station were entered into the regression equation to produce the estimated Q's of interest.

Discharge estimates for the Lewis River station were obtained by summing the Q's of two upstream gauging stations, 14222500 and 14220500, each approximately 20 miles from the Lewis R. station.

Treatment of Data

All of the 1993 and 1994 monitoring data downloaded from STORET or borrowed from USGS reports was entered into EXCEL and ACCESS data bases set up to calculate and categorize loads. Load values were derived from same day and site mean Q discharge numbers coupled against constituent concentration values; example, using copper (Cu):

Cu Load (Lbs/day) = [*u*g Cu/L]X[flow (MGD)X[conversion factor]
Suspended sediment parameter loadings (Lbs/day) were transformed from measured ug/g suspended sediment to *u*g/L concentrations using suspended sediment concentrations (mg/L) before applying the above formula.

Where 'total' or 'total recoverable' values for metals were available from point sources or from urban runoff studies, water column monitoring values for 'suspended sediments' were added to corresponding parameter 'dissolved' values to provide an estimate of the 'total' or 'total recoverable' tributary load for comparative purposes.

Those pollutants for which no detections were made during 1993 or 1994, were excluded from these comparisons. For those pollutants that had non-detects, 1/2 the detection limit was used to calculate loads.

Load numbers represent daily values collated into monthly categories. Where several monitorings took place within one month, measured values were averaged for that month for use in the comparisons to PS and urban NPS pollutant loads. For between-tributary comparisons, one sampling day was chosen from each month which best corresponded to other tributary or main-stem sampling days (see Table 46).

The load contributions of the five tributaries (LCR Tribs) and the Upper Columbia River (UCR Tot) summed, are assumed to represent the predominant proportion of upstream point source (PS) and non-point source pollution (NPS) to the Columbia River above the estuary (CR Tot); (see Table 37 for Load Code designations):

CR Tot = LCR Tribs + UCR Tot + LCR Main

Where, LCR Main : Lower Columbia River mainstem discharges; see Table 45 for other load code designations.

For each independent station:

LCR Trib = Upstream (PS NPDES + NPS Urban + NPS Rural)
UCR Tot = Upstream (PS NPDES + NPS Urban + NPS Rural)
CR tot = Upstream (PS NPDES + NPS Urban + NPS Rural)

Where, PS NPDES: Major and Minor NPDES permitted discharge loads; any other point source pollutant discharges permitted under General permits.

NPS Urban: Runoff* from impervious and non-impervious urban areas, not treated through point sources.

NPS Rural: Runoff* from impervious and non-impervious areas outside urban boundaries, not treated through point sources.

[Runoff* : includes atmospheric deposition.]

Data Limitations and QA/QC

State of the collected 1993, 1994 LCR loads data:

LCR Tot: day specific measurements; collated by month, 1994

LCR Tribs: day specific measurements; collated by month, 1994

CR Tot:	day specific measurements; collated by month, 1994
LCR Main:	not directly measurable
PS NPDES:	Monthly means were averaged for corresponding periods: wet (10/1-4/30) or dry (5/1-10/30); for evaluated Major and Minor NPDES permittees; 1993 data.
NPS Urban:	Annual averages estimated from storm- event related measurements; weighted monthly according to seasonal trends; 1992, 1993 data.
NPS Rural:	Not quantified; may be roughly estimated for some parameters as 'unidentified' loads in mass balance equations; requires modeling. Nonpoint source modeling will be completed as the next phase of the project.

Ambient water column loading data (1994) was calculated for measured parameters which registered at above detection levels. Pollutants could have been excluded from this survey either because they were not measured for, or because they may have been present but were simply to low to be measured due to high dilution volumes in the tributaries or LCR Main-stem. Because they were not detected does not mean that they do not pose a threat to the ecosystem since biota can bioaccumulate harmful amounts of low-level toxics over time.

Also, many metals or trace elements were detected in water column suspended sediments but not in the dissolved form. This may have led to less than accurate load numbers where the two forms were added together in order to estimate 'total' or 'total recoverable' loads for comparisons to PS and urban runoff loads. This problem was addressed in individual cases where it occurred.

The ambient water column monitoring was not synoptically scheduled. However, the 1994 sampling dates chosen for the Warrendale, Willamette, and Beaver Army Terminal Stations, and evaluated in this study, were all within three days of one another, except for December (7 day spread), and May (10 day spread). These three stations were considered to be key in making any pollutant load comparisons, and the date spread is close enough for the purposes of this report.

Most of the NPDES data was obtained from discharge monitoring reports (DMRs) which provide compliance monitoring information but do not present complete effluent discharge data. Unmonitored pollutant loads were estimated (NOAA comparisons) for some constituents but not verified for this study, and were therefore excluded from mass balance equations.

1993 NPDES point source data, and 1992 and 1993 urban storm water data were compared to 1994 ambient water quality monitoring data. While it would have been ideal to compare all 1992, 1993, or 1994 information, this was not possible due to the lack of usable data sets.

However, these comparisons were believed to provide good estimates of percent load contributions since the variability of PS data appears to be relatively small from year to year for the time period evaluated (Rosetta, 1995), and urban runoff loads are expected to be in a large part dependent on fairly regular pollutant depositions to impervious surfaces.

Still, the urban runoff numbers are probably the least reliable due to their extrapalatory nature (see Section 2), the potential for annual variability due to the magnitude of storm and sunlight events, and atmospheric deposition and runoff related to precipitation. Also, stormwater load estimates for Eugene, Corvallis, Albany, or Salem were not included in either the Willamette River or Columbia River mass balance equations due to the lack of usable data. However, most of the major urban areas along the Columbia River main-stem were included (see Section 2).

Tributary loadings were calculated from single day, single sampling regimes (USGS) for each month (in limited cases, two or more values were averaged). Therefore, they do not necessarily represent average monthly values, and must be considered indicators only for pollutant load occurrences during the months of 1994. Judging from the tributary flow and suspended sediments seasonal trends observed in the utilized data, the single day samplings appear to be adequate indicators for general between-month comparisons.

NPDES point source DMR data averages for wet and dry periods were believed to be accurate representations of the pollutant discharges monitored. Urban stormwater runoff data was weighted according to monthly precipitation events. Comparisons were therefore considered to be appropriate and in line with the goals of this study.

Results and Conclusions

BETWEEN-TRIBUTARY COMPARISONS

Flow and Suspended Sediments Background: Tributary flow (Q) volume and suspended sediment concentrations (mg/Liter of Flow) are the dominant transport factors to be considered in relation to pollutant loading to the LCR Basin. Even small concentrations of metals or organics detected either in the dissolved form, or attached to suspended sediments, can represent significant pollutant loads to areas of deposition and bioproductivity, such as the confluence of the Willamette and Columbia Rivers, the LCR Estuary, and backwater areas.

When fresh riverine waters mix with ocean salt waters, creating estuary conditions such as those of the LCR Estuary, many important physical and chemical processes can take place, affecting water quality and toxicity to organisms. Fine organic sediments tend to coagulate and settle (Thurman, 1985). Fine sediment deposition is evident in the LCR Estuary, and organic chemicals are strongly associated with fine sediments, to which they may remain neutrally-bound during mixing processes. Therefore, pesticides, PCBs, dioxin/furans, and other organic compounds are likely to be deposited at estuary locations.

Ionically-bound metals may be released from sediments into the dissolved form due to increased concentrations of salts. Changes in pH associated with mixing may also influence metal partitioning. These processes could potentially increase the exposure of toxic metals and organics to organisms which either develop in, feed in, or move through the LCR Estuary.

Flow (Q): 1994 Major tributary Qs (LCR Tribs), as well as the Q observed at Warrendale (UCR Tot), were compared as total Qs (MGD), and as percentages of the flow at the Beaver Army Terminal Station (CR Tot); (Figure 8 and Table 41).

[Note: all Figures depicting between-tributary comparisons are restricted to the following Stations: Warrendale, Willamette, Cowlitz, and Beaver Army Terminal. The Sandy, Lewis, and Kalama Stations were excluded because they simply did not show up in the figures (small flow values). Also, if a load value column appears completely flat (zero) it signifies that no sampling took place during that particular month, and does not represent a 'zero' value.]

The 1994 average Q at Beaver, 111,230 MGD, was considerably less than the median-annual Q observed there between 1928 and 1985, 167,395 MGD, ranking 1994 in the bottom 10 % when compared to other years of that time period (Fuhrer, 1995). In short, 1994 was a dry year.

Between 1928 and 1965 the Willamette River's average yearly percent contribution to the Columbia River's total flow (Q) at its mouth was 13%, comparable to the 12% calculated for this 1994 evaluation using only ten data points.

Highest Q's for 1994 occurred in June at Warrendale and Beaver Army Terminal, and in November at the Willamette River at Portland (R.M. 12.8) for the months and sampling dates evaluated (excludes December and January), while August and September saw relatively low flows.

The Warrendale Q averaged 80% plus or minus 15% of the total observed at Beaver Army Terminal, ranging to as high as >100% in August and as low as 55% in December; the Willamette Q averaged 12% plus or minus 10%, ranging from as high as 35% in December and to as low as 4 % in June, increasing inversely to the Warrendale Q; The Cowlitz Q averaged 3.1 plus or minus 0.9% over the one wet month (April), and the three dry months with data.

The mass balances appear to exhibit error where negative numbers are showing up in the last column of Table 41, unless large quantities of water were leaving the system; for example in August where the 'percent unaccounted' was [-16%], and the Warrendale Q was >100% of the total at Beaver. It is more likely that this was due to either Q approximation errors or mismatched sampling dates. This potential type of error should be considered in all between-tributary pollutant load mass balance estimations.

The other three tributaries each contributed less than 2% of the total flow, with the Lewis River > the Sandy River > the Kalama River (data was limited to four measurements at Sandy and Lewis monitoring stations, and two measurements for the Kalama River).

Suspended Sediments: 1994 monthly and annual suspended sediment loads were considered to be similar to corresponding 1977 suspended sediment loads. Both 1994 and 1977 were defined as 'Low-flow years' periods (Fuhrer, 1995). Suspended sediment concentrations are strongly dependent on flow volume and velocity, as well as land use-related runoff characteristics. Deposition and resuspension of sediments within the LCR Basin streams are thought to be common occurrences, presenting considerable difficulty in accurately defining mass balances.

In 1994, deposition of suspended sediments in January through April was thought to create the deficits observed at the Beaver Army Terminal Station, downstream from the Willamette River and Upper Columbia River inputs. May through November saw a surplus of suspended sediments, suggesting resuspension and/or sizable contributions from the Cowlitz River for which data was very limited (Fuhrer, 1995).

These USGS conclusions, based on monthly mean averages, were not reflected in the single-day sample comparisons performed for this study (Figure 9 and Table 42), which showed nearly the opposite effect. This is probably due in part to daily variability in deposition and resuspension of sediments which is evened out in monthly averages, just as monthly variability is evened out in annual averages, as was shown by USGS statistics (Fuhrer, 1995). This happens because the upstream suspended sediments are continually, although sporadically, moving toward and passing through areas of lower energy (downstream locations). Some deposition, of a more permanent nature, particularly of heavier sediments, is also taking place, requiring dredging. Our data evaluation showed a Willamette River (R.M. 12.8) suspended sediment load (11/3/94) of approximately twice as great as that measured during the same month at Beaver, ten days later (not reflected in USGS monthly mean estimates). The sampling date difference certainly could have affected this comparison, but it is not unreasonable to assume that some level of deposition was taking place. The Port of Portland (1992) reported that approximately 0.6 feet of sediments are deposited annually in the Portland Harbor (R.M. 10 to 3).

Note: When Willamette River waters are slowed by gradient changes, tidal influences, and/or by joining with slower velocity Columbia River waters, Willamette River suspended sediments can sink and be deposited due to a loss of energy and suspended sediment carrying capacity.

Our single day estimates agreed with the USGS monthly means in the following respects:

- On average, suspended sediment loads at Warrendale > Willamette > other individual LCR tributaries;
- Willamette Suspended sediment loads were greater during December, 1994, than Warrendale and other individual LCR tributaries;
- May and June registered the highest Upper Columbia river suspended sediment loads measured at Warrendale, and for the entire Columbia River above the Beaver Army terminal, while these were amongst the lowest level months for the Willamette River;
- November was one of the highest suspended sediment level months for the Willamette River;

- The months July through October were relatively low for all stations reporting; and

- Suspended sediment load levels, in general and on average, increased and decreased with flow (Q). [Single storm events can produce torrential runoff, also introducing short-term heavy suspended sediment loads such as that seen in November for the Willamette River, and for which the Q was not correspondingly high (Figure 9 and Table 42).]

Toxics: Results discussed in this sub-section will include comparative evaluations for metals, pesticides, total organic halides, and radionuclides. Information from the USGS Report (1995) pertaining to conventional parameters: dissolved oxygen, total dissolved gas, Fecal Coliform bacteria, temperature, pH, is also summarized in this Section.

Note: Investigative study results involving potential sources of PCBs and dioxin/furans are included in the next section.

USGS tributary pollutant data pertaining to pollutants included in the 'Bi-State List of Chemicals of Concern' is summarized in Table 43, with additional data regarding measurements and detections of all individual parameters presented in Appendix C.

'The Bi-State List of Chemicals of Concern' (Table 1) includes 17 metals (including cyanide), 30 pesticides, 18 dioxin/furans, 23 semi-volatiles, 6 PCBs, and 3 radionuclides, as well as 7 conventional parameters. The 1994 USGS analysis takes into account only a limited number of these parameters and should not be considered a complete evaluation in respect to the Bi-State list.

Additional information, utilizing USGS data, comparing loads (Lbs/day) and tributary load contributions as percentages of the 'total' load measured at the Beaver Army Terminal for metals, pesticides, and other parameters of interest is listed alphabetically and presented in Appendix D.

Metals: The following LCR Bi-State Metals (or Trace Elements) of Concern were detected, and evaluated in respect to between-tributary load comparisons, utilizing 1994 USGS data (antimony, cadmium, lead, selenium, and silver were not detected in the dissolved phase; mercury was detected only twice in the dissolved phase; nickel was detected only once in the dissolved phase; beryllium was detected only twice in suspended sediments and not at all in the dissolved phase; see Appendix E. for data):

Antimony (Sb, suspended sediment) :	Figure 10
Aluminum (Al, suspended sediment) :	Figure 11
Aluminum (Al, dissolved) :	Figure 12
Arsenic (As, suspended sediment) :	Figure 13
Arsenic (As, dissolved) :	Figure 14

Barium (Ba, suspended sediment) : Figure 15
Barium (Ba, dissolved) : Figure 16
Cadmium (Cd, suspended sediment) : Figure 17
Chromium (Cr, suspended sediment) : Figure 18
Chromium (Cr, dissolved) : Figure 19
Copper (Cu, suspended sediment) : Figure 20
Copper (Cu, dissolved) : Figure 21
Iron (Fe, suspended sediment) : Figure 22
Iron (Fe, dissolved) : Figure 23
Mercury (Hg, suspended sediment) : Figure 24
Manganese (Mn, suspended sediment): Figure 25
Manganese (Mn, dissolved) : Figure 26
Nickel (Ni, suspended sediment) : Figure 27
Lead (Pb, suspended sediment) : Figure 28
Selenium (Se, suspended sediment) : Figure 29
Silver (Ag, suspended sediment) : Figure 30
Zinc (Zn, suspended sediment) : Figure 31
Zinc (Zn, dissolved) : Figure 32

Note the following in viewing figures: All suspended sediments figures include comparisons (at most) for the 'dry' months of May, June, August, and the 'wet' months of October, November, and April (May and June were actually relatively high flow periods, probably due to snow melt).

Also, since there was no Warrendale sampling for April, it's suspended sediment contaminant levels can be assumed to have been roughly the difference between the 'white' and 'black' bars (Figure 9), corresponding to the load measured at Beaver and the 'total' load of the measured stations (summed) for April, 1994. Similarly, the Willamette load can be estimated for May and August, assuming a minor contribution, only, from the Cowlitz River. The June estimates of the 'total' (black bar) include the two major contributors, the Upper Columbia River measured at Warrendale, and the Willamette River. This may be an underestimation of what would be seen at Beaver, according to the suspended sediment differential (see Figure 9). The same scenario holds true for December, except that the sum of the Warrendale and Willamette loads were probably an overestimate of the load at Beaver (also, see Figure 9). Cowlitz data is also missing for June and December.

The same types of extrapolations can be carried out for the dissolved metal forms. Caution must be observed since mass balances were off as much as 20% (October, 1994) for Q values.

<u>Comparisons to Background Levels:</u> In order to determine if metal concentrations in suspended sediment exhibited unusually high levels compared to potential land based runoff, 1994 USGS metal contaminant levels were compared to geochemical baselines for western soils from the United States (data provided by USGS). The following metals exhibited less than the expected 95-percentile range maximum: aluminum, arsenic, barium, chromium, lead, and selenium.

A survey of geochemical baselines for the LCR Basin would be necessary in order to determine if any of these and other metals of interest in suspended sediments stand out in relation to local soil conditions. There were not enough data points to regress the pollutant loads against the suspended sediment loads which contained them, although this might be another way to check for high and low pollutant values and might give some clue as to the sources of pollutants in the sediment.

For example, low suspended sediment concentrations (mg/L) during summer low-flow periods might contain relatively higher metal and other pollutant concentrations (ug/L) because there would be less suspended sediments in the stream while NPDES point sources would still be discharging pretty much the same pollutant loads year around. Therefore, smaller volumes of suspended sediments would be presented with more potential for the adsorbance of pollutants. This might create higher levels of pollutants attached to the suspended sediments than what would be seen during high flow periods.

The following metals exhibited greater than the expected 95-percentile range maximum, suggesting evidence of potential metal-rich soil runoff, or additionally adsorbed metals from point and land based (NPS) sources (data from single samples and a maximum of four sampling dates for each monitoring station):

Pollutant [Background Concentration]		**Month (1994)**
Copper [>90 ppm]	Sandy River	8 (August)
	Willamette River	6 (June)
	Lewis River	4 (April)
	Beaver	10 (October)
Iron [>8 %]	Willamette River	4, 6, 11
Mercury [>0.25 ppm]	Willamette River	4 (6 X > max)
	Cowlitz River	4
	Beaver	4
Manganese [>1500 ppm]	Warrendale	8, 11
	Sandy River	7, 8, 9
	Willamette River	4, 6, 9, 11
	Lewis River	4, 6, 7, 9
	Kalama River	8, 9
	Cowlitz River	6, 7
	Beaver	8, 10
Nickel [>66 ppm]	Sandy River	4
	Lewis River	9
Zinc [>180 ppm]	Warrendale	5, 6, 8, 11
	Sandy	8
	Willamette	6
	Beaver	5, 8, 10

No expected 95-percentile range maximum values were listed for silver, cadmium, or antimony.

A USGS (1995) evaluation concluded that dissolved iron (ug/L) originating from the Willamette River was the only constituent which exceeded the interquartile range for background concentrations of dissolved metals or trace elements in North American streams. Historically, Willamette River filtered-water iron concentrations have exceeded water quality criterion for the protection of human health, and aquatic life fresh water chronic criterion values (Rosetta, 1995).

These comparisons of metals to background levels provide one piece of information about seasonal river sources of potentially high metal loadings and will aid in the understanding of important tributary contributions of pollutant loads as this discussion proceeds.

As might be expected, the estimated pollutant loads in water column suspended sediments evaluated in this report were strongly dependent on the suspended sediment loads (Lbs/day) observed in the Columbia River and tributaries. The following metals exhibited the same seasonal and between-tributary patterns observed for suspended sediment loads: aluminum, antimony, arsenic, barium, chromium, iron, manganese, nickel, selenium, silver, and zinc (Figures 10 through 32):

- On average, pollutant loads in water column suspended sediments were higher as follows: Warrendale > Willamette > Cowlitz > other individual LCR tributaries (the Warrendale > Willamette comparison agrees in general to a 1989 study utilizing USGS data (Tetra Tech, 1992);
- Willamette pollutant loads in water column suspended sediments were greater during November, 1994, than Warrendale and other individual LCR tributaries (due to high suspended sediment loads in the Willamette River);
- May and June registered the highest Upper Columbia river contaminant loads in suspended sediments measured at Warrendale, and for the entire Columbia River above the Beaver Army terminal, while these were amongst the lowest level months for the Willamette River;
- November was the highest contaminant load level month for the Willamette River (in suspended sediments for the months of 1994 evaluated);
- Levels for the months July through October were relatively low for all stations reporting; and
- Pollutant load levels in water column suspended sediments, in general and on average, increased and decreased with flow (Q).

It should be noted that USGS (1995) reported that while the Willamette River stream flow was only 10% of the Beaver stream flow during the low-flow period, it contributed 60% of the silver load. More limited data comparisons from this evaluation neither supported nor refuted that claim.

Quantifiable dissolved phases of the above metals exhibited similar patterns to observed Q's except in the following cases: dissolved loads of aluminum, iron, and manganese were much higher than expected, based on flow, in November in the Willamette, which also exhibited high suspended sediment loads for these metals (Figures 12, 23, and 26).

This phenomenon did not occur for barium, copper, or zinc which saw much smaller proportions of the dissolved phase as compared to loads in the suspended sediments in November for the Willamette River (Figures 16, 21, and 32). This may exemplify some metal-specific partitioning processes between dissolved and sediment phases.

Zinc in the LCR is expected to result from human activities (USGS, 1995). Exceedences of the 95-percentile range maximum value (180 ppm) of the geochemical baseline for zinc for western soils from the United States (see above Section) may be indicators of this.

Dissolved iron was also unusually high for the Willamette in April as well, although the mass balance showed a deficit at Beaver (Figure 23 and Appendix D) not reflected in the Q mass balance (Figure 8); a possibility exists that downstream influxes of high iron-affinity suspended sediments either from a tributary or from resuspension processes could have taken out some of the dissolved portion through adsorption processes.

Most of the dissolved arsenic (and suspended sediment arsenic) appears to be attributable to the Upper Columbia River (see Warrendale Station, Figure 14). Nearly equivalent loads were measured at Beaver (CR Tot).

The following metals also exhibited the same general seasonal and between tributary patterns observed for suspended sediment loads, with notable exceptions for specific months (1994):

Cadmium:	The level measured in October at Beaver appears lower than expected and may be an anomalous data point (either in respect to Warrendale or Beaver), or deposition/re-suspension processes are introducing sediments of differential cadmium quality between these upstream and downstream sites (Figure 17). Also, the December cadmium level for the Willamette River is much lower then expected based on the high suspended sediment load for that month.
Copper:	Cu registered unusually high (greater than the expected 95-percentile range maximum: 90 ppm) in suspended sediments in October at Beaver, probably attributable to the Upper Columbia

River (Warrendale); extrapolating from dissolved copper measurements (Figure 21), and assuming that high Cu dissolved loads occur with high Cu suspended sediment loads. The dissolved loading fraction, while not always measurable or quantifiable, has often been seen as the dominant transport phase for many if not most trace elements and metals (Fuhrer, 1995).

Mercury: Extremely high Hg suspended sediment loading was observed in the Willamette River and at the Beaver Army Terminal in April, while the dissolved phases were not detectable at either location (Figure 25, and Appendix D). USGS (1995) reported a high potential for mercury contamination in laboratory samples which may or may not also account for high dissolved mercury measurements for the Willamette River in June and at Beaver in August, each exceeding ambient water-quality criteria standards.

Lead: Lead in suspended sediments measured higher than expected at Beaver in October, in relation to it suspended sediment concentration (mg/L); (Figure 28). Since information on Pb levels or elevations were not available from any of the other stations, it is not possible to surmise the potential source measured in October.

Most of the identified industrial metals waste enters the LCR via sewage treatment plants, primary metals industries, and pulp and paper mills (see Section 1.1) [via the Willamette River and the Columbia River main-stem]. However, the major source to the LCR overall, appears to be the Upper Columbia River (followed by the Willamette River, and then the Cowlitz River).

Due to a lack of replication in sampling, and the use of single-day/month monitoring data utilized for this evaluation, there certainly exists an unquantifiable error in regard to high or low measurements relative to the actual processes taking place in the LCR Basin. However, all suspended sediment samples were stream width- and depth-integrated composites and laboratory QA/QC was expected to be excellent. The greatest potential for error probably comes from Q and suspended sediment measurements which carry the estimated pollutant loads. This of course can be compounded when making between-tributary comparisons, particularly when considering deposition and resuspension processes. However, the single-sample, single sampling day/month monitoring data used for these evaluations was supported by trends reported by USGS evaluations based on monthly means. Conclusions drawn from these evaluations may still require further verification.

Pesticides: 26 different pesticides, out of the 45 measured, were detected at least once in the LCR Basin, for at least one of the seven selected sites evaluated here. This 1994 USGS data is summarized in Tables 43 and 44 for the 26 detected pesticides, with all 45 pesticides listed in Appendix C. All Pesticide loading data is presented in Appendix D.

Of the 26 detected pesticides in the water column, only two were on the Bi-State list of 'chemicals of concern': DDT and gamma-BHC (lindane). Each of these were measured for only, and detected only, in the Willamette River in 1994.

The Willamette River exhibited the most pesticide hits, partly because it was measured two to four times as much as the other stations for most of the pollutants. Yet it registered nearly 100% of the detections among all monitoring stations for simazine, metalochlor, and atrazine, and also high ratios (>30%) for deethyl atrazine, fonofos, diazinon, terbacil, and napropamide. Detections of any kind for pesticides should be considered important for LCR major tributaries due to the high dilution volumes and resulting high magnitude loads.

No other 1994 ambient water column monitoring data pertaining to organics was available for the selected stations reviewed for this evaluation. However, the following information was obtained from an inventory of Willamette River Basin for toxics detected between 1985 and 1995:

- 190+ toxic parameters (metals and organics) of varying concentrations and toxicities had quantifiable detections in the Willamette River Basin.
- Eighty-three of the 190 are regulated under present or proposed water quality criterion, and 57 of these resulted in at least one exceedence of a water quality criteria, sediment or tissue reference value.
- Eighteen of the 57 are water column pollutants with at least 15% detections, and which the mean concentration value resulted in at least one water quality criteria exceedence.
- Fifty-six of the 190 detected parameters were on the Bi-State list of 'chemicals of concern': 2 dioxin/furans; 3 PCBs; 21 pesticides; 15 semi-volatiles; and 15 metals (or trace elements). [This list will be made into a table and included in the Appendices Section].
- Twenty-three of the 56 are believed to be 'endocrine disruptors'. 37 total endocrine disruptors were detected in the Willamette Basin between 1985 and 1995.

Endocrine disruptors are a group of chemicals that are suspected of having similar deleterious (reproductive and developmental) effects on organisms. While the cumulative effects of endocrine disruptors cannot be presently quantified in natural systems, a growing number of studies have established powerful qualitative links.

Reproductive developmental abnormalities observed in mink and river otter in the LCR main-stem near the mouth of the Willamette River may be the result of exposure to endocrine disruptors. Many pesticides, including atrazine, metribuzin and carbaryl, which are <u>not</u> on the Bi-State list of chemicals of concern, but were detected in 1994 and evaluated in this study (see Table 44), are potential endocrine disruptors.

Realistic approaches to assessing and correcting stream health in the Basin should be cognizant of these and other potential additive and synergistic effects.

Total Organic Halides: The measurement of total organic halides (TOX) has been used as a method for measuring the total amount of chlorinated compounds in effluents. Sources include: pulp and paper, organic chemicals, plastics and synthetic industry, sewage treatment plants, and in the chlorine disinfection of drinking water as well as natural sources.

Figure 33 shows the total organic halide load at Warrendale, in the Willamette and Cowlitz rivers and at Beaver Army Terminal. Increased TOX load was seen during periods of high flow, April through June, for all of the identified sampling points. In most cases, the greatest TOX load was seen at Beaver Army Terminal. When comparing the load at Beaver Army Terminal to the Total Load, white vs black columns in Figure 33, the total TOX load does not add up to the TOX load seen at Beaver Army Terminal, suggesting a Lower Columbia River main-stem industrial influence. There are several sources of TOX below the Willamette River which include pulp and paper mills and sewage treatment plants. The Upper Columbia River (Warrendale) was also an influential contributor of TOX.

Note: Another measurement, adsorbable organic halides (AOX), is a better indicator of the organic halides that have a greater potential of causing adverse health effects to aquatic organisms.

Radionuclides: Radionuclides in the Lower Columbia River Basin were monitored by the Oregon Health Division from 1961 to 1993. Though no measured constituents exceeded any domestic or international standards during that period, the radionuclide activity has declined dramatically since 1962 (R.M. 74) (Oregon Health Division, Radiation Protection Services, 1994a, 1994b).

Conventional Parameters Background: Water temperature, dissolved oxygen, pH, total dissolved gas and fecal Coliform in excess levels can have detrimental effects on aquatic organisms within a watershed. These parameters were measured by NPDES facilities, and compiled in the point source section of this report but no data analysis will be completed at this time. Instead the results of a historical and instantaneous data analysis has been summarized from the USGS (1995) report, "Water Quality of the Lower Columbia River: Analysis of Current and Historical Water Quality Data through 1994."

Water Temperature: USGS gathered temperature data from 14 different continuous sampling stations in the Lower Columbia River (LCR) with each station spanning from between 2 (1968-1969) to as many as 17 (1975-1992) years. The distribution of daily mean water temperature was found to be generally uniform among sites in the LCR. A study by Moore (1968) showed temperature increases between July 1966 and September 1967 principally occurring well upstream of the LCR in an area between Coulee Dam (RM 596.6) and McNary Dam (RM 292), probably due to the influence of reservoirs and increased operation at Hanford Reservation. Exceedences of 20 °C, a Washington State water quality standard, was seen at Bonneville Dam from as early as 1938. A seasonal Kendall trend test for water temperature indicated that a significant ($p < 0.05$) upward trend exists in the Columbia River at Warrendale (1969-1992). The median water temperature of 11.9 °C was found to be increasing by 0.6% per year.

Between the same years, the stream flow in the Willamette River did not significantly affect the water temperature in the Columbia River. During the summer months a temperature gradient is expected between the two rivers but due to the large difference in stream flow and possibly because of the tidal flow reversals and the associated mixing at the confluence of the two rivers, no gradient is seen in the Columbia River. The highest median water temperatures were seen in August (Columbia and Willamette). As with the Columbia River at Warrendale a seasonal Kendall trend test indicated a significant ($p < 0.05$) upward trend exists in the Willamette River at Portland (1969-1992). The median water temperature of 12.5 °C was found to be increasing 1.1 % per year. A similar flow adjusted estimate showed an increase of 0.9 percent per year.

The instantaneous water temperatures measured during the three summer months of 1994 were generally similar at the main stem sampling sites and exceeded 20 °C during July and August. Between July and September the Willamette River was generally the warmest tributary entering the LCR with temperatures upward of 24.2 °C. The Lewis and Kalama Rivers were the coldest tributaries entering the LCR with temperatures downwards of 14.3 °C and 15.8 °C respectively.

Dissolved Oxygen: Between 1972 and 1994, when compared to earlier years,.the Willamette River at Portland saw an increase in dissolved-oxygen concentration during the three summer months, probably due to the releasing of water from dams during summer navigation and the upgrading of waste water discharges to secondary treatment levels. But waste water rich in organic carbon, such as from food processors, sewage treatment plants, pulp and paper industry and a wide variety of other industries, cause an increase in microbial respiration and can cause a decrease in dissolved oxygen concentration and have localized effects in back water areas (Connell, 1984).

Figures 34 and 35 show Suspended and Dissolved Organic Carbon loads for Warrendale, the Willamette and Cowlitz Rivers and Beaver Army Terminal. Large dissolved and suspended Organic Carbon loads were seen during the high flow months of April, May and June. This may imply non-point source, such as runoff, is a major contributor of organic carbon to the river. Also, there appears to be largely a main-stem influence since both Warrendale and Beaver have high levels of suspended and dissolved organic carbon. [Note: Toxic organic contaminants are often associated with and directly related to the amount of organic carbon content present (dissolved and in sediments). Certain organic contaminants can be detrimental to advantageous micro-organisms potentially decreasing dissolved oxygen concentrations.]

Dissolved Oxygen Concentrations at all Columbia River main-stem sites met the Oregon (1994) and Washington (1992) dissolved-oxygen standards. Supersaturation was seen in 1994 at Warrendale between March and most of July and is probably the result of spilling water at Bonneville Dam.

One exceedence of dissolved oxygen standard (Oregon) was seen on the Sandy River but was most likely due to the time and date of the measurement (high temperature and measurement taken late in the day).

In general, every month except July through September saw dissolved-oxygen concentrations within 10% of saturation. July through September are low flow months and saw lower dissolved oxygen due to higher temperatures, point and non-point sources placing a biochemical demand on the river, and higher biological respiration due to increased temperature.

The Washington tributary sites had no dissolved oxygen measurements that were below the Washington standards.

pH: In 1993 three measurements between April and May exceeded pH 8.5, a level that is toxic to freshwater aquatic life. These pH measurements, taken at RM 102, were associated with increased Chlorophyll *a* concentrations (Figure 35). Chlorophyll *a* is a surrogate of algae productivity in the water column which suggests that phytoplankton may have been playing a role in the measured pH levels. [Point source pH information is available but has not been analyzed at this time.]

Total Dissolved Gas: Total Dissolved gas saturation in the water column is caused by the spilling of water from dams. The US Army Corps of Engineers have been monitoring total dissolved gas since 1984 and have historically seen the highest levels between April and July because the stream flow exceeds the capacity of the hydropower turbines and the dams have to spill water. In 1994 between July and August, higher total dissolved gas values from Bonneville Dam to Puget Island were seen due to the spilling of water for out migration of anadromous fish. Good agreement of average dissolved gas saturation (120%) was seen between 1993 and 1994 instantaneous sampling data (USACE, 1994).

Fecal-indicator Bacteria: The transmission of Pathogenic microorganisms in water can be associated with fecal contamination from warm-blooded animals, including man (USEPA, 1976). Fecal-Coliform, enterococcal, and fecal-streptococcal are indicator bacterium whose presence in water, from fecal sources, may indicate a potential health risk.

Levels of concern for more than one fecal-indicator test were seen several times in 1994 in the Willamette near Portland and the Columbia River at Beaver Army Terminal sites, especially during September, January, April, October, November, and December. But, at a majority of the other sites, no concentrations of concern were seen. Historical analysis, a period from 1976 through 1994, showed the Columbia river at Warrendale had consistent low concentrations of Fecal Coliform bacteria year round whereas the Willamette River at Portland has variable concentrations during wet months (Fall and Winter). A probable explanation for the variation on the Willamette River is its large urban influence.

POINT SOURCE (PS) AND URBAN RUNOFF PERCENT CONTRIBUTIONS TO TRIBUTARY LOADINGS

Load values for NPDES point sources, urban runoff, and water column monitoring previously described in this report (Sections 1, 3, and 4, respectively) were utilized in comparisons to approximate percent load contributions. Table 45 presents comparisons of flow (Q) and suspended sediments (or solids).

Willamette R. Load Comparison

Percent contributions of PS and NPS urban storm water runoff are presented in Tables 46-47.

Flow discharge: NPDES point sources (PS) and estimated urban storm water runoff above Willamette River mile 12.8 contributed 0.3 - 4%, and 0.2 - 1%, respectively, to the total discharge (MGD) of the Willamette River at Portland over a twelve month period in 1994. This excludes Minor NPDES permittees and urban runoff above Willamette Falls. Highest percent discharge contributions for NPDES PS and for estimated urban storm water runoff, compared to the Willamette River discharges, tended to be during dry periods (May 1-Sept.30).

Suspended Solids: Suspended solids from both PS and storm water runoff were seen predominantly at load levels < 5% of the Willamette River loads for suspended sediments (Figure 36). Months 5-7, and 9 had percent loads at levels between 5-20% for PS facilities, while months 3,5,6,9, and 10 had percent loads between 5-20% for storm water runoff. Suspended sediment load contributions from PS and NPS urban storm water runoff are presented in Table 45.

PS Metals comparisons: 15 metal parameters were evaluated for percent PS contributions to the total Willamette River tributary loads: *as total*: Silver (Ag), Arsenic (As), Barium (Ba), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Mercury (Hg), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Selenium (Se), and Zinc (Zn); *as dissolved*: Zn. Metal load contributions from point sources are presented in Figures 37-47.

9 of 15 metals discharged from PS were predominantly < 10% of the total Willamette River load: *as total*: Ba, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Se.

3 of 15 metals discharged from PS were predominantly 10-100% of the total Willamette River load: *as total*: Pb, and Zn; as dissolved: Zn.

3 of 15 metals discharged from PS were predominantly > 100% of the total Willamette River load: *as total*: Ag, As, Cd.

Months 6 and 9 (dry months) saw the greatest % metal loadings from PS.

Urban stormwater metals comparisons: 16 metal parameters were evaluated for percent storm water contributions to the total Willamette River tributary loads: *as total*: Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Zn; *as dissolved*: Cu, Ni, Pb, Zn. Metal load contributions from urban storm water runoff are presented in Figures 37-47.

11 of 16 metals discharged from storm water were predominantly < 10% of the total Willamette River load: *as total*: Ag, Be, Cr, Cu, Hg, Ni, Se; *as dissolved*: Cu, Ni, Pb, Zn.

5 of 16 metals discharged from storm water were predominantly 10-100% of the total Willamette River load: *as total*: As, Cd, Pb, Sb, and Zn.

Months 6 and 9 (dry months) saw the greatest percent metal loadings.

Total Columbia River Load Comparison

Percent contributions of PS and NPS urban storm water runoff are presented in Tables 48-49.

Flow discharge: NPDES point sources (PS) and estimated urban storm water runoff above Columbia River mile 53.8 contributed 0.29 - 1.1%, and 0.1 - 0.5%, respectively, to the total discharge (MGD) of Columbia River at the Beaver Army Terminal over a twelve month period in 1994. This excludes Minor NPDES permittees and urban runoff above Willamette Falls, and all PS and urban runoff above Bonneville dam. Highest percent discharge contributions for NPDES PS and for estimated urban storm water runoff, compared to the Columbia River discharges, tended to be during dry periods (May 1-Sept.30). Wet months saw the highest percent discharges for storm water compared to the Columbia River discharges.

Suspended Solids: Suspended solids for both PS and storm water runoff were all seen at load levels < 5.02% of the total Columbia River loads for suspended sediments. Suspended sediment loads from point and urban storm water runoff sources are presented in Figure 48.

PS metals comparisons: 18 metal parameters were evaluated for percent PS contributions to the total Columbia River loads: *as total*: Ag, Al, As, Ba, Cd, Cr, Cu, Fe, Hg, Mg, Mn, Mo, Ni, Pb, Sb, Se, and Zn; *as dissolved*: Zn. Percent metal load contributions from Point sources are presented in Figures 49-58.

14 of 18 metals discharged from PS were predominantly < 10% of the total Columbia River load: *as total*: Al, As, Ba, Cr, Cu, Fe, Hg, Mg, Mn, Ni, Pb, Sb, Se, and Zn; *as dissolved*: Zn.

1 of 18 metals discharged from PS were predominantly 10-100% of the total Columbia River load: *as total*: Cd.

3 of 18 metals discharged from PS were predominantly > 100% of the total Columbia River load: *as total*: Ag and Mo.

Months 4, 5, 8, and 10 (dry months) saw the greatest percent metal loadings from PS.

Urban stormwater metals comparisons: 18 metal parameters were evaluated for percent storm water contributions to the total Columbia River loads: *as total*: Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, and Zn; *as dissolved*: As, Cu, Fe, Mg, Ni, Zn. Percent load contributions from NPS urban storm water runoff are presented in Figures 49-58.

14 of 18 metals discharged from storm water were predominantly < 10% of the total Columbia River load: *as total*: As, Be, Cd, Cr, Cu, Ni, Pb, Sb, Se, and Zn; *as dissolved*: As, Cu, Fe, Mg, Ni, Zn.

3 of 18 metals discharged from storm water were predominantly 10-100% of the total Columbia River load: *as total*: Ag, Pb, Se.

Months 4, 5, 8, and 10 (dry months) saw the greatest percent metal loadings.

Upper Columbia River Contribution (Warrendale Monitoring Station)

Presented in Table 50 are the results of the Warrendale and Beaver Army Terminal USGS Tributary Stations, Point Sources and Urban Storm Water Runoff monthly load comparisons. For each pollutant, the unaccounted loads and percent load contributions from each of the different sources, including the percent unidentified, are listed. A negative unidentified load indicates greater than 100% of the load found in the Columbia River was accounted for. This occurrence may signify error in the mass balance due to variability caused by: one time (no duplicates) and non-synoptic sampling, sinks or extreme wet weather occurrences.

Total Suspended Sediment: More confidence is given in the mass balance calculations for Total Suspended Sediments because: 11 months were compared, there was never greater than 100% of the load accounted for and in all cases the UCR (Warrendale Tributary Station) contributed a greater percentage to the Columbia river load than did either the point or urban storm water runoff sources.

When the suspended sediment data was graphed, a trend was seen between the percent load at Warrendale (UCR) and the percent unidentified load in the LCR during the wet and dry months of the year. The Trend shows that during the dry months of the year the water column suspended sediment load coming from the Upper Columbia River (Warrendale Tributary Station) is greater than the suspended sediment load coming from the Lower Columbia River. Just the opposite trend is seen for the wet month. Figure 59 shows the suspended sediment loads and trend lines.

The results are consistent with USGS (USGS, 1995) and make sense because during the rainy months of the year it is expected the tributaries (especially Willamette and Cowlitz) in the Lower Columbia River are contributing a larger portion of the suspended sediment, from non-point sources, to the LCR than the UCR is.

Metals: Complete mass balance calculations, to account for the total load seen at the Beaver Army Terminal Monitoring Station, were completed for the months of May and August for Ag, As, Cd, Cr, Cu, Ni, Pb and Zn (total and dissolved).

Three pictorial representations, two diagrams and one bar chart, for each of the above metals are presented in Figures 60 - 70. Only one diagram and one bar chart are displayed for Mercury and Selenium. The diagrams display percent metal loadings for: the Upper Columbia River, the identified point and urban storm water runoff sources and unidentified amounts. In certain cases, like As, greater than 100% of the load seen at Beaver Army Terminal was identified, so a circle was added to represent the other non-point sources not identified. The bar charts show the load, in lbs/day, coming from the Upper Columbia River (Warrendale) and the identified point and urban storm water runoff sources and the load seen in the Lower Columbia River at Beaver Army Terminal (RM 53.8).

Some of the discrepancy with total Cadmium, Lead, Silver and Selenium can be explained by the fact that no dissolved concentration was included for either compound (Beaver and Warrendale) thus potentially underestimating the actual river load at Beaver and increasing the percent contribution for point sources, storm water runoff and the Upper Columbia River loads. For Cadmium and Silver, point sources and storm water runoff contributed > 100% of the load to the river which may indicate a sink.

It is interesting to note that for Silver and Cadmium a greater percentage of their unidentified load occurred during August, a dryer month, than in May. This gives more evidence to the sink theory.

Between month discrepancies for Chromium and dissolved Zinc probably occurred because in May, 1/2 the detection limit was used to estimate the dissolved river load and in August an actual detected value was used.

Less than 100% of the load was seen in May for Arsenic, in August for Chromium and Zinc (total and dissolved) and in both months for Copper and Nickel. This may signify additional unincluded sources contributing to the LCR mainstem.

For a majority of these chemicals good mass balance was seen. Less than ±4% unaccounted load, was seen in May and August for Arsenic and Copper. Other advantageous results were observed in August for Chromium and Zinc (total and dissolved).

The discrepancy seen in May for Chromium potentially occurred because only 1/2 the detection limit was used to estimate the dissolved load at Beaver Army terminal. This would decrease the amount in the river and thus explain the greater than 100% identified load. Nickel is the exception because 1/2 the detection limit was used to estimate its dissolved load so the actual percent unidentified load may be higher implying an unidentified Lower Columbia River Source.

Further erroneous results can be explained by variation in tributary sampling dates. For this reason alone these results should only be viewed as order of magnitude estimates until further sampling is completed. Conclusions that can be drawn from the results with some degree of certainty is, the Upper Columbia River contributes a notable portion (37%-138%) of the total metal load to the Lower Columbia River (except Silver, Cadmium and Mercury).

Findings

A majority of all pollutant load comparisons made for the main-stem Columbia River and its tributaries were unaccounted for by point sources and urban runoff. Unaccounted source loads would include unmonitored PS, and urban storm water runoff, C.S.O. and other non-point sources. Of the unaccounted source loads, the Upper Columbia River loads, measured at Warrendale (USGS station), represented the greatest percent contribution (9% to 138%). However, several metals, including Ag, As, Cd, Mo, Pb, Sb, Se, and Zn, were measured at greater than 10 % of the total tributary and/or Columbia River main-stem loads on numerous occasions, particularly during dry months. Of these, Ag, As, Cd, and Mo exceeded 100 % of the River loads, signifying that some pollutant loads are either leaving the watershed system or entering sinks.

Recommendations

1. Review point source Discharge Monitoring Report (DMR) Limits for metals that are contributing large proportions of tributary loadings.

2. Ecology and DEQ should, in cooperation with USGS, increase the frequency of full scan monitoring of the mainstem Columbia including all tributaries with urban influence. Available information was not extensive enough to determine pollutant loading trends in the Lower Columbia River Basin.

3. DEQ and Ecology, in cooperation with USGS, should conduct synoptic tributary mass loading evaluations that would analyze water, sediment and fish tissue contaminant levels and in addition at times of maximum concern (e.g., high flows, after or during major storm events) for water quality conditions for the Lower Columbia River Basin. Synoptic tributary loading evaluations have not been achieved to date for most toxic parameters. Information gathered from this research would enable mass balance estimates providing a clearer picture of pollutant partitioning in the Basin.

4. Perform extensive modeling to determine the source of 'unaccounted' loads including pesticides, other organics and metals.

5. A full inventory of chemical contaminants in the upper Columbia River and a complete cumulative impact analysis is recommended. Inventory and characterize point sources to the Canadian border. Make a database. Sample water, sediment and tissue upstream of Bonneville.

6. Characterize the environmental fate of all contaminants of concern of the LCR and Estuary, in order to better understand their hazard potential.

SECTION 4 Investigative Studies; Potential Sources of Dioxin/Furans, PCBs and DDT

Dioxins/Furans

Background

Chlorinated Dioxins/Furans, like PCB's, have been identified by the Lower Columbia River Bi-State Program as being pollutants of concern due to their extreme toxicity, wide spread distribution and persistence in the environment. Results of numerous studies indicate that chlorinated Dioxins/Furans are widely distributed in soils, sediments and air from industrialized and heavily populated environments at part per trillion concentrations (Wenning, 1993). Toxicological data shows that of the 210 chloro-substituted dioxins and furans, seventeen congeners with chlorines located in the 2,3,7 and 8 positions congeners are the most toxic (BCI, 1990). These compounds are not detectable in the water column due to current analysis technology restrictions but have been detected at appreciable levels in fish. Fish have been shown to be highly sensitive to the effects of Chlorinated Dioxin/Furans and these compounds have the potential for trophic transfer up the food chain (Curtis, 1993).

The primary sources of Chlorinated Dioxin/Furans are reported to be of anthropogenic nature because analysis of sediment samples from lake-bed bottoms indicate that there were no chlorinated Dioxins/Furans deposited prior to 1930 (Hites, 1990). Also, residue patterns observed in urban waterways have been shown to relate to municipal and industrial sources (Wenning, 1993). The major processes that create chlorinated Dioxins/Furans are:

- As contaminants in commercial products whose normal processing conditions generate Chlorinated Dioxin/Furans as by-products.
- As contaminants in chemical processing under improperly controlled reaction conditions.
- As products of combustion of general municipal, hosipital, commercial, and industrial wastes.
- As combustion products and residues from burning vegetation that has been sprayed with chlorinated herbicides/fungicides.
- As incidental products of fires in facilities such as chemical pesticide warehouses, farm buildings in which pesticides are stored, and facilities for storage of chemically treated wood products such as lumber or poles.
- As by-products of materials such as polychlorinated biphenyls (PCB's).
- As minor constituents in pentachlorophenol (PCP), other wood-treating agents and incineration of PCP-treated wood products.
- As by-products of the chlorination or bleaching of plant or organic material containing condensed ring structures, such as lignin.

Minor processes which may generate low levels of Chlorinated Dioxins/Furans would include waste streams containing: chlorinated organics, chlorinated phenols, catechols and guaiacols, chlorophenoxy herbicides, PCBs and other chlorinated aromatics, and products of combustion/incineration (US EPA 1980;SAIC 1990).

Industries that have one or several of the above processes in their operation and thus are potential sources of chlorinated Dioxins/Furans include (BCI, 1990):

- Wood treating operations and leather tanners using PCP.
- Bleached Kraft pulp and paper mills due to chorine bleaching of wood pulp and paper.
- Non-chlorine bleaching pulp mills, lumber yards and saw mills due to PCP usage as a fungicide.
- Herbicide and chlorinated pesticide manufacturers, distributors and users.
- Industrial and municipal incinerators, wood-fired boilers and smelters.
- Municipal wastewater treatment plants due to receiving and handling of Wastewaters containing herbicides, chlorinated pesticides, PCBs, PCP and combustion products.
- Urban/industrial storm drains and combined storm overflows (CSOs) that discharge urban runoff and/or collection system wastes containing herbicides, chlorinated phenolics, PCBs, PCP and combustion products.
- Investment casting facilities and foundries using PCBs and chlorinated terphenyls in casting waxes.
- Heavy machinery users, manufacturers and maintenance/repair facilities, including aircraft, ship, boat and other transportation equipment repair and building centers due to possible loss of PCB-containing hydraulic and lubricating fluids and use of antifouling coatings containing PCP and PCBs.
- Major users of chlorine gas and chlorine dioxide for bleaching, disinfection or electrolytic processes.

Identification of Sources of chlorinated Dioxin/Furans

In 1990, BCI completed a preliminary inventory of potential point sources of Dioxins/Furans to the Columbia River and its Tributaries. Information on industries and major municipal sewage treatment plants in Region X was gathered from EPAs Toxic Release Inventory and National Pollutant Discharge Elimination System (NPDES) data base. 25 industry categories, by SIC code, were identified as being potential sources of Dioxin/Furans (Table 51). A similar survey was completed using 1993 facility discharge information from Section 1 of the Bi-State Identification of Sources of Pollution to the Lower Columbia River Basin, and EPA's Toxic Release Inventory.

Data Treatment

The 25 SIC codes identified in the 1990 BCI report were used to identify the potential sources of chlorinated Dioxins/Furans from major and minor facilities discharging to the Lower Columbia River mainstem and its tributaries including the Willamette River (Section 1 and EPA TRI database). Sources located above Bonneville Dam were identified in the 1990 BCI report and will be referred to as Upper Columbia River Sources. SIC codes and their corresponding industry categories along with the number of facilities discharging to the Upper Columbia, Lower Columbia and Willamette Rivers are presented in Table 51.

Results

147 facilities were identified as having the potential of releasing chlorinated Dioxin/Furans into the environment; 49 discharge to the Upper Columbia River (not including Canadian sources), 57 Discharge to the Lower Columbia River (or a tributary) and 41 discharge to the Willamette. 14% are either pulp/paper mills or saw mills, 3% are wood treaters, 66% are sewage treatment plants and 17% are other assorted industries. Of the 57 facilities (39%) discharging to the Lower Columbia River or one of its tributaries (excluding the Willamette), 65% were located in Washington and 35% were located in Oregon. Facilities located on the Willamette River account for 28% of the identified facilities with the potential to release chlorinated Dioxin/Furans.

Though potential air sources were not accounted for in this survey, atmospheric deposition has been identified as the predominant source of chlorinated Dioxins/Furans in relatively remote waterbodies with no industrial or sewage treatment plant waste water discharges(Csuczwa and Hites, 1984). Major air sources of chlorinated Dioxin/Furans include: MSW incinerators, copper smelters, and home heating systems that burn coal or wood (Stillman, 1990). In the future, additional chlorinated Dioxin/Furan surveys should be completed to include atmospheric sources.

PCBs

Background

The Bi-State program has identified Polychlorinated Biphenyls (PCBs) as a pollutant of interest in the Lower Columbia River. This group of chlorinated aromatic organic compounds are of increasing concern because their apparent wide spread use, high toxicity, lipophilic nature, bioaccumulation potential and improper disposal have resulted in the contamination of every component of the global ecosystem.

Since the passage of the Toxics Substance Control Act of 1976 no further manufacturing of PCBs or distribution in commerce was allowed as of July 1, 1979. However, they were still allowed to be used in non-substation capacitors until 1988 and grid network askarel transformers until 1990 (Stokes, 1987). PCB's are a family of anthropogenic chemicals which have been in use since 1929. Their industrial versatility includes resistance to acids and bases, compatibility with organic materials, resistance to oxidation and reduction, excellent electrical insulating properties, thermal stability and nonflammability (Mullin 1984). Their primary applications were as coolants and lubricants in transformers, capacitors and other electrical equipment but they were also used for heat transfer and hydraulic fluids, dye carrier in carbonless copy paper, and as a plasticizer in paints, adhesives and caulking compounds.

PCB's for closed electrical systems were generally sold as one of four mixtures called Arochlors that ranged from between 41% and 54% chlorine content. Prior to 1971 mixtures of 68% were sold for other uses (hydraulic fluids) and it is estimated that half of the these are still in service. In 1974 approximately 450,000 pounds of PCB's were imported primarily for use in open systems (EPA 1980). It is estimated that between 1929 and 1976, 1.4 billion pounds of PCB's were manufactured in the United States and that about half of that is still in service (Currents, 1995).

PCB Sources to the Lower Columbia River

Global transport of PCBs through airborne transport and deposition as well as leaking landfills, capacitors and transformer explosions, and oiling of roads are all ways PCBs can enter the Lower Columbia River. Once in the river PCBs absorb to fine grain sediment high in organic carbon content and are distributed throughout the watershed by the normal suspension and deposition processes of sediments especially during heavy rainfall or floods. Throughout the rest of this section possible sources of PCBs will be identified.

In 1987, USEPA Region 10 completed a Hazardous Waste Management in the Northwest Status Report which concluded the electrical utility industry is the primary source of PCBs in the Region producing upwards of 2000 tons of waste in 1985 (Stokes, 1987). It was estimated that in 1985 all sources in Region 10 generated over 6450 tons of PCB contaminated waste. Table 52 presents a breakdown of the specific type and amount of PCB waste generated. The collected hazardous waste was disposed of by either incineration, chemical treatment, landfill or fuel blending.

For the electrical industry it was concluded that in 1985 just under half of the PCB waste disposal program is currently completed and 11.4 years of PCB disposal remain. In 1991 BPA estimated total phase out of PCB in 34 contaminated Oregon Power Plants by 2006 (EPA Utility Survery Report, 1991). A rough prediction for Region 10 showed a steady increase in the rate of PCB waste generation until 1987 followed by a rapid decrease in 1991 for high level PCB oils (>500 ppm). In contrast, the low concentration oils will remain in the waste streams for up to 30 years.

For the entire nation, in 1985, it was estimated that the cumulative production of PCBs was upwards of 1.2 million tons; 31% remain in the environment, 4% has degraded or been incinerated and 65% has been stock-piled in landfills or still in use in older electrical equipment (Tanabe, 1988). Of the 374,000 tons left in the environment 60% is assumed to be in the mainly in the open ocean in the mid to upper northern hemisphere (Twatsukawa & Tanabe, 1984). This implies that the Pacific Ocean could be a potential source of PCB sediment contamination in the estuary due to tidal influx.

Direct influx of PCB contaminated waste into surface waters can occur from explosions (It has been estimated by EPA that 3% of transformers and 2% of capacitors leak yearly), spills, runoff from environmental cleanup sites and ground water. On August 18, 1986 a power house bushing explosion occurred at Bonneville Dam releasing 8 liters of super heated tar containing PCBs at levels of 100,000 ppm (US Army Corps of Engineers, 1991). Approximately 1 liter, in solid form, of the tar substance was estimated to enter the Columbia River. A second explosion occurred in 1991 with a similar amount of PCB tar released. Both Clean-ups of on-site contamination was successful and sampling revealed remaining concentrations well under levels of concern. Human and Ecological Risk from exposure of surface water was assumed to be almost zero but no river sampling was completed.

PCB contaminated well water due to leaking submersible well pumps, either from mineral oil or dielectric fluids, has been of recent concern. Depending on its size, submersible well pump motors can contain up to 20 liters of oil and the capacitors can contain up to five ounces of PCBs (Wisconsin Department of Natural Resources, 1992). Not only is this a direct human health risk but depending on the organic carbon content and location and rate of movement within the aquifer, these PCB laden wells may contaminate surface waters and cause adverse ecological effects.

55 Environmental cleanup sites in the State of Oregon, and 13 sites in the State of Washington contain PCB contamination in either Groundwater, sediment or soil which may have the potential to impact the Lower Columbia River (Appendix F). In general industries that have huge electrical demands will be a potential source of PCB contamination. According to Bill Hedgbetch (EPA), the large industries such as the pulp and paper and metal companies are not the major problems but instead the smaller industries like plywood mills, wood treaters and saw mills pose the current threat of PCB contamination to the Lower Columbia River. Usually with the closure of these sites, the PCB laden electrical equiptment is left on site and not removed or disposed of properly.

DDT

Background

DDT and metabolite DDE have been identified as pollutants of concern for the LCR because of their persistence and broad toxicity. DDT, an insecticide, was first used in the early 1940's. Three decades of use, almost 4 billion pounds used, passed before EPA banned DDT in 1972 after its adverse effects on wild-life and cancer causing potential became known. The most pronounced effect has been on the reproductivity capabilities, specifically egg shell thinning, of fish eating birds.

USGS detected and quantified DDE and DDT at Willamette at R.M. 9.1 in 1977, with highest levels of many of the same first generation pesticides detected in 1982 at R.M. 7.1 (Doane Lake). A high concentration of DDT (2700 ug/kg) at Willamette R.M. 7.1 as well as a high proportion of DDT, compared to its associated analogues, suggested a recent movement of DDT into the harbor.

In 1988 the U.S. Geological Survey detected DDT in 72 percent of the sites sampled in the Yakima River or one of its major Tributaries. (USGS Survey Circular 1090) Water column concentrations as high as 0.120 ug/l and stream-bed sediment concentrations of 2.1ug/g were detected in agriculture return flows of the lower 110 miles of the Yakima river. Also, levels of 4.8 ug/g DDT were found in fish residing in the river.

According to the USGS, the source of DDT in the Yakima River is due to continuous soil runoff from past contaminated agricultural land (USGS Survey Circular 1090) Water column sampling has shown that the levels of DDT are declining but detectable concentrations will be present well into the future. Random sampling of agriculture soils in the LCR would aid in nonpoint source modeling projects targeted at determining the amount of DDT making its way to the river and the expected time span until the pollution will stop.

The authors of a 1988 USGS report noted that DDT and metabolite concentrations measured in Johnson Creek exceeded those documented for one of the most agriculturally affected areas in the U.S.: Yakima River Basin, Washington. (Rosetta, 1993) The headwater area of Johnson Cr. is predominantaly agricultural (from R.M. 24) and then is impacted by a mixture of land uses, flowing through Gresham, Portland, and Milwaukie, and then into the Willamette River. Agricultural runoff and stormwater discharges from residential, commercial, and industrial areas contributes to Johnson Cr. contamination. 'Runoff characteristics of Johnson Creek are typical of streams in the area with summer low flows increasing into high flows during winter rainstorms, and flows between storms receding steadily until the next storm' (USGS authors).

Even though DDT has been banned since 1972, the Washington Coalition believe it is being illegally used in several areas within the Lower Columbia River Basin. In three Oregon Voluntary Agriculture Pesticide Waste Collection events (1991, 1993 and 1995), a total of 21,546 lbs of DDT (including mixtures) were collected.

SECTION 5 Other Potential Sources of Identified Pollutants

Overview

In an effort to locate other potential sources of pollutants to the Lower Columbia River, Environmental Clean-up sites, Leaking Underground Storage sites, Landfills, Contaminated Landfills, Hazardous Waste Generators and facilities releasing Hazardous and Criteria Air Pollutants were identified in the Oregon Counties of Clackamas, Clatsop, Columbia, Multnomah and Washington. Environmental Clean-up sites and facilities releasing Hazardous Air Pollutants were identified in the Washington Counties of Clark, Cowlitz, Lewis, Pacific, Skamania, and Wahkiakum. Spills to the Columbia River were also included.

Contaminated cleanup sites have the potential of impacting the river through ground water and storm water runoff. Air pollutants can enter the ground compartments (water and soil) by wet and dry deposition and can directly or indirectly (soil runoff) affect bodies of water. Vegetation killed by air pollutants can have a detrimental effect on the quantity of runoff potentially carrying pollutants to the river. Facilities generating hazardous waste have to dispose of it. Whether this is done by incineration or landfill, several pathways exist by which the pollutants can find their way to the river. Spills, because of the usually high concentration, can contribute severe contaminant loading to bodies of water.

This report is intended as an initial step in the identification of potential non-point sources of pollution to the Lower Columbia River Basin. No contaminant load calculation estimates will be made for the non-point sources identified in this section of the report, only lists of sites and pollutants will be provided.

Sources of Data

Oregon Environmental Cleanup sites and Contaminated Landfills information was obtained from DEQ's Environmental Cleanup Site Information System (ECSI). ECSI contains approximately 1600 cleanup sites statewide where DEQ has conducted an initial evaluation, preliminary assessment, and other actions and includes descriptive information collected during site discovery. Data included in ECSI includes the the characteristics and exposure potential of any contamination as well as the ownership of the property and status of any investigation or cleanup activities at the site. ECSI also provides information required for the confirmed release list and the site inventory. Washington's Environmental Cleanup sites were obtained form Ecology's Toxics Clean-up Program Site Information System and contains similar information to DEQ's ECSI system.

Oregon and Washington's Hazardous Air Pollutant information was obtained from EPA's Toxic Release Inventory (TRI). Facilities are required to report to EPA's TRI if all three of the following criteria are met: 1) The facility has 10 or more full-time employees; 2) the facility is included in Standard Industrial Classification (SIC) Codes 20 through 39; and 3) the facility manufactures, processes, or otherwise uses any listed toxic chemical in quantities equal to or greater than the established threshold in the course of a calendar year. The data base contains an enormous amount of information on facilities releasing toxins to the air, water or land (including POTW discharges).

Leaking Underground Storage sites information for Oregon was obtained from DEQ's Underground Storage Information System (UST). To date approximately 4,800 petroleum releases have been reported to DEQ of which only 2,200 have been cleaned up. This leaves 2,600 active sites. Landfill information was obtained from DEQ's Solid Waste Information System (SWMS) and Air Quality Criteria Pollutant information was obtained from DEQ's Air Contaminant Source Identification System (ACSIS). The criteria pollutants tracked include: Ozone, particulate, carbon monoxide, sulfur dioxide, nitrogen dioxide, volatile organic compounds, asbestos and lead.

Information on spills to the Lower Columbia River and the Willamette River information was obtained from the U.S. Coast Guard's (USCG) Spill Planning Exercise and Response System (SPEARS).

Data Treatment

All Oregon information was obtained from internal DEQ databases and queries were built in Microsoft Access to include information for only the above mentioned counties. Information from Washington was obtained from Ecology. The data was received as requested. The U.S. Coast Guard supplied all the spill information for the Columbia and Willamette Rivers.

Results

For each of the following data sources all mediums of contamination may not have been identified.

Environmental Cleanup Sites

OREGON

336 Environmental Clean-up sites were identified in the Oregon counties listed above. 40 Sites have surface water contamination, 18 have sediment contamination and 148 have ground water contamination. A list of 185 chemicals was compiled from these sites, of which 66 are on Tetra Tech's 100+ contaminant list. The mediums where contamination was found (and the corresponding number of chemicals identified in each) includes: Air (4), Groundwater (10), Leachate (3), Sediment (53), Soil (152), Surface Water (51), other (34). **Appendix E** contains the site: ID, name, address, city, zip code, county, HUC Code, latitude, longitude, basin designation, start and end date (Often missing), acres contaminated, minimum and maximum concentration (if available), comments and contaminant CAS Code and name for all 336 Environmental Clean-up sites.

WASHINGTON

Within the above mentioned Washington counties, 112 Environmental Clean-up sites were identified. 29 have drinking water contamination, 91 have groundwater contamination, 39 have surface water contamination and 11 have sediment contamination. Contamination was also found in the air and soil. Compound specific identification of the types of pollutants found was not possible from the Washington data base because contaminants were grouped into categories. The categories where contaminants were found include: Base/Neutral/Acid Organic, Halogenated Organic Compounds, EPA Priority Metals and Cyanide, Metals-other, Polychlorinated biPhenyls (PCBs), Pesticides, Petroleum Products, Phenolic Compounds, Non-Halogenated Solvents, Dioxin, Polynuclear Aromatic Hydrocarbons (PAH), Reactive Wastes, Corrosive Wastes, Conventional Organic and Inorganic Contaminants and Asbestos. **Appendix F** contains the following Washington Environmental Clean-up site information: site name, address, city, zip code and county, Ecology site status, Independent site status, Washington site rank and affected media contaminant groups found with identifiers (confirmed, suspected or remediated). Specific category explanations are included in the Appendix.

Oregon Landfills and Contaminated Landfills

6 landfills in Oregon were identified with contamination. A total of 25 contaminants were found of which 11 were identified on Tetra-Techs 100+ chemical list. The mediums where contamination was found (and the corresponding number of chemicals identified in each) includes: Groundwater (17), Leachate (3), Sediment (4), Soil (2), Surface Water (6), other (8). **Appendix G** lists the contaminated landfills including: ID, name, HUC code, basin designation, address, city, state, zip code, county, acres contaminated, comments (includes concentrations) and contaminant type.

17 operating municipal or industrial solid waste landfills (including pulp/paper and demolition) were identified in the above counties. **Table 53** lists the 17 operating solid waste landfills along with counties and class and types for each.

12 Washington Landfills were identified by Tetra Tech in 1992. Additional work is under way to compile a more recent list of Washington landfills with the potential of contaminating the LCR, but is not available at this time.

Oregon Leaking Underground Storage Tanks Sites

2410 UST incidences occurred between 1980 and 1993 with 792 directly impacting drinking water, ground water or surface water. 1618 of the total UST incidences have been either cleaned or are under control. The remaining 792 incidences are ongoing or their status is unknown. 13 material mixture spills were reported and include: bunker oil, diesel, fuel oil, heating oil, leaded gasoline, unleaded gasoline, misc. gasoline, other petroleum products, waste oil, lubricant, chemical and other. The impacted mediums are: drinking water, ground water, surface water, soil, facility vapor and unknown. **Appendix H** lists each UST: Incident ID, year reported, facility ID (if applicable), site name, address, city, zip code and county, contaminant type, medium contaminated, amount released (in gallons), date spill controlled and date site cleaned.

Oregon Permitted Facilities Releasing Criteria Air Pollutants

For 1993, 104 facilities were identified, in ACSIS, releasing either particulate, carbon monoxide, sulfur dioxide, nitrogen dioxide, volatile organic compounds or lead in the Oregon Counties of Clackamas, Columbia, Multnomah and Washington (81 facilities release Volatile Organic Compounds). **Table 54** lists the sums of the criteria pollutants identified by city. Facilities located in Portland, St. Helens, West Linn and Forest Grove contribute a large portion of the criteria pollutants to the area. **Appendix I** lists the following facility specific information obtained from ACSIS: year reported, facility ID, address, city, zip code and county, and the amount of particulate (total PT and > PM10), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic compounds (VOC) and lead (Pb) [All parameter amounts given in lbs/year].

Oregon and Washington Permitted Hazardous Air Polluters

In 1993, a total of 139 Oregon and Washington facilities reported to EPA's Toxic Release Inventory. 89 facilities reported releasing a combined total of 69 pollutants (11 identified in Tetra Techs 100+ list) to the atmosphere in the 5 identified Oregon counties. 50 facilities reported releasing a combined total of 47 chemicals (10 identified in Tetra Techs 100+ list) to the 3 identified Washington counties. **Appendix J** lists the following TRI facility information for both Oregon and Washington: year, facility ID, address, city, zip code and county, CAS code, pollutant name, air, water, land and POTW releases in lbs/year. Note: Air releases are the primary information sought.

Columbia and Willamette River Spills

Between the years of 1992 and 1995 the USGS reported 343 individual spill incidents to the LCR in which 39 substances were identified. For the same years 298 spill incidents occurred in the Willamette River in which 47 substances were identified. In a majority of the spills the identified substances were complex mixtures such as gasoline or diesel oil. **Appendix K** lists the following Columbia and Willamette River Spills information obtained from SPEARS: case number, date of spill, responsible party, river mile, waterbody, substance, amount spilled in water, total potential, source of spill , spill severity, amount recovered in water, spill amount out of water, amount recovered out of water and spill units.

Oregon Hazardous Waste Generators

In 1993, 83 facilities reported generating hazardous waste containing a combined total of 22 toxic pollutants (8 were identified on Tetra Techs 100+ chemical list). **Appendix L** lists the following Hazardous Waste Generator information obtained from HWIMS: EPA-I.D. ,facility address, city, zip code, county, HUC code and Basin and the toxic chemical present in the waste stream (bold text represents chemicals that are on Tetra-Techs 100+ chemical list).

Summary

Non-point sources are considered to contribute a significant portion of the total pollution entering the Lower Columbia River. For this reason a list of non-point sources were compiled to assist in the qualitative identification of pollutants to the Lower Columbia River. Some non-point sources identified in this report have the potential to contaminate the LCR. In the future, when an extensive modeling effort of the entire watershed is undertaken, these non-point sources will be revisited and their load contribution to the LCR will be quantified.

SECTION 6 Summary of Findings and Recommendations

Section 1 Findings:

The greatest loads from identified waste water discharges of Organics, Conventionals and Metals to the LCR came from the Willamette River point sources. AOXs (Adsorbable Organic Halides) were not monitored for regularly by all facilities, but appear to be discharged predominantly directly to the LCR mainstem.

Based on 1993 data, 52% of the inventoried point sources' waste water discharge flow volume is coming from sewage treatment plants, 39% from paper and allied products, 5% from chemical and allied products and 3% from primary metal. However, 71% of the suspended sediment load to the Lower Columbia Basin from point sources came from the paper and allied products industry, 26% from sewage treatment plants and 1% from the chemical and allied products industry. Annual average point source wastewater discharge [500 million gallons per day (MGD)] is less than 2% of the discharge from the five largest Lower Columbia tributaries (30,000 MGD) and less than half of a percent of the Upper Columbia River discharge (120,000 MGD).

Lack of load data from minor facilities above Willamette Falls and all facilities above Bonneville Dam make it difficult to accurately identify all point source contributions to the LCR. Also, Organic and Metal parameter data were not frequently reported, depending on permit requirements, but Conventional parameters were regularly reported.

Comparison of Oregon NPDES facility waste water discharges with National averages suggest that there may be a significant load of pollutants being discharged to the LCR basin waterways which is not regularly monitored and for which little or no direct information was obtained for this report. These comparisons with national averages involved only twelve pollutant parameters (9 metals and three conventional parameters) and grouped facilities into SIC designations which may not provide perfectly matched wastewater processes. Therefore, this study can provide indicators only.

Section 2 Findings:

Storm water runoff load estimates were variable within and between areas and thus only represent order of magnitude predictions. River Segment comparisons showed that the Willamette River contributes the greatest urban storm water runoff load for nearly every identified parameter to the LCR. Urban stormwater runoff contributes more of the total load to the LCR than the identified Point Sources for most of the Organics and over half of the Metals (Rural non-point source contributions were not quantified, but for some pollutants it may be the largest source).

Section 3 Findings:

Identified metals quantified in suspended sediments as well as the dissolved phase appear to enter the LCR predominantly from the Upper Columbia River (UCR), followed by the Willamette River, and then followed by the Cowlitz River. The magnitude of the suspended sediment load is strongly dependent on river flow (Q). Both flow and suspended sediment load are powerfully associated with the magnitudes of the metals that they carry. However, metal loading from the UCR and the tributaries is variable, suggesting a variety of sources including metal-rich soils or other sources including point sources. Ambient water column organics were limited to pesticides and Total Organic Halides (TOX). Pesticides were measured more often and detected much more often in the Willamette River than other tributaries or the UCR. TOX inputs appear to originate predominantly from the LCR mainstem industries. A Willamette River Basin inventory indicated that 56 of the Bi-State Chemicals (102) of concern were detected between 1985 and 1995, seen mostly in smaller streams of the Willamette River Basin. Similar information on other tributaries has not been gathered.

The instantaneous water temperatures measured during the three summer months of 1994 were generally similar at the main stem sampling sites and exceeded 20 °C during July and August. Between July and September 1994, the Willamette River was generally the warmest tributary entering the LCR with temperatures upward of 24.2 °C. The Lewis and Kalama Rivers were the coldest tributaries entering the LCR with temperatures downwards of 14.3 °C and 15.8 °C respectively.

Between 1972 and 1994, when compared to earlier years, the Willamette River at Portland saw an increase in dissolved-oxygen concentration during the three summer months, probably due to the releasing of water from dams during summer navigation and the upgrading of waste water discharges to secondary treatment levels. In general, every month except July through September saw dissolved-oxygen concentrations within 10% of saturation. July through September are low flow months and saw lower dissolved oxygen due to higher temperatures, point and non-point sources placing a biochemical demand on the river, and higher biological respiration due to increased temperature.

Total dissolved gas (TDG) saturation in the water column is caused by the spilling of water from dams. The US Army Corps of Engineers has been measuring TDG since 1984 and has historically seen the highest levels between April and July because the stream flow exceeds the capacity of the hydropower turbines and the dams have to spill water. In 1994, between July and August, higher TDG values from Bonneville Dam to the Estuary were seen due to the spilling of water for out migration of anadromous fish.

Levels of concern for more than one fecal-indicator test were seen several times in 1994 in the Willamette River near Portland and the Columbia River at Beaver Army Terminal especially during September, January, April, October, November, and December. At a majority of the other sites no concentrations of concern were seen. Although, bacteria levels were the highest and at levels of concern following rainfall events at locations throughout the LCR in backwater and near urban areas.

A majority of all pollutant load comparisons made for the mainstem Lower Columbia River and its tributaries were unaccounted for by point sources and urban runoff. Unaccounted source loads would include unmonitored point sources, and urban storm water runoff, C.S.O. and other nonpoint sources such as from rural areas. Of the total source loads, the Upper Columbia River loads, measured at Warrendale (USGS station), represented the greatest percent pollutant contribution (up to 138%). However, several metals originating from point and urban storm water runoff sources, including Ag, As, Cd, Hg, Mo, Pb, Se, and Zn, were measured at greater than 10% of the total tributary and/or LCR mainstem loads on numerous occasions, particularly during dry months. Of these Ag, As, Cd, Hg, and Mo exceeded 100% of the river loads as measured at Beaver Army Terminal, signifying that some pollutant loads are either leaving the watershed system or <u>entering sinks</u> within the LCR basin.

<u>Section 4 Findings:</u>

Dioxin/Furans: According to an EPA report, 147 facilities were identified as having the potential of releasing chlorinated Dioxin/Furans into the environment; 49 discharge to the Upper Columbia River (not including Canadian sources), 57 Discharge to the Lower Columbia River (or a tributary) and 41 discharge to the Willamette. 14% are either pulp/paper mills or saw mills, 3% are wood treaters, 66% are sewage treatment plants and 17% are other assorted industries. Of the 57 facilities (39%) discharging to the Lower Columbia River or one of its tributaries (excluding the Willamette), 65% were located in Washington and 35% were located in Oregon. Facilities located on the Willamette river account for 28% of the identified facilities with the potential to release chlorinated Dioxin/Furans.

PCBs: 55 Environmental cleanup sites in the State of Oregon, and 13 sites in the State of Washington contain PCB contamination in either Groundwater, sediment or soil which may have the potential to impact the Lower Columbia River (**Appendix F**). In general industries that have huge electrical demands will be a potential source of PCB contamination. According to Bill Hedgbetch (EPA), the large industries such as the pulp and paper and metal companies are not the major problems but instead the smaller industries like plywood mills, wood treaters and saw mills pose the current threat of PCB contamination to the Lower Columbia River.

DDT: USGS detected and quantified DDE and DDT at Willamette R.M. 9.1 in 1977, with highest levels of many of the same first generation pesticides detected in 1982 at R.M. 7.1 (Doane Lake). A high concentration of DDT (2700 ug/kg) at Willamette R.M. 7.1 as well as a high proportion of DDT, compared to its associated analogues, suggested a recent movement of DDT into the harbor. In 1988 the U.S. Geological Survey in the process of completing the National Water-Quality Assessment Study, detected DDT in 72 percent of the sites sampled in the Yakima River or one of its major Tributaries. The authors of a 1988 USGS report noted that DDT and metabolite concentrations measured in Johnson Creek exceeded those documented for one of the most agriculturally affected areas in the U.S.: Yakima River Basin, Washington.

Even though DDT has been banned since 1972, the Washington Coalition believe it is being illegally used in several areas within the Lower Columbia River Basin. In three Oregon

Voluntary Agriculture Pesticide Waste Collection events (1991, 1993 and 1995), a total of 21,546 lbs of DDT (including mixtures) were collected.

Section 5 Findings:

336 Environmental Clean-up sites were identified in the Oregon counties of Clackamas, Clatsop, Columbia, Multnomah and Washington. 40 Sites have surface water contamination, 18 have sediment contamination and 148 have ground water contamination. A list of 185 chemicals was compiled from these sites, 66 of which are on 'Bi-State List of Chemicals of Concern'. The mediums where contamination was found (and the corresponding number of chemicals identified in each) includes: Air (4), Groundwater (10), Leachate (3), Sediment (53), Soil (152), Surface Water (51), other (34).

Within the Washington counties of Clark, Cowlitz, Lewis, Pacific, Skamania, and Wahkiakum, 112 Environmental Clean-up sites were identified. 29 have drinking water contamination, 91 have groundwater contamination, 39 have surface water contamination and 11 have sediment contamination. Contamination was also found in the air and soil. Compound specific identification of the types of pollutants found was not possible from the Washington data base because contaminants were grouped into categories. The categories where contaminants were found include: Base/Neutral/Acid Organic, Halogenated Organic Compounds, EPA Priority Metals and Cyanide, Metals-other, Polychlorinated biPhenyls (PCB), Pesticides, Petroleum Products, Phenolic Compounds, Non-Halogenated Solvents, Dioxin, Polynuclear Aromatic Hydrocarbons (PAH), Reactive Wastes, Corrosive Wastes, Conventional Organic and Inorganic Contaminants and Asbestos.

6 landfills in Oregon were identified with contamination. A total of 25 contaminants were found of which 11 were identified on 'Bi-State List of Chemicals of Concern'. The mediums where contamination was found (and the corresponding number of chemicals identified in each) includes: Groundwater (17), Leachate (3), Sediment (4), Soil (2), Surface Water (6), other (8). 17 operating municipal or industrial solid waste landfills (including pulp/paper and demolition) were identified in the above counties.

12 Washington Landfills were identified by Tetra Tech in 1992. Additional work is under way to compile a more recent list of Washington landfills with the potential of contaminating the LCR, but is not available at this time.

2410 UST incidences occurred between 1980 and 1993 with 792 directly impacting drinking water, ground water or surface water. 1618 of the total UST incidences have been either cleaned-up or are under control. The remaining 792 incidences are ongoing or there status is unknown. 13 material mixture spills were reported and include: bunker oil, diesel, fuel oil, heating oil, leaded gasoline, unleaded gasoline, misc. gasoline, other petroleum products, waste oil, lubricant, chemical and other. The impacted mediums are: drinking water, ground water, surface water, soil, facility vapor and unknown.

For 1993, 104 facilities were identified, in ACSIS, releasing either particulate, carbon monoxide, sulfur dioxide, nitrogen dioxide, volatile organic compounds or lead in the Oregon Counties of Clackamas, Columbia, Multnomah and Washington (81 facilities release Volatile Organic

Compounds. Facilities located in Portland, St. Helens, West Linn and Forest Grove contribute a large portion of the criteria pollutants to the area.
In 1993, a total of 139 Oregon and Washington facilities reported to EPA's Toxic Release Inventory. 89 facilities reported releasing a combined total of 69 pollutants (11 identified on 'Bi-State Chemicals of Concern') to the atmosphere in the 5 identified Oregon counties. 50 facilities reported releasing a combined total of 47 chemicals (10 identified on the 'Bi-State List of Chemicals of Concern') to the 3 identified Washington counties.

Between the years of 1992 and 1995 the USGS reported 343 individual spill incidents to the LCR in which 39 substances were identified. For the same years 298 spill incidents occurred in the Willamette River in which 47 substances were identified. In a majority of the spills the identified substances were complex mixtures such as gasoline or diesel oil.

In 1993, 83 facilities reported generating hazardous waste containing a combined total of 22 toxic pollutants (8 were identified on the 'Bi-State List of Chemicals of Concern').

Recommendations

1. Calculate loads for all minor facilities above Willamette Falls and all facilities located above Bonneville Dam.

2. Compare point source load results with Tetra-Tech's fish and sediment sampling data to determine if contaminated fish or sediment locations correspond to point source hot spots.

3. Use available documentation pertaining to potential sources of chlorinated dioxins and furans in order to design and implement a monitoring program for improved tracking of these contaminants in the Lower Columbia River Basin.

4. DEQ and Ecology should gather and review all relevant ambient monitoring data (i.e., mixing zone studies, dilution studies, or other special ambient monitoring studies required by permits) submitted by NPDES permittees. In cases where such data has not been collected, DEQ and Ecology, in cooperation with all municipal and industrial permit holders should require periodic ambient measurements of those pollutants found in the permittee's discharge upstream and downstream from the permittee's outfall to better determine the fate and transport of those pollutants in receiving waters in relation to background levels. This could be accomplished as a permit renewal requirement.

5. Establish a system to expand monitoring of permitted point source dischargers, as required, to include a "beneficial uses impact analysis" and to identify the concentrations and loading contribution of all possible pollutants discharged (conduct full-scan analysis of effluent). This would be required at least once for all permittees and periodically for the Major permittees.

6. DEQ and Ecology should assess the cumulative impacts of General Permitting discharges on receiving water. General permittees were excluded from the 1993 inventory (which included Major and Minor permittees). Most General permittees do not report their discharge volume making load estimates impossible using traditional means (Concentration of pollutant times discharge volume).

7. Substitute 'toxic equivalent' values for pollutant loads (Lbs/day) in making comparisons of potential NPDES discharge impacts in respect to river segments and industry types.

8. NPDES DMR Data reporting requires:

    - Uniformity and clarity in titling monitored chemicals. Data bases are being developed to handle large fields of point-source data and they will need precise constituent identities for entry and retrieval purposes.

    - Inclusion of detection limits in DMRs. This will be important for load calculations (useful in TMDL analysis) which are based on detection limits in cases where pollutants are not detected.
    - Full use of NPDES discharge monitoring report (DMR)data requires uniform and accurate use of '<' (and '>') signs in Discharge monitoring reports. These designations can greatly influence load calculations which are usually estimated using the detection limits in the case of non-detected parameters. These reports should also include a regularly administered QA/QC program.

    - Computer disk DMR reporting for easy entry of monitoring data into data bases such as DMS (Discharge Monitoring System). This would enable automatic flagging of permit limit exceedences, more immediate access to data, timely permittee notification of necessary compliance actions, comparative analysis of monitoring results, facility performance tracking, and other efficient data audits, surveys and reviews. An <u>annual summary</u> could be submitted on paper to reduce filing.

9. DEQ and Ecology, in cooperation with permit holders, should gather the most up-to-date monitoring data for each major and minor NPDES permittee pertaining to the presence and concentrations of the 168 "priority pollutants". This data could include analytical data reported as a part of the permit renewal process (Form C), routine monitoring data, or other data collected as specified by each discharger's NPDES permit, such as special studies required as a condition of a permit. The data should be systematically reviewed keeping in mind that trace concentrations of persistent pollutants from several dischargers might cumulatively account for the presence in the Lower Columbia River of chemicals of concern to the Bi-State Program. Analytical methodology and detection levels should be specified.

10. Provide a central location for NPDES permit application/renewal scans, ideally in an electronic data base. Scans of this nature are the best source of comprehensive wastewater effluent information.
11. Calculate urban stormwater runoff load estimates for cites upstream on Willamette River, such as Albany, Corvallis, Salem and Eugene.

12. Existing stormwater monitoring data by land use type should be use in characterizing pollutant loading, and municipalities should be allowed to develop more cost-effective monitoring schemes that better reflect actual water quality impacts from runoff.

13. Ecology and DEQ should coordinate with municipalities in order to assure comparable analysis of chemical constituents and should use an analysis method with the lowest practical detection limit to ensure accurate identification of compounds and compatibility in urban stormwater samples from the different municipalities.

14. Develop and use more sophisticated non-point source modeling techniques that would take into account such factors as soil type, vegetation cover and slope. Non-point source modeling would greatly increase the confidence in the load attributed to urban storm water run-off from non-permitted cities and allow load estimates to be made for agricultural and forested areas.
15. Review point source Discharge Monitoring Report Limits for metals that are contributing large proportions of tributary loadings.

16. Ecology and DEQ should, in cooperation with USGS, increase the frequency of full scan monitoring of the mainstem Columbia including all tributaries with urban influence. Available information was not extensive enough to determine pollutant loading trends in the Lower Columbia River Basin.

17. DEQ and Ecology, in cooperation with USGS, should conduct synoptic tributary mass loading evaluations that would analyze water, sediment and fish tissue contaminant levels and in addition at times of maximum concern (e.g., high flows, after or during major storm events) for water quality conditions for the Lower Columbia River Basin. Synoptic tributary loading evaluations have not been achieved to date for most toxic parameters. Information gathered from this research would enable mass balance estimates providing a clearer picture of pollutant partitioning in the Basin.

18. Perform extensive modeling to determine the source of 'unaccounted' loads including pesticides, other organics and metals.

19. A full inventory of chemical contaminants in the upper Columbia River and a complete cumulative impact analysis is recommended. Inventory and characterize point sources to the Canadian border. Make a database. Sample water, sediment and tissue upstream of Bonneville.

20. Characterize the environmental fate of all contaminants of concern of the LCR and Estuary, in order to better understand their hazard potential.

References and Bibliography

BCI, 1990. Potential Surface Water Point Sources of Chlorinated Dioxins and Furans In the Columbia River Basin.

BCI, 1991. Ambient Monitoring Plan for Characterization of Point Source Emissions of Selected Contaminants To Surface Waters of the Columbia River Basin.

BCI, 1991. Quality Assurance Plan for Selected Toxics Monitorings in the Columbia river Basin.

Bureau of Water Supply, 1992. The Potential for Drinking Water Contamination from Submersible Well Pumps. PUBL-WA-025-92.

City of Gresham and Co-Applicants, 1993. NPDES, National Pollutant Discharge Elimination System Municipal Stormwater Permit Application, Part 2.

City of Portland and Co-Applicants, 1993. NPDES, National Pollutant Discharge Elimination System, Municipal Stormwater Permit Application, Part 2.

Clackamas County and Co-Applicants, 1993. NPDES, National Pollutant Discharge Elimination System, Municipal Stormwater Permit Application, Part 2.

Connell Des W., Gregory J. Miller. Chemistry and Ecotoxicology of Pollution

Crawford, David W., Nancy L. Bonnevie, and Richard J. Wenning. 1995. Sources of Pollution and Sediment Contamination in Newark Bay, New Jersey. Ecotoxicology and Environmental Safety 30, pp. 85-100.

Curtis, Lawrence R., Hillary M. Carpenter, Regina M. Donohoe, David E. Williams, Olaf R. Hedstrom, Max L. Delner, Michael A. Bellstein, Eugene Foster, and Richard Gates. 1993. Sensitivity of Cytochrome P450-1A1 Induction in Fish as a Biomaker for Distribution of TCDD and TCDF in the Willamette River, Oregon. Environmental Science & Technology, Vol. 27.

Czuczwa, J.M., R.A. Hites, 1984. Environmental fate of combustion-generated polychlorinated dioxins and furans. Environ. Sci. Technol. 18; pp. 444-450.

Ehrlich, R., R. J. Wenning, G.W. Johnson, S.H. Su, and D. J. Paustenbach, 1994. A Mixing Model for Polychlorinated Dibenzo-*p*-Dioxins and Dibenzofurans in Surface Sediments from Newark Bay, New Jersey Using Polytopic Vector Analysis. Archives of Environmental Contamination and Toxicology, 27, pp. 486-500.

Finley, Brent, Richard J. Wenning, Michael J. Ungs, Steve Huntley, and Dennis J. Paustenbach. PCDDs and PCDFs in Surfical Sediments From the Lower Passaic River and Newark Bay. Organohalogen Compounds.

Fuhrer, Gregory J., Dwight Q. Tanner, Jennifer L. Morace, Stuart W. McKenzie and Kenneth A. Skach. Water Quality of the Lower Columbia River Basin: Analysis of Current and Historical Water Quality Data through 1994. U.S. Geological Survey, Water Resources Investigations Report 96. 1990.

Hites, R.A. Acc. Chem Res., 1993, 23, 194-201, 1993.

Hubbard, L.E., T.A. Herrett, R.L. Kraus, G.P. Ruppert, and M.L. Courts, 1993. Water Resources Data Oregon Water Years 1992. US Geological Survey Water-Data Report OR-92-1.

Hubbard, L.E., T.A. Herrett, R.L. Kraus, G.P. Ruppert, and M.L. Courts, 1993. Water Resources Data Oregon Water Years 1993. US Geological Survey Water-Data Report OR-93-1.

Hubbard, L.E., T.A. Herrett, R.L. Kraus, G.P. Ruppert, and M.L. Courts, 1994. Water Resources Data Oregon Water Years 1994. US Geological Survey Water-Data Report OR-94-1.

Huntley, S.L., R.J. Wenning, D.J. Paustenbach, A.S. Wong, W.J. Luksemburg, 1994. Potential Sources of Polychlorinated Dibenzothiophenes in the Passaic River, New Jersey. Chemosphere, Vol. 29, No. 2, pp. 257-272.

Lower Columbia River Bi-State Program. Reconnaissance Survey of the Lower Columbia River. Task 2 Data Analysis Report: Inventory and Characterization of Pollutants, 1992. Final Report.

McFarland, Victor A. and Joan U. Clarke, 1989. Environmental Occurrence, Abundance, and Potential Toxicity of Polychlorinated Biphenyl Congeners: Considerations for a Congener-Specific Analysis. Environmental Health Perspectives, Vol.81, pp. 225-289.

Miles, M.B., W.D. Wiggins, G.P. Ruppert, R.R. Smith, L.L. Reed, L.E. Hubbard and M.L. Courts, 1992. Water Resource Data Washington Water Year 1992. U.S. Geological Survey Water-Data Report WA-92-1.

Miles, M.B., W.D. Wiggins, G.P. Ruppert, R.R. Smith, L.L. Reed, L.E. Hubbard and M.L. Courts, 1993. Water Resource Data Washington Water Year 1993. U.S. Geological Survey Water-Data Report WA-93-1.

Miles, M.B., W.D. Wiggins, G.P. Ruppert, R.R. Smith, L.L. Reed, L.E. Hubbard and M.L. Courts, 1994. Water Resource Data Washington Water Year 1994. U.S. Geological Survey Water-Data Report WA-94-1.

Moore, A.M., 1968. Water temperatures in the Columbia River Basin, July 1966 to September 1967; U.S. Geological Survey Open-File Report, 39p.

Mullin Michael D., Cynthia M. Pochini, Sheila McCrindle, Marjorie Romkes, Stephen H. Safe and Lorna M. Safe, 1984. High-Resolution PCB Analysis: Synthesis and Chromatographic Properties of All 209 PCB Congeners. Environ. Sci. Technol., 18, pp. 468-476.

Newman, Michael C. and Alan W. McIntosh. Metal Ecotoxicology, Concepts and Applications, 1991. Library of Congress.

NOAA, 1993. The National Coast Pollutant Discharge Inventory. Point Source Methods Document. National Oceanic and Atmospheric Administration.

Oregon Department of Environmental Quality & Washington Department of Ecology. PCBs. Currents, The Lower Columbia River Bi-State Water Quality Program.

Parsons, A.H., S.L. Huntley, E.S. Ebert, E.R. Algeo and R.E. Keenan, 1991. Risk Assessment for Dioxin in Columbia River Fish. Chemosphere. Vol 23, Nos. 11-12, pp. 1709-1717.

Port of Portland, 1992. Portland Ship Yard Dry Dock 4 Sediment Quality Testing Final Results and QA/QC.

Rosetta, Thomas. 1995. Willamette River Basin Water Quality Study, Phase II Preliminary report Compilation and Evaluation of Toxics Data (1985-1995). Department of Environmental Quality, unpublished in-house document.

Science Applications International Corporation, 1990. Indicator Parameters In the NPDES Permit Program: PCDDs and PCDFs In Bleach Kraft Paper Mill Effluents. DRAFT. Prepared for United States Environmental Protection Agency, Region 10 under Contract No 68-C8-0066, WA #C-1-20(P).

Smith, Gregory J. 1987. Pesticide Use and Toxicology in Relation to Wildlife: Organophosphorus and Carbamate Compounds. US Dept of the Interior, Fish & Wildlife Service, Resource Publication 170.

Stokes, Lee W., 1987. Hazardous Waste Management/in the Northwest: A Status Report.

Thurman, E.M., 1985. Organic geochemistry of natural waters: Dordrech, the Netherlands, Martinus Nijhoff/ Dr. W. Junk Publishers, 497 p.

United States Environmental Protection Agency, 1980. Dioxins. Produced by M.P. Esposito et al., PEDCo Environmental, Inc. Cincinnati, OH. EPA/600/2-80/197.

United States Environmental Protection Agency, 1991. Potential Surface Water Point Source of Chlorinated Dioxins and Furans In The Columbia River Basin.

United States Environmental Protection Agency, 1991. Total Maximum Daily Loading (TMDL) To Limit Discharges of 2,3,7,8,-TCDD (Dioxin) To The Columbia River Basin.

United States Environmental Protection Agency, 1994. New Dioxin Data to Complete Reassessment Process.

United States Environmental Protection Agency, 1980. Ambient Water Quality Criteria for Polychlorinated Biphenyls. EPA 440/5-80-068.

US ACE, Corps of Engineers, North Pacific Division, Portland, OR, 1994. Dissolved Gas Monitoring Columbia and Snake Rivers.

U.S. Army Corps of Engineers, Portland District, July, 1991, Revised March 1992. Preliminary Assessment Report, Bonneville Lock and Dam Project, Oregon. Bushing Failures and PCB Exposure.

US Geological Survey Circular 1090, (1993). Persistence of the DDT Pesticide in the Yakima River Basin Washington.

Wenning, Richard J., Mark A. Harris, Dennis J. Paustenbach, Hadley Bedbury, 1992. Chemometric Comparisons of Polychlorinated Dibenzo-*p*-Dioxin and Dibenzofuran Residues in Surfical Sediments from Newark Bay, New Jersey, and Other Industrialized Waterways. Arch. Environ. Contam. Toxicol. 22, pp. 397-413.

Wenning, Richard J., Mark A. Harris, Dennis J. Paustenbach, Hadley Bedbury, 1992. Potential Sources of 1,2,8,9-Tetrachlorodibenzo-P-Dioxin in the Aquatic Environment. Ecotoxicology and Environmental Safety 23, pp. 133-146.

Wenning, Richard J., Dennis J. Paustenbach, Mark A. Harris, Hadley Bedbury, 1993. Principal Compounds Analysis of Potential Sources of Polychlorinated Dibenzo-p-Dioxin and Dibenzofuran Residues in Surfical Sediments from Newark Bay, New Jersey. Archives of Environmental Contamination and Toxicology, 24.

TABLES

Table 1. The Bi-State List of Chemicals of Concern; developed from water column, sediment , and tissue criteria or reference value exceedances observed from ambient water quality analysis (1991-1993 data)

CHEMICAL	CHEMICAL_GROUP	CAS_CODE	CHEMICAL	CHEMICAL_GROUP	CAS_CODE
1,2,3,4,6,7,8-HpCDD	DIOXIN/FURANS	37871004	p,p'-DDT	PESTICIDES	50293
1,2,3,4,6,7,8-HpCDF	DIOXIN/FURANS	67562394	Parathion	PESTICIDES	56382
1,2,3,4,7,8,9-HpCDF	DIOXIN/FURANS	55673897	Total BHC	PESTICIDES	
1,2,3,4,7,8-HxCDD	DIOXIN/FURANS	39227286	Total Chlordane	PESTICIDES	
1,2,3,4,7,8-HxCDF	DIOXIN/FURANS	70648269	Total DDT	PESTICIDES	
1,2,3,6,7,8-HxCDD	DIOXIN/FURANS	57653857	Toxaphene	PESTICIDES	8001352
1,2,3,6,7,8-HxCDF	DIOXIN/FURANS	57117314	Cesium 137	RADIONUCLIDES	10045973
1,2,3,7,8,9-HxCDD	DIOXIN/FURANS	19408743	Plutonium 238	RADIONUCLIDES	13981163
1,2,3,7,8,9-HxCDF	DIOXIN/FURANS	72918219	Plutonium 239/240	RADIONUCLIDES	
1,2,3,7,8-PeCDD	DIOXIN/FURANS	40321764	1,2,4-Trichlorobenzene	SEMI-VOLATILES	120821
1,2,3,7,8-PeCDF	DIOXIN/FURANS	57117416	2,4-Dinitrotoluene	SEMI-VOLATILES	121142
2,3,4,6,7,8-HxCDF	DIOXIN/FURANS	60851345	4-Nitrophenol	SEMI-VOLATILES	100027
2,3,4,7,8-PeCDF	DIOXIN/FURANS	57117314	Bis(2-ethylhexyl)phthalate	SEMI-VOLATILES	117817
2,3,7,8-TCDD	DIOXIN/FURANS	1746016	Di-n-octylphthalate	SEMI-VOLATILES	117810
2,3,7,8-TCDF	DIOXIN/FURANS	51207319	Isophorone	SEMI-VOLATILES	78591
OCDD	DIOXIN/FURANS	3268879	N-Nitroso-di-n-propylamine	SEMI-VOLATILES	621647
OCDF	DIOXIN/FURANS		Acenaphthene	SEMI-VOLATILES PAHs	83329
TOTAL HxCDD	DIOXIN/FURANS		Anthracene	SEMI-VOLATILES PAHs	120127
Aroclor 1232	PCBs	11141165	Benz[a]anthracene	SEMI-VOLATILES PAHs	56553
Aroclor 1242	PCBs	53469219	Benzo[a]pyrene	SEMI-VOLATILES PAHs	50328
Aroclor 1248	PCBs	12672296	Benzo[b,k]fluoranthene	SEMI-VOLATILES PAHs	
Aroclor 1254	PCBs	11097691	Benzo[b]fluoranthene	SEMI-VOLATILES PAHs	205992
Aroclor 1260	PCBs	11096825	Benzo[g,h,i]perylene	SEMI-VOLATILES PAHs	191242
TOTAL PCBs	PCBs	13336363	Benzo[k]fluoranthene	SEMI-VOLATILES PAHs	207089
Aldrin	PESTICIDES	309002	Chrysene	SEMI-VOLATILES PAHs	218019
alpha-BHC	PESTICIDES	319846	Dibenz[a,h]anthracene	SEMI-VOLATILES PAHs	53703
alpha-Chlordane	PESTICIDES	5103719	Fluoranthene	SEMI-VOLATILES PAHs	206440
beta-BHC	PESTICIDES	319857	Fluorene	SEMI-VOLATILES PAHs	86737
Chlordane	PESTICIDES	57549	Indeno[1,2,3-cd]pyrene	SEMI-VOLATILES PAHs	193395
[illegible]ordane (Tech)	PESTICIDES		Phenanthrene	SEMI-VOLATILES PAHs	85018
delta-BHC	PESTICIDES	319868	Pyrene	SEMI-VOLATILES PAHs	129000
Dicofol	PESTICIDES	115322	Aluminum	TRACE METALS	7429905
Dieldrin	PESTICIDES	60571	Antimony	TRACE METALS	7440360
Endosulfan	PESTICIDES	115297	Arsenic	TRACE METALS	7440382
Endosulfan I	PESTICIDES	959988	Barium	TRACE METALS	7440393
Endosulfan II	PESTICIDES	33213659	Beryllium	TRACE METALS	7440417
Endrin	PESTICIDES	72208	Cadmium	TRACE METALS	7440439
gamma-BHC	PESTICIDES	58899	Chromium	TRACE METALS	7440473
gamma-Chlordane	PESTICIDES	5103742	Copper	TRACE METALS	7440508
Heptachlor	PESTICIDES	76448	Cyanide	TRACE METALS	57125
Heptachlor epoxide	PESTICIDES	1024573	Cyanide, Total	TRACE METALS	
Hexachlorobenzene	PESTICIDES	118741	Cyanide, weak & diss.	TRACE METALS	
Malathion	PESTICIDES	121755	Iron	TRACE METALS	7439896
Methoxychlor	PESTICIDES	72435	Lead	TRACE METALS	7439921
Methyl parathion	PESTICIDES	298000	Manganese	TRACE METALS	7439965
Mirex	PESTICIDES	2385855	Mercury	TRACE METALS	7439976
o,p'-DDD	PESTICIDES	53190	Nickel	TRACE METALS	7440020
o,p'-DDE	PESTICIDES	3424826	Selenium	TRACE METALS	7782492
o,p'-DDT	PESTICIDES	789026	Silver	TRACE METALS	7440224
p,p'-DDD	PESTICIDES	72548	Zinc	TRACE METALS	7440666
p,p'-DDE	PESTICIDES	72559			

Table 2. Identified Oregon and Washington NPDES Point Source Dischargers.

Facilities	Industrial		Domestic	
	Major	Minor	Major	Minor
OREGON	15	21	25	15
WASHINGTON	8	11	4	20

Table 3. Identified Oregon NPDES Point Source Discharges Located Above Willamette Falls.

Facility Type	Major
Industrial	10
Domestic	18

Table 4. Parameters reported in DMRs and inventoried for this evaluation in order to calculate loads (or levels).

ORGANICS	ORGANICS	GENERAL ORGANICS	METALS	CONVENTIONALS
*1,1,1-TRICHLOROETHANE	Carbon Disulfide	*CARBON TOTAL ORGANIC	*ALUMINUM	BOD, 5-DAY (20 DEG. C)
*1,1,2-TRICHLOROETHANE	*CARBON TETRACHLORIDE	PETROLEUM HYDROCARBONS	*ANTIMONY	BOD, CARBONACEOUS, 5-DAY (20°C)
*1,1-DICHLOROETHANE	*Chlorinated Phenols	OIL & GREASE	*ARSENIC	BOD, CARBONACEOUS, 5-DAY (5°C)
1,1-DICHLOROETHYLENE	*CHLOROBENZENE	ORGANICS, TOTAL TOXIC	*BARIUM	CHEMICAL OXYGEN DEMAND
*1,2,4-TRICHLOROBENZENE	*CHLOROETHANE	AOX	BORON	*COLIFORM, FECAL
*1,2-DICHLOROBENZENE	CHLOROFORM		*CADMIUM	SOLIDS SETTLEABLE
*1,2-DICHLOROETHANE	*CHRYSENE		*CHROMIUM	*SOLIDS TOTAL
*1,2-DICHLOROPROPANE	*DI-N-BUTYL PHTHALATE		*CHROMIUM	SOLIDS TOTAL DISSOLVED
*1,2-TRANS-	*DIETHYL PHTHALATE		COBALT	*SOLIDS, TOTAL SUSPENDED
*1,3-DICHLOROBENZENE	*DIMETHYL PHTHALATE		*COPPER	COLOR
*1,4-DICHLOROBENZENE	*DIOXIN (2,3,7,8 TCDD)		CYANIDE	OXYGEN DISSOLVED (DO)
2,3,4,6-	*ETHYLBENZENE		FLOURIDE	PH
*2,4-DICHLOROPHENOL	*FLUORANTHENE		*IRON	TEMPERATURE
*2,4-DIMETHYLPHENOL	*FLUORENE		*LEAD	
*2,4-DINITROPHENOL	*FURAN (2,3,7,8 TCDF)		MAGNESIUM	
*2,4-DINITROTOLUENE	*HEXACHLOROBENZENE		MANGANESE	
*2,6-DINITROTOLUENE	*HEXACHLOROBUTADIEN		*MERCURY	
*2-CHLOROPHENOL	*METHYL CHLORIDE		METALS	
*2-NITROPHENOL	*METHYLENE CHLORIDE		MOLYBDEU	
*3,4 BENZOFLUORANTHENE	*NAPHTHALENE		*NICKEL	
4,6-DINITRO-O-CRESOL	NITROBENZENE		*SELENIUM	
*4-NITROPHENOL	*PENTACHLOROPHENOL		*SILVER	
*ACENAPHTHENE	*PHENANTHRENE		*ZINC	
*ACENAPHTHYLENE	*PHENOL			
ACRYLONITRILE	*PHENOLICS, TOTAL			
*ANTHRACENE	*PHENOLS			
*BENZENE	*PYRENE			
*BENZO(A)ANTHRACENE	*TETRACHLOROETHENE			
*BENZO(A)PYRENE	TETRACHLOROETHYLEN			
*BENZO(B)FLUORANTHENE	*TOLUENE			
*BENZO(G,H,I)PERYLENE	*TRICHLOROETHENE			
*BENZO(K)FLUORANTHENE	TRICHLOROETHYLENE			
*Bis(2-ethylhexyl)phthalate	VINYL CHLORIDE			

* - Parameters of concern identified by Tetra Tech as being known or suspected to be present in water, sediment, or fish tissue that may be impacting fish, wildlife or human health in LCR.

Table 5. Columbia River mainstem Segment Designations by River Mile.

Segment	Columbia Mainstem River Mile	Major Tributary Inputs
1A	0 - 13	
[illegible]B	13 - 18.5	
1C	18.5 - 30	
2A	30 - 47	
2B-	47 - 53.5	
2C	53.5 - 72	Cowlitz R.
3A	72 - 87.5	Lewis R. & Kalama R.
3B	87.5 - 102	Willamette R. & Columbia Sl.
4A	102 - 125.3	Sandy R.
4B	125.3 - 145	Upper Columbia R.

Table 6. Total NPDES facilities with effluent discharge inputs to designated Lower Columbia River mainstem segments.

RIVER SEGMENT	OREGON	WASHINGTON	TOTAL
1A	4	4	8
1B	1	0	1
1C	0	0	0
2A	1	1	2
2B	3	0	3
2C	2	16	18
3A	5	5	10
3B	50	2	52
4A	8	9	17
4B	2	6	8

Table 7. Identified NPDES facilities discharging directly to the LCR, or one of 5 major river tributaries.

River (Tributary)	# of Facilities
Columbia R.	41
Willamette R.	45
Columbia Slough	5
Sandy R.	3
Lewis R.	10
Kalama R.	0
Cowlitz R.	10
LCR Minor Tribs.	5

Table 8. Summary of Identified NPDES Facilities by General SIC Code

GENERAL SIC CODE	FACILITIES	INDUSTRY TYPE
2000	3	FOOD AND KINDRED PRODUCTS
2200	1	TEXTILE MILLS
2400	6	LUMBER AND WOOD PRODUCTS
2600	13	PAPER AND ALLIED PRODUCTS
2800	8	CHEMICALS AND ALLIED PRODUCTS
3200	1	STONE, CLAY, AND GLASS PRODUCTS
3300	10	PRIMARY METAL INDUSTRIES
3400	1	FABRICATED METAL PRODUCTS
3500	1	INDUSTRIAL METAL PRODUCTS
3600	2	ELECTRONIC AND OTHER ELECTRICAL EQUIPTMENT AND COMPONENTS
3700	2	TRANSPORTATION EQUIPTMENT
4000	1	RAILROAD TRANSPORTATION
4900	65	ELECTRIC AND SANITARY SERVICES (3 Electric Services and 62 Sanitary Services)
5100	1	WHOLESALE TRADE, NONDURABLE GOODS
6500	2	REAL ESTATE (e.g. mobile home parks)
7600	1	MISCELLANEOUS REPAIR SERVICES
8200	1	EDUCATIONAL SERVICES

Table 9. Summary statistics: % Pollutant type loading by river segment type for all inventoried LCR Basin NPDES Major and Minor facilities.

Category	Table #	1A	1B	2A	2B	2C	3A	3B	4A	4B
Organics	7	0	0	0	<1%	0.0004%	4.44%	**93%**	2.4%	<1%
General Organics	8	<1%	0	0	15%	<1%	**45%**	10%	29.54%	<1%
Metals	9	0	0	0	<1%	18.18%	1.83%	**54.16%**	25.49%	<1%
Conventionals	10	<1%	<1%	<1%	4.47%	14%	14%	**45%**	21%	<1%

* Bold and underlined text represents category maximums.

Table 10. Organic Parameter Loads (lbs/day) by River Segment for all inventoried LCR Basin NPDES Major and Minor facilities.

	RIVER SEGMENT						
PARAMETER	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
BENZO(A)ANTHRACENE	0	0	0	7.83E-04	0	0	7.83E-04
BENZO(A)PYRENE	0	0.01	0	1.59E-03	0	0	0.01
BENZO(B)FLUORANTHENE	0	0	0	1.28E-03	0	0	1.28E-03
BENZO(G,H,I)PERYLENE	0	0	0	2.26E-03	0	0	2.26E-03
BENZO(K)FLUORANTHENE	0	0	0	0.60	0	0	0.60
Bis(2-ethylhexyl)phthalate	0	0	0	1147.03	0	0	1147.03
Carbon Disulfide	0	0	0	0.15	0	0	0.15
CARBON TOTAL ORGANIC	0	0	0	81.37	57.81	0	139.18
Chlorinated Phenols	0	0	0	5.31E-04	0	0	5.31E-04
CHLOROFORM	0	0	16.54	939.29	0	0	955.83
CHRYSENE	0	0	0	0.58	0	0	0.58
DI-N-BUTYL PHTHALATE	0	0	6.67E-04	0	0	0	6.67E-04
DIOXIN (2,3,7,8 TCDD)	1.12E-06	1.85E-06	3.51E-06	7.53E-07	6.04E-06	0	1.33E-05
FLUORANTHENE	0	0	0	1.29E-03	0	0	1.29E-03
FURAN (2,3,7,8 TCDF)	4.55E-06	7.54E-06	1.81E-05	1.21E-06	1.27E-05	0	4.41E-05
METHYLENE CHLORIDE	0	0	0	2.17	0	0	2.17
PHENANTHRENE	0	0	6.67E-04	4.97E-04	0	0	1.16E-03
PHENOL	0	0	1.88E-03	1.00	10.18	0.08	11.26
PHENOLICS, TOTAL	0	0	113.30	0	0	0	113.30
PHENOLS	0	0	0	100.49	2.52	0	103.00
PYRENE	0	0	0	1.02E-03	0	0	1.02E-03
TETRACHLOROETHENE	0	0	0	1.90E-04	0	0	1.90E-04
TETRACHLOROETHYLENE	0	0	0	0.01	0	0	0.01
TOLUENE	0	0	0	450.39	0	0	450.39
TRICHLOROETHENE	0	0	0	5.12E-04	0	0	5.12E-04
TRICHLOROETHYLENE	0	0	0	0.03	0	0	0.03
Grand Total	5.67E-06	0.01	129.85	2723.12	70.51	0.08	2923.57
% TOTAL BY RIVER SEGMENT	**0.0000002%**	**0.0004%**	**4.44%**	**93.14%**	**2.41%**	**0.003%**	**100.00%**

Table 10a. % Organic Parameter Loads by River Segment for all inventoried LCR Basin NPDES Major and Minor facilities

	RIVER SEGMENT						
PARAMETER	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
BENZO(A)ANTHRACENE	0	0	0	100.00%	0	0	100.00%
BENZO(A)PYRENE	0	87.90%	0	12.10%	0	0	100.00%
BENZO(B)FLUORANTHENE	0	0	0	100.00%	0	0	100.00%
BENZO(G,H,I)PERYLENE	0	0	0	100.00%	0	0	100.00%
BENZO(K)FLUORANTHENE	0	0	0	100.00%	0	0	100.00%
Bis(2-ethylhexyl)phthalate	0	0	0	100.00%	0	0	100.00%
Carbon Disulfide	0	0	0	100.00%	0	0	100.00%
CARBON TOTAL ORGANIC (TOC)	0	0	0	58.46%	41.54%	0	100.00%
Chlorinated Phenols	0	0	0	100.00%	0	0	100.00%
CHLOROFORM	0	0	1.73%	98.27%	0	0	100.00%
CHRYSENE	0	0	0	100.00%	0	0	100.00%
DI-N-BUTYL PHTHALATE	0	0	100.00%	0	0	0	100.00%
DIOXIN (2,3,7,8 TCDD)	8.43%	13.92%	26.47%	5.67%	45.50%	0	100.00%
FLUORANTHENE	0	0	0	100.00%	0	0	100.00%
FURAN (2,3,7,8 TCDF)	10.31%	17.09%	41.02%	2.75%	28.83%	0	100.00%
METHYLENE CHLORIDE	0	0	0	100.00%	0	0	100.00%
PHENANTHRENE	0	0	57.28%	42.72%	0	0	100.00%
PHENOL	0	0	<1%	8.90%	90.40%	<1%	100.00%
PHENOLICS, TOTAL	0	0	100.00%	0	0	0	100.00%
PHENOLS	0	0	0	97.56%	2.44%	0	100.00%
PYRENE	0	0	0	100.00%	0	0	100.00%
TETRACHLOROETHENE	0	0	0	100.00%	0	0	100.00%
TETRACHLOROETHYLENE	0	0	0	100.00%	0	0	100.00%
TOLUENE	0	0	0	100.00%	0	0	100.00%
TRICHLOROETHENE	0	0	0	100.00%	0	0	100.00%
TRICHLOROETHYLENE	0	0	0	100.00%	0	0	100.00%

Table 11. General Organic Parameter Loads (lbs/day) by River Segment for all inventoried LCR Basin NPDES Major and Minor facilities

	RIVER SEGMENT							
PARAMETER	**1A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
AOX (ABSORBABLE ORGANIC HALIDES)	0	5370	0	2933	1891	10034	0	20228
HP	0	0	0	0	1514	0	0	1514
OIL & GREASE	119	7	83	3243	818	30	37	4336
ORGANICS, TOTAL TOXIC (TTO)	0	0	0	10033	0	0	0	10033
Grand Total	119	5378	83	16209	4222	10063	37	36111
% TOTALBY RIVER SEGMENT	**<1%**	**14.89%**	**<1%**	**44.89%**	**11.69%**	**27.87%**	**<1%**	**100.00%**

Table 11(a). % General Organic Parameter Loads By River Segment for all inventoried LCR Basin NPDES Major and Minor facilities.

	RIVER SEGMENT						
PARAMETER	**1A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**
AOX (ABSORBABLE ORGANIC HALIDES)	0.00%	26.55%	0.00%	14.50%	9.35%	49.60%	0.00%
HP	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%
OIL & GREASE	2.73%	<1%	1.92%	74.80%	18.85%	<1%	<1%
ORGANICS, TOTAL TOXIC (TTO)	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%

Table 12. Metal Parameter Loads (lbs/day) by River Segment for all inventoried LCR Basin NPDES Major and Minor facilities.

	RIVER SEGMENT						
PARAMETER	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
ALUMINUM, TOTAL (AS AL)	0.000	51.333	0.000	0.000	5.131	0.000	56.465
ANTIMONY, TOTAL (AS SB)	0.000	0.000	0.000	0.000	0.247	0.000	0.247
ARSENIC, TOTAL (AS AS)	0.000	0.000	0.000	3.483	2.794	0.681	6.959
BARIUM TOTAL	0.000	0.000	0.000	10.435	0.519	0.000	10.955
BORON TOTAL	0.000	0.000	0.000	69.661	15.963	0.000	85.623
CADMIUM, TOTAL (AS CD)	0.000	0.000	0.003	4.918	3.327	0.000	8.248
CHROMIUM HEXAVALENT	0.000	0.000	0.000	0.048	0.000	0.000	0.048
CHROMIUM, TOTAL (AS CR)	0.000	0.000	0.000	9.016	4.325	2.737	16.078
COBALT, TOTAL (AS CO)	0.000	0.000	0.170	0.000	0.000	0.000	0.170
COPPER, TOTAL (AS CU)	0.114	0.000	0.020	22.295	34.903	0.743	58.075
YANIDE, TOTAL (AS CN)	0.000	2.193	0.020	18.621	18.387	0.000	39.220
FLOURIDE, TOTAL (AS F)	0.000	199.167	0.000	322.635	128.517	0.000	650.319
IRON, TOTAL (AS FE)	0.409	0.000	0.001	45.782	13.326	0.000	59.518
LEAD, TOTAL (AS PB)	0.000	0.000	0.018	6.178	9.017	0.000	15.213
MAGNESIUM TOTAL	0.000	0.000	0.000	0.000	13.007	0.000	13.007
MANGANESE TOTAL	0.000	0.000	0.000	25.247	3.195	0.000	28.442
MERCURY, TOTAL (AS HG)	0.000	0.000	0.000	1.467	0.432	0.000	1.899
MOLYBDEUM TOTAL	0.000	0.000	0.000	4.983	1.542	0.000	6.526
NICKEL, TOTAL (AS NI)	0.000	0.525	0.034	9.875	5.745	0.000	16.179
SELENIUM, TOTAL (AS SE)	0.000	0.000	0.000	0.068	0.000	0.000	0.068
SILVER TOTAL	0.000	0.000	0.000	2.569	48.994	0.000	51.563
ZINC, DISSOLVED (AS ZN)	0.000	0.000	0.000	61.849	0.000	0.000	61.849
ZINC, TOTAL (AS ZN)	0.000	0.000	25.217	135.337	45.763	0.000	206.317
Grand Total	0.523	253.218	25.483	754.470	355.134	4.161	1392.989
% TOTAL BY RIVER SEGMENT	**<1%**	**18.18%**	**1.83%**	**54.16%**	**25.49%**	**<1%**	**100.00%**

Table 12(a). % Metal Parameter Loads (lbs/day) by River Segment for all inventoried LCR Basin NPDES Major and Minor facilities.

PARAMETER	2B	2C	3A	3B	4A	4B	Grand Total
ALUMINUM, TOTAL (AS AL)	NA	90.91%	NA	NA	9.09%	NA	100.00%
ANTIMONY, TOTAL (AS SB)	NA	NA	NA	NA	100.00%	NA	100.00%
ARSENIC, TOTAL (AS AS)	NA	NA	NA	50.06%	40.15%	9.79%	100.00%
BARIUM TOTAL	NA	NA	NA	95.26%	4.74%	NA	100.00%
BORON TOTAL	NA	NA	NA	81.36%	18.64%	NA	100.00%
CADMIUM, TOTAL (AS CD)	NA	NA	0.04%	59.63%	40.33%	NA	100.00%
CHROMIUM HEXAVALENT	NA	NA	NA	100.00%	NA	NA	100.00%
CHROMIUM, TOTAL (AS CR)	NA	NA	NA	56.08%	26.90%	17.02%	100.00%
COBALT, TOTAL (AS CO)	NA	NA	100.00%	NA	NA	NA	100.00%
COPPER, TOTAL (AS CU)	<1%	NA	<1%	38.39%	60.10%	1.28%	100.00%
CYANIDE, TOTAL (AS CN)	NA	5.59%	0.05%	47.48%	46.88%	NA	100.00%
FLOURIDE, TOTAL (AS F)	NA	30.63%	NA	49.61%	19.76%	NA	100.00%
IRON, TOTAL (AS FE)	<1%	NA	0.00%	76.92%	22.39%	NA	100.00%
LEAD, TOTAL (AS PB)	NA	NA	<1%	40.61%	59.27%	NA	100.00%
MAGNESIUM TOTAL	NA	NA	NA	NA	100.00%	NA	100.00%
MANGANESE TOTAL	NA	NA	NA	88.77%	11.23%	NA	100.00%
MERCURY, TOTAL (AS HG)	NA	NA	NA	77.25%	22.75%	NA	100.00%
MOLYBDEUM TOTAL	NA	NA	NA	76.37%	23.63%	NA	100.00%
NICKEL, TOTAL (AS NI)	NA	3.24%	0.21%	61.04%	35.51%	NA	100.00%
SELENIUM, TOTAL (AS SE)	NA	NA	NA	100.00%	NA	NA	100.00%
SILVER TOTAL	NA	NA	NA	4.98%	95.02%	NA	100.00%
ZINC, DISSOLVED (AS ZN)	NA	NA	NA	100.00%	NA	NA	100.00%
ZINC, TOTAL (AS ZN)	NA	NA	12.22%	65.60%	22.18%	NA	100.00%

Table 13. Conventional Parameter Loads (lbs/day) by River Segment for all inventoried LCR Basin NPDES Major and Minor facilities.

	RIVER SEGMENT									
PARAMETER	**1A**	**1B**	**2A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	171	293	2781	7079	14253	7528	27416	44415	327	1.04E+05
BOD CARBONACEOUS, 5-DAY (20 DEG. C)	0	0	0	0	0	4636	5792	425	0	1.09E+04
BOD, CARBONACEOUS, 5-DAY (5 DEG. C)	0	0	0	0	390	0	0	0	0	390
COD (CHEMICAL OXYGEN DEMAND)	0	0	0	0	0	0	0	0	384	384
SOLIDS SETTLEABLE	0	0	0	0	0	12	0	0	0	1.18E+01
SOLIDS TOTAL	0	0	0	0	0	0	0	1084	0	1.08E+03
SOLIDS TOTAL DISSOLVED	0	0	0	0	0	40317	126077	61	0	1.66E+05
SOLIDS, TOTAL SUSPENDED	843	468	1686	13444	49280	13432	48608	47592	640	1.76E+05
Grand Total	1E+03	8E+02	4E+03	2E+04	6E+04	7E+04	2E+05	9E+04	1E+03	5E+05
% TOTAL BY RIVER SEGMENT	**0.22%**	**<1%**	**0.97%**	**4.47%**	**13.91%**	**14.35%**	**45.25%**	**20.37%**	**<1%**	**100.00%**

Table 13(a). % Conventional Parameter Loads (lbs/day) by River Segment for all inventoried LCR Basin NPDES Major and Minor facilities.

	RIVER SEGMENT									
PARAMETER	**1A**	**1B**	**2A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	<1%	<1%	2.67%	6.79%	13.67%	7.22%	26.29%	42.60%	<1%	100.00%
BOD, CARBONACEOUS, 5-DAY (20 DEG. C)	0.00%	0.00%	0.00%	0.00%	0.00%	42.72%	53.37%	3.91%	0.00%	100.00%
BOD, CARBONACEOUS, 5-DAY (5 DEG. C)	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
COD (CHEMICAL OXYGEN DEMAND)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
SOLIDS SETTLEABLE	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
SOLIDS TOTAL	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
SOLIDS TOTAL DISSOLVED	0.00%	0.00%	0.00%	0.00%	0.00%	24.22%	75.74%	<1%	0.00%	100.00%
SOLIDS, TOTAL SUSPENDED	<1%	<1%	<1%	7.64%	28.00%	7.63%	27.62%	27.04%	<1%	100.00%

Table 14. Summary of % Organic Loading by Facility Type for each River Segment and the Entire Lower Columbia River (Grand Total).

	RIVER SEGMENT						
SIC_DEFINITION	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
[illegible]IEMICALS AND ALLIED PRODUCTS	0	0	87.26%	<1%	0	0	3.95%
ELECTRIC AND SANITARY SERVICES	0	0	12.74%	96.97%	100.00%	0	**93.30%**
INDUSTRIAL METAL PRODUCTS	0	0	0	<1%	0	0	<1%
LUMBER AND WOOD PRODUCTS	0	0	0	<1%	0	0	<1%
PAPER AND ALLIED PRODUCTS	100.00%	<1%	0	<1%	0.00003%	0	<1%
PRIMARY METAL INDUSTRIES	0	99.92%	0	2.95%	0	0	2.75%
TEXTILE MILLS	0	0	0	0	0	100.00%	0.00%
GRAND TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Table 14(a). Organic Parameter Loads (lbs/day) by River Segment for **CHEMICALS AND ALLIED PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT		
PARAMETER	**3A**	**3B**	**Grand Total**
BENZO(A)ANTHRACENE	0.0000	0.0008	0.0008
BENZO(A)PYRENE	0.0000	0.0016	0.0016
BENZO(B)FLUORANTHENE	0.0000	0.0013	0.0013
BENZO(G,H,I)PERYLENE	0.0000	0.0023	0.0023
BENZO(K)FLUORANTHENE	0.0000	0.6008	0.6008
CARBON TOTAL ORGANIC (TOC)	0.0000	0.9471	0.9471
Chlorinated Phenols	0.0000	0.0005	0.0005
CHLOROFORM	0.0007	0.0000	0.0007
CHRYSENE	0.0000	0.5834	0.5834
DI-N-BUTYL PHTHALATE	0.0007	0.0000	0.0007
FLUORANTHENE	0.0000	0.0013	0.0013
PHENANTHRENE	0.0007	0.0005	0.0012
PHENOL	0.0019	0.0000	0.0019
PHENOLICS, TOTAL	113.3	0.0000	113.3
PHENOLS	0.0000	0.0029	0.0029
PYRENE	0.0000	0.0010	0.0010
TETRACHLOROETHYLENE	0.0000	0.0000	0.0000
TOLUENE	0.0000	0.0000	0.0000
TRICHLOROETHYLENE	0.0000	0.0000	0.0000
Grand Total	113.3085	2.1434	115.4520
% TOTAL BY RIVER SEGMENT	98.14%	1.86%	100.00%

* no discharges to remaining river segments by identified facility type

Table 14(b). Organic Parameter Loads (lbs/day) by River Segment for **ELECTRIC AND SANITARY SERVICES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**3A**	**3B**	**4A**	**Grand Total**
Bis(2-ethylhexyl)phthalate	0	1147.03	0	1147.03
Carbon Disulfide	0	0.15	0	0.15
CARBON TOTAL ORGANIC (TOC)	0	0	57.81	57.81
CHLOROFORM	16.54	939.29	0	955.83
DIOXIN (2,3,7,8 TCDD)*	3.51E-06	0	0	3.51E-06
FURAN (2,3,7,8 TCDF)*	1.81E-05	0	0	1.81E-05
METHYLENE CHLORIDE	0	2.17	0	2.17
PHENOL	0	1.00	10.18	11.19
PHENOLS	0	100.48	2.52	103.00
TOLUENE	0	450.39	0	450.39
Grand Total	16.54	2640.51	70.51	2727.56
% TOTAL BY RIVER SEGMENT	<1%	96.81%	2.59%	100.00%

* Boise Cascade's St. Helens Mill discharges wastewater to City of St. Helen's Wastewater Treatment Plant (Segment 4A).

* 100% of Dioxin/Furan and 95% of remaining parameters discharged by St. Helens STP originate from Boise Cascade (St. Helens Staff).

* no discharges to remaining river segments by identified facility type.

Table 14(c). Organic Parameter Loads (lbs/day) by River Segment for **INDUSTRIAL METAL PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
TETRACHLOROETHENE	0.0002	0.0002
TRICHLOROETHENE	0.0005	0.0005
Grand Total	0.0007	0.0007
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 14(d). Organic Parameter Loads (lbs/day) by River Segment for **LUMBER AND WOOD PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
TRICHLOROETHYLENE	0.03	0.03
Grand Total	0.03	0.03
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 14(e). Organic Parameter Loads (lbs/day) by River Segment for **PAPER AND ALLIED PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT				
PARAMETER	**2B**	**2C**	**3B**	**4A**	**Grand Total**
DIOXIN (2,3,7,8 TCDD)	1.12E-06	1.85E-06	7.53E-07	6.04E-06	9.76E-06
FURAN (2,3,7,8 TCDF)	4.55E-06	7.54E-06	1.21E-06	1.27E-05	2.60E-05
Grand Total	5.67E-06	9.38E-06	1.96E-06	1.88E-05	3.58E-05
% TOTAL BY RIVER SEGMENT	15.84%	26.23%	5.49%	52.44%	100.00%

* no discharges to remaining river segments by identified facility type

Table 14(f). Organic Parameter Loads (lbs/day) by River Segment for **PRIMARY METAL INDUSTRIES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT		
PARAMETER	**2C**	**3B**	**Grand Total**
BENZO(A)PYRENE	0.01	0.00	0.01
CARBON TOTAL ORGANIC (TOC)	0.00	80.42	80.42
TETRACHLOROETHYLENE	0.00	0.01	0.01
Grand Total	0.01	80.43	80.45
% TOTAL BY RIVER SEGMENT	<1%	99.99%	100.00%

* no discharges to remaining river segments by identified facility type

Table 14(g). Organic Parameter Loads (lbs/day) by River Segment for <u>**TEXTILE MILLS**</u> facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**4B**	**Grand Total**
PHENOL	0.08	0.08
Grand Total	0.08	0.08
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15. Summary of % General Organic Loading by Facility Type for each River Segment and the Entire Lower Columbia River (Grand Total).

	RIVER SEGMENT							
SIC DEFINITIONS	**1A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
CHEMICALS AND ALLIED PRODUCTS	0	0	0	20.01%	<1%	0	0	8.98%
ELECTRIC AND SANITARY SERVICES	0	<1%	<1%	79.99%	3.34%	0	0	36.32%
ELECTRONIC AND OTHER ELECTRICAL EQUIPTMENT AND COMPONENTS	0	0	0	0	<1%	0	0	<1%
FOOD AND KINDRED PRODUCTS	100.00%	0	0	0	0	0	0	<1%
LUMBER AND WOOD PRODUCTS	0	0	<1%	0	0	<1%	74.01%	<1%
MISCELLANEOUS REPAIR SERVICES	0	0	0	0	<1%	0	0	<1%
PAPER AND ALLIED PRODUCTS	0	99.86%	0	0	80.63%	99.71%	0	**52.09%**
PRIMARY METAL INDUSTRIES	0	0	99.21%	0	15.27%	<1%	0	2.09%
RAILROAD TRANSPORTATION	0	0	0	0	0.0003%	0	0	<1%
TEXTILE MILLS	0	0	0	0	0	0	25.99%	<1%
TRANSPORTATION EQUIPTMENT	0	0	0	0	<1%	0	0	<1%
WHOLESALE TRADE, NONDURABLE GOODS	0	0	0	0	0.00001%	0	0	<1%
GRAND TOTAL	100%	100%	100%	100%	100%	100%	100%	100%

*Electric Services contribute 5.57% Oil & Grease load to the LCR.

Table 15(a). General Organic Parameter Loads (lbs/day) by River Segment for <u>**CHEMICALS AND ALLIED PRODUCTS**</u> facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**3A**	**3B**	**4A**	**Grand Total**
OIL & GREASE	3243.25	0.08	0.00	3243.33
ORGANICS, TOTAL TOXIC (TTO)	0.00	0.00	0.00	0.00
Grand Total	3243.25	0.08	0.00	3243.33
% TOTAL BY RIVER SEGMENT	100.00%	<1%	0.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(b). General Organic Parameter Loads (lbs/day) by River Segment for **ELECTRIC AND SANITARY SERVICES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT				
PARAMETER	**2B**	**2C**	**3A**	**3B**	**Grand Total**
AOX (ABSORBABLE ORGANIC HALIDES)	0.00	0.00	2933.22	0.00	2933.22
OIL & GREASE	7.37	0.48	0.00	140.87	148.72
ORGANICS, TOTAL TOXIC (TTO)	0.00	0.00	10032.90	0.00	10032.90
Grand Total	7.37	0.48	12966.12	140.87	13114.84
% TOTAL BY RIVER SEGMENT	<1%	<1%	98.87%	1.07%	100.00%

* Boise Cascade's St. Helens Mill discharges wastewater to City of St. Helen's Wastewater Treatment Plant (Segment 4A).
100% of Dioxin/Furan and 95% of remaining parameters discharged by St. Helens STP originate from Boise Cascade (St. Helens Staff).
* Electric Services contribute 7.85 lbs/day Oil & Grease load to the LCR.
* no discharges to remaining river segments by identified facility type.

Table 15(c). General Organic Parameter Loads (lbs/day) by River Segment for **ELECTRONIC AND OTHER ELECTRICAL EQUIPTMENT AND** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
ORGANICS, TOTAL TOXIC (TTO)	0.11	0.11
Grand Total	0.11	0.11
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

[illegible]ble 15(d). General Organic Parameter Loads (lbs/day) by River Segment for **FOOD AND KINDRED PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**1A**	**Grand Total**
OIL & GREASE	118.56	118.56
Grand Total	118.56	118.56
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(e). General Organic Parameter Loads (lbs/day) by River Segment for **LUMBER AND WOOD PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**2C**	**4A**	**4B**	**Grand Total**
OIL & GREASE	0.18	0.73	27.08	27.99
Grand Total	0.18	0.73	27.08	27.99
% TOTAL BY RIVER SEGMENT	<1%	2.61%	96.75%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(f). General Organic Parameter Loads (lbs/day) by River Segment for **MISCELLANEOUS REPAIR SERVICES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
OIL & GREASE	0.40	0.40
Grand Total	0.40	0.40
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(g). General Organic Parameter Loads (lbs/day) by River Segment for **PAPER AND ALLIED PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**2B**	**3B**	**4A**	**Grand Total**
AOX (ABSORBABLE ORGANIC HALIDES)	5370.42	1890.63	10033.56	17294.60
HP	0.00	1514.00	0.00	1514.00
Grand Total	5370.42	3404.63	10033.56	18808.60
% TOTAL BY RIVER SEGMENT	28.55%	18.10%	53.35%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(h). General Organic Parameter Loads (lbs/day) by River Segment for **PRIMARY METAL INDUSTRIES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**2C**	**3B**	**4A**	**Grand Total**
OIL & GREASE	82.43	644.87	28.88	756.18
ORGANICS, TOTAL TOXIC (TTO)	0.00	0.00	0.00	0.00
Grand Total	82.43	644.87	28.88	756.18
% TOTAL BY RIVER SEGMENT	10.90%	85.28%	3.82%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(i). General Organic Parameter Loads (lbs/day) by River Segment for **RAILROAD TRANSPORTATION** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
OIL & GREASE	0.01	0.01
Grand Total	0.01	0.01
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(j). General Organic Parameter Loads (lbs/day) by River Segment for **TEXTILE MILLS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT.	
PARAMETER	**4B**	**Grand Total**
OIL & GREASE	9.51	9.51
Grand Total	9.51	9.51
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(k). General Organic Parameter Loads (lbs/day) by River Segment for **TRANSPORTATION EQUIPTMENT** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
OIL & GREASE	31.29	31.29
Grand Total	31.29	31.29
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 15(l). General Organic Parameter Loads (lbs/day) by River Segment for **WHOLESALE TRADE, NONDURABLE GOODS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
ARAMETER	**3B**	**Grand Total**
OIL & GREASE	0.0004	0.0004
Grand Total	0.0004	0.0004
% TOTAL BY RIVER SEGMENT	100.00%	100.00%

* no discharges to remaining river segments by identified facility type

Table 16. Summary of % Metal Loading by Facility Type for each River Segment and the Entire Lower Columbia River (Grand Total).

	RIVER SEGMENT						
GENERAL DEFINITION	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
CHEMICALS AND ALLIED PRODUCTS	0	0	1.13%	<1%	0	0	<1%
ELECTRIC AND SANITARY SERVICES	100.00%	0	98.87%	75.78%	85.70%	0	**64.74%**
ELECTRONIC AND OTHER ELECTRICAL EQUIPTMENT AND COMPONENTS	0	0	0	<1%	0	0	<1%
FABRICATED METAL PRODUCTS	0	0	0	<1%	0	0	<1%
LUMBER AND WOOD PRODUCTS	0	0	0	0	0	93.79%	<1%
PAPER AND ALLIED PRODUCTS	0	<1%	0	18.38%	0	0	9.96%
PRIMARY METAL INDUSTRIES	0	100.00%	0	4.17%	14.30%	0	24.08%
TEXTILE MILLS	0	0	0	0	0	6.21%	<1%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Electric Services contribute 0.21% copper, .41% iron, 1.43% residual chlorine and 39.46% Boron load to the LCR.

Table 16(a). Metal Parameter Loads (lbs/day) by River Segment for CHEMICALS AND ALLIED PRODUCTS facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT		
	3A	3B	Grand Total
ARSENIC, TOTAL (AS AS)	0.000	0.003	0.003
CADMIUM, TOTAL (AS CD)	0.003	0.000	0.003
CHROMIUM, TOTAL (AS CR)	0.000	0.187	0.187
COBALT, TOTAL (AS CO)	0.170	0.000	0.170
COPPER, TOTAL (AS CU)	0.020	0.576	0.596
CYANIDE, TOTAL (AS CN)	0.020	0.000	0.020
LEAD, TOTAL (AS PB)	0.018	0.274	0.292
NICKEL, TOTAL (AS NI)	0.034	0.315	0.349
ZINC, TOTAL (AS ZN)	0.022	4.705	4.727
Grand Total	0.287	6.059	6.347
% TOTAL BY RIVER SEGMENT	**4.53%**	**95.47%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 16(b). Metal Parameter Loads (lbs/day) by River Segment for ELECTRIC AND SANITARY SERVICES facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT				
PARAMETER	**2B**	**3A**	**3B**	**4A**	**Grand Total**
ALUMINUM, TOTAL (AS AL)	0.000	0.000	0.000	0.361	0.361
ARSENIC, TOTAL (AS AS)	0.000	0.000	3.480	2.794	6.275
BARIUM TOTAL	0.000	0.000	10.435	0.519	10.955
BORON TOTAL	0.000	0.000	69.661	15.963	85.623
CADMIUM, TOTAL (AS CD)	0.000	0.000	4.918	3.327	8.245
CHROMIUM, TOTAL (AS CR)	0.000	0.000	8.443	4.287	12.731
COPPER, TOTAL (AS CU)	0.114	0.000	20.592	34.903	55.609
CYANIDE, TOTAL (AS CN)	0.000	0.000	18.154	18.381	36.534
FLOURIDE, TOTAL (AS F)	0.000	0.000	289.174	83.034	372.208
IRON, TOTAL (AS FE)	0.409	0.001	45.735	13.326	59.470
LEAD, TOTAL (AS PB)	0.000	0.000	5.670	9.017	14.688
MAGNESIUM TOTAL	0.000	0.000	0.000	13.007	13.007
MANGANESE TOTAL	0.000	0.000	25.247	3.195	28.442
MERCURY, TOTAL (AS HG)	0.000	0.000	1.467	0.432	1.899
MOLYBDEUM TOTAL	0.000	0.000	4.006	1.542	5.548
NICKEL, TOTAL (AS NI)	0.000	0.000	7.937	5.618	13.555
SELENIUM, TOTAL (AS SE)	0.000	0.000	0.068	0.000	0.068
SILVER TOTAL	0.000	0.000	2.569	48.994	51.563
ZINC, TOTAL (AS ZN)	0.000	25.195	54.155	45.667	125.017
Grand Total	0.523	25.196	571.712	304.367	901.798
% TOTAL BY RIVER SEGMENT	**<1%**	**2.79%**	**63.40%**	**33.75%**	**100.00%**

* Boise Cascade's St. Helens Mill discharges wastewater to City of St. Helen's Wastewater Treatment Plant (Segment 4A).
100% of Dioxin/Furan and 95% of remaining parameters discharged by St. Helens STP originate from Boise Cascade (St. Helens Staff).
* Electric Services contribute 0.11 bls/day copper, .41 lbs/day iron and 33.78 lbs/day boron load to the LCR.
* no discharges to remaining river segments by identified facility type.

Table 16(c). Metal Parameter Loads (lbs/day) by River Segment for **ELECTRONIC AND OTHER ELECTRICAL EQUIPTMENT AND COMPONENTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
CHROMIUM HEXAVALENT	0.05	0.05
CHROMIUM, TOTAL (AS CR)	0.09	0.09
FLOURIDE, TOTAL (AS F)	6.35	6.35
Grand Total	6.49	6.49
% TOTAL BY RIVER SEGMENT	**100.00%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 16(d). Metal Parameter Loads (lbs/day) by River Segment for **FABRICATED METAL PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
COPPER, TOTAL (AS CU)	0.0123	0.0123
CYANIDE, TOTAL (AS CN)	0.0002	0.0002
NICKEL, TOTAL (AS NI)	0.0095	0.0095
Grand Total	0.0220	0.0220
% TOTAL BY RIVER SEGMENT	**100.00%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 16(e). Metal Parameter Loads (lbs/day) by River Segment for **LUMBER AND WOOD PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**4B**	**Grand Total**
ARSENIC, TOTAL (AS AS)	0.68	0.68
CHROMIUM, TOTAL (AS CR)	2.48	2.48
COPPER, TOTAL (AS CU)	0.74	0.74
Grand Total	3.90	3.90
% TOTAL BY RIVER SEGMENT	**100.00%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 16(f). Metal Parameter Loads (lbs/day) by River Segment for **PAPER AND ALLIED PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT		
PARAMETER	**2C**	**3B**	**Grand Total**
COPPER, TOTAL (AS CU)	0.00	0.91	0.91
LEAD, TOTAL (AS PB)	0.00	0.00	0.00
NICKEL, TOTAL (AS NI)	0.00	0.00	0.00
ZINC, DISSOLVED (AS ZN)	0.00	61.85	61.85
ZINC, TOTAL (AS ZN)	0.00	75.93	75.93
Grand Total	0.00	138.69	138.69
% TOTAL BY RIVER SEGMENT	**0.00%**	**100.00%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 16(g). Metal Parameter Loads (lbs/day) by River Segment for **PRIMARY METAL INDUSTRIES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**2C**	**3B**	**4A**	**Grand Total**
ALUMINUM, TOTAL (AS AL)	51.33	0.00	4.77	56.10
ANTIMONY, TOTAL (AS SB)	0.00	0.00	0.25	0.25
CHROMIUM, TOTAL (AS CR)	0.00	0.30	0.04	0.33
COPPER, TOTAL (AS CU)	0.00	0.21	0.00	0.21
CYANIDE, TOTAL (AS CN)	2.19	0.47	0.01	2.67
FLOURIDE, TOTAL (AS F)	199.17	27.11	45.48	271.76
IRON, TOTAL (AS FE)	0.00	0.05	0.00	0.05
LEAD, TOTAL (AS PB)	0.00	0.23	0.00	0.23
MOLYBDEUM TOTAL	0.00	0.98	0.00	0.98
NICKEL, TOTAL (AS NI)	0.53	1.61	0.13	2.27
ZINC, TOTAL (AS ZN)	0.00	0.54	0.10	0.64
Grand Total	253.22	31.50	50.77	335.48
% TOTAL BY RIVER SEGMENT	**75.48%**	**9.39%**	**15.13%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 16(h). Metal Parameter Loads (lbs/day) by River Segment for **TEXTILE MILLS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**4B**	**Grand Total**
CHROMIUM, TOTAL (AS CR)	0.26	0.26
Grand Total	0.26	0.26
% TOTAL BY RIVER SEGMENT	**100.00%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 17. Summary of % Conventional Loading by Facility Type for each River Segment and the Entire Lower Columbia River (Grand Total).

	RIVER SEGMENT									
GEN_DEF	**1A**	**1B**	**2A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
CHEMICALS AND ALLIED PRODUCTS	0	0	0	0	0	<1%	1.13%	0	<1%	<1%
ELECTRIC AND SANITARY SERVICES	37.28%	100%	100%	<1%	2.86%	99.97%	13.10%	39.32%	54.25%	30.07%
ELECTRONIC AND OTHER ELECTRICAL EQUIPTMENT AND COMPONENTS	0	0	0	0	0	0	<1%	<1%	0	<1%
FABRICATED METAL PRODUCTS	0	0	0	0	0	0	<1%	0	0	<1%
FOOD AND KINDRED PRODUCTS	62.72%	0	0	0	0	0	0	0	0	<1%
LUMBER AND WOOD PRODUCTS	0	0	0	0	<1%	0	<1%	0	9.13%	<1%
MISCELLANEOUS REPAIR SERVICES	0	0	0	0	0	0	<1%	0	0	<1%
PAPER AND ALLIED PRODUCTS	0	0	0	99.74%	95.62%	0	24.49%	60.52%	0	**41.08%**
PRIMARY METAL INDUSTRIES	0	0	0	0	1.51%	0	60.91%	<1%	0	27.79%
REAL ESTATE	0	0	0	0	<1%	0	<1%	0	0	<1%
TEXTILE MILLS	0	0	0	0	0	0	0	0	36.59%	<1%
TRANSPORTATION EQUIPTMENT	0	0	0	0	0	0	<1%	0	0	<1%
[illegible]and Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

* Electric Services contribute 0.0012% BOD and .11% total suspended solids load to the LCR.

Table 17(a). Conventional Parameter Loads (lbs/day) by River Segment for **CHEMICALS AND ALLIED PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**3A**	**3B**	**4B**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	3.12	0.00	0.28	3.40
SOLIDS SETTLEABLE	11.79	0.00	0.00	11.79
SOLIDS, TOTAL SUSPENDED	4.54	2339.93	0.04	2344.51
Grand Total	19.45	2339.93	0.32	2359.70
% TOTAL BY RIVER SEGMENT	**<1%**	**99.16%**	**<1%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 17(b). Conventional Parameter Loads (lbs/day) by River Segment for **ELECTRIC AND SANITARY SERVICES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT									
PARAMETER	**1A**	**1B**	**2A**	**2B**	**2C**	**3A**	**3B**	**4A**	**4B**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	166	293	2781	29	372	7525	8921	18148	292	3.85E+04
BOD, CARBONACEOUS, 5-DAY (20 DEG. C)	0	0	0	0	0	4636	5792	425	0	1.09E+04
BOD, CARBONACEOUS, 5-DAY (5 DEG. C)	0	0	0	0	390	0	0	0	0	3.90E+02
SOLIDS TOTAL	0	0	0	0	0	0	0	1084	0	1.08E+03
SOLIDS TOTAL DISSOLVED	0	0	0	0	0	40317	0	0	0	4.03E+04
SOLIDS, TOTAL SUSPENDED	212	468	1686	25	1069	13427	12529	17140	441	4.70E+04
Grand Total	4E+02	8E+02	4E+03	5E+01	2E+03	7E+04	3E+04	4E+04	7E+02	1.38E+05
% TOTAL BY RIVER SEGMENT	**<1%**	**<1%**	**3.23%**	**<1%**	**1.33%**	**47.70%**	**19.72%**	**26.63%**	**<1%**	**100.00%**

* Boise Cascade's St. Helens Mill discharges wastewater to City of St. Helen's Wastewater Treatment Plant (Segment 4A).
100% of Dioxin/Furan and 95% of remaining parameters discharged by St. Helens STP originate from Boise Cascade (St. Helens Staff).
* Electric Services contribute .43 lbs/day BOD and 47.65 total suspended solids load to the LCR.
* no discharges to remaining river segments by identified facility type.

Table 17(c). Conventional Parameter Loads (lbs/day) by River Segment for **ELECTRONIC AND OTHER ELECTRICAL EQUIPTMENT AND COMPONENTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT		
PARAMETER	**3B**	**4A**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	13.09	0.00	13.09
SOLIDS TOTAL DISSOLVED	0.00	60.74	60.74
SOLIDS, TOTAL SUSPENDED	32.72	0.00	32.72
Grand Total	45.81	60.74	106.55
% TOTAL BY RIVER SEGMENT	**42.99%**	**57.01%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 17(d). Conventional Parameter Loads (lbs/day) by River Segment for **FABRICATED METAL PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
SOLIDS, TOTAL SUSPENDED	0.32	0.32
Grand Total	0.32	0.32
% TOTAL BY RIVER SEGMENT	**100%**	**100%**

* no discharges to remaining river segments by identified facility type

Table 17(e). Conventional Parameter Loads (lbs/day) by River Segment for **FOOD AND KINDRED PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**1A**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	5.32	5.32
SOLIDS, TOTAL SUSPENDED	631.08	631.08
Grand Total	636.40	636.40
% TOTAL BY RIVER SEGMENT	**100%**	**100%**

* no discharges to remaining river segments by identified facility type

Table 17(f). Conventional Parameter Loads (lbs/day) by River Segment for **LUMBER AND WOOD PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**2C**	**3B**	**4B**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	0.24	535.80	0.00	536.04
SOLIDS, TOTAL SUSPENDED	0.24	516.00	123.40	639.64
Grand Total	0.48	1051.80	123.40	1175.68
% TOTAL BY RIVER SEGMENT	**<1%**	**89.46%**	**10.49%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 17(g). Conventional Parameter Loads (lbs/day) by River Segment for **MISCELLANEOUS REPAIR SERVICES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT	
PARAMETER	**3B**	**Grand Total**
SOLIDS, TOTAL SUSPENDED	3.15	3.15
Grand Total	3.15	3.15
% TOTAL BY RIVER SEGMENT	**100%**	**100%**

* no discharges to remaining river segments by identified facility type

Table 17(h). Conventional Parameter Loads (lbs/day) by River Segment for **PAPER AND ALLIED PRODUCTS** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT				
PARAMETER	**2B**	**2C**	**3B**	**4A**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	7.05E+03	1.39E+04	1.79E+04	2.62E+04	6.51E+04
SOLIDS, TOTAL SUSPENDED	1.34E+04	4.73E+04	3.26E+04	3.04E+04	1.24E+05
Grand Total	2.05E+04	6.11E+04	5.05E+04	5.66E+04	1.89E+05
% TOTAL BY RIVER SEGMENT	**10.86%**	**32.38%**	**26.75%**	**30.01%**	**100.000%**

* no discharges to remaining river segments by identified facility type

Table 17(i). Conventional Parameter Loads (lbs/day) by River Segment for **PRIMARY METAL INDUSTRIES** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT			
PARAMETER	**2C**	**3B**	**4A**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	15.98	0.00	41.85	57.83
SOLIDS TOTAL DISSOLVED	0.00	1.26E+05	0.00	1.26E+05
SOLIDS, TOTAL SUSPENDED	948.90	558.99	44.30	1552.19
Grand Total	9.65E+02	1.27E+05	8.62E+01	1.28E+05
% TOTAL BY RIVER SEGMENT	**<1%**	**99.177%**	**<1%**	**100.000%**

* no discharges to remaining river segments by identified facility type

Table 17(j). Conventional Parameter Loads (lbs/day) by River Segment for **REAL ESTATE (including Mobile Home Parks)** facilities (inventoried LCR Basin NPDES Major and Minor facilities) including % Contributions by River Segment.

	RIVER SEGMENT		
PARAMETER	**2C**	**3B**	**Grand Total**
BOD, 5-DAY (20 DEG. C)	0.69	0.16	0.85
SOLIDS, TOTAL SUSPENDED	0.17	0.22	0.39
Grand Total	8.63E-01	3.82E-01	1.24E+00
% TOTAL BY RIVER SEGMENT	**69.34%**	**30.66%**	**100.00%**

* no discharges to remaining river segments by identified facility type

Table 19. Permitted and Non-Permitted Urban Storm Water Runoff Areas by Land Use Type and the Impacted River Segment.

	Municipalities of:				Urban Growth Boundary of:				City Limits of Longview
	USA	Portland	Clackamas	Gresham	Camas	St. Helens	Vancouver	Washougal	
LAND USE TYPE	**AREA** (Acres)	**AREA** (Acres)	**AREA** (Acres)	**AREA** (Acres)	**AREA** (Acres)	**AREA** (Acres)	**AREA** (Acres)	**AREA** (Acres)	**AREA** (Acres)
Residential (light)	25482	9040	5342.45		2574	764	19513	1831	2482
Residential (heavy)	2984	655			229	191	3380	89	167
Industrial	2241	3058	1477.64		1242	788	3902	184	388
Commercial	11960	5187	928.47		349	207	2710	118	415
Parks & Open Space	2984	9426	415.23		300	60	4165	452	963
Traffic Corridors	746								
Agricultural	11202	954							
Vacant	17183	15989			2010	490	13116	1278	2453
Total	**74782**	**44309**	**8163.79**	**38000**	**6704**	**2500**	**46786**	**3952**	**6868**
Impacted River Seg.	**3B**	**3B & 4A**	**3B**	**3B & 4B**	**4A**	**3A**	**4A**	**4B**	**2C**

Table 20. Non-Permitted Urban Storm Water Runoff Areas Rainfall Statistics

	Camas	St. Helens	Vancouver	Washougal	Longview	Portland
R-Square Value	0.93	0.84	0.97	0.93	0.89	
Avg. Rainfall/storm (in)	0.69	0.56	0.47	0.69	0.68	.49
Avg. # of Storms	70	70	70	70	70	70
avg. Annual Rainfall (ft)	4	3.27	2.75	4	3.94	2.86

Table 21. Summary of Permitted Municipalities Total Urban Storm Water Runoff Load (lbs/year) estimates.

PARAMETER	TOTAL LOAD (lbs/year) CITY OF PORTLAND	Major Contributing Land Use Type	USA	Major Contributing Land Use Type	CITY OF GRESHAM	Major Contributing Land Use Type	CLACKAMAS COUNTY	Major Contributing Land Use Type	GRAND TOTAL
BOD5	2.17E+06	Ind.	2.85E+06	Res. (light)	1.36E+06	na	3.68E+05	Res.	6.73E+06
COD	8.63E+06	Comm.	1.39E+07	Res. (light)	1.06E+07	na	1.14E+06	Res.	3.43E+07
FCB	3.42E+15	Vacant	1.10E+15	Res. (light)	3.79E+12	na	2.52E+14	Res.	4.77E+15
TSS	1.33E+07	Res. (light)	2.77E+07	Res. (light)	1.27E+07	na	1.30E+06	Ind.	5.50E+07
TDS	2.34E+07	Comm.	1.68E+07	Comm.	4.59E+06	na	2.07E+06	nd.	4.70E+07
Chlorine Res.	nd	na	1.12E+07	Comm.	nd	na	nd	na	1.12E+07
Cd	123.03	Ind.	72.80	Comm.	nd	na	25.48	Comm.	222.04
Cu	2995.72	Comm.	3596.32	Res. (light)	1925.56	na	440.44	Res.	8958.04
Pb	4622.80	Comm.	16700.32	Comm.	4648.28	na	309.40	Res.	2.63E+04
Ag	41.13	Comm.	2.18	Res. (light)	nd	na	nd	na	43.68
Zn	1.89E+04	Ind.	2.90E+04	Res. (light)	1.78E+04	na	2770.04	Ind.	6.85E+04
Sb	94.64	Res. (light)	69.16	Res. (light)	nd	na	nd	na	163.80
As	294.84	Res. (light)	265.72	Res. (light)	171.08	na	nd	na	731.64
Be	21.84	Res. (light)	10.92	Comm.	nd	na	nd	na	32.76
Cr	1634.36	Ind.	4.31E+04	Ind.	1132.04	na	nd	na	4.59E+04
Hg	21.84	Comm.	0.00	na	14.56	na	nd	na	36.40
Ni	640.64	Ind.	538.72	Comm.	nd	na	nd	na	1179.36
[illegible]	91.00	Res. (light)	0.00	na	nd	na	nd	na	91.00
[illegible]	40.04	Comm.	2.91	Comm.	nd	na	nd	na	43.68
O&G	3.89E+05	Comm.	6.15E+05	Comm.	2.58E+05	na	4.22E+05	Ind.	1.69E+06
Total Cyanide	254.80	Comm.	0.00	na	nd	na	nd	na	254.80
Total Phenols	1102.92	Res. (light)	1361.36	Comm.	3785.60	na	nd	na	6249.88
Petr. Hydrocarbons	2.89E+05	Comm.	nd	na	nd	na	nd	na	2.89E+05
DCM	72.80	Res. (light)	nd	na	396.76	na	nd	na	469.56
Toluene	3432.52	Traffic Corridor	1106.56	Res. (light)	nd	na	nd	na	4539.08
Dichloroethane	47.32	Ind.	nd	na	nd	na	nd	na	47.32
Tetrachloroethene	218.40	Ind.	nd	na	nd	na	nd	na	218.40
TCA	462.28	Ind.	491.40	Comm.	nd	na	nd	na	953.68
TCE	367.64	Ind.	265.72	Comm.	nd	na	nd	na	633.36
Total Xylenes	54.60	Ind.	1812.72	Res. (light)	nd	na	nd	na	1867.32
Fluoranthene	14.56	Ind.	nd	na	nd	na	nd	na	14.56
Phenanthrene	14.56	Ind.	nd	na	nd	na	nd	na	14.56
Pyrene	32.76	Ind.	nd	na	nd	na	nd	na	32.76
Naphthalene	25.48	Ind.	nd	na	nd	na	nd	na	25.48
DDE	1.09	Res. (light)	nd	na	nd	na	nd	na	1.09
DDT	2.55	Res. (light)	nd	na	nd	na	nd	na	2.55
Diazon	123.76	Comm.	nd	na	nd	na	nd	na	123.76
PCP	40.04	Comm.	nd	na	nd	na	nd	na	40.04
Benzene	nd	na	251.16	Res. (light)	nd	na	nd	na	251.16
Ethylbenzene	nd	na	411.32	Res. (light)	nd	na	nd	na	411.32
[illegible]bon Disulfide	nd	na	971.88	Comm.	nd	na	nd	na	971.88
Chloroform	nd	na	7.28	Ind.	nd	na	nd	na	7.28

E = Exponent, "na"= not applicable and "nd"= not detected.

Table 22. USA's Annual Urban Storm Water Runoff Estimates by Land Use Category.

LAND USE CATEGORY	% OF TOTAL AREA	TOTAL AREA (ft.^{2})	RUNOFF COEF.	AVERAGE ANNUAL RAIN VOLUME (ft.)	AVERAGE ANNUAL STORM VOLUME (ft.^{3})	AVERAGE ANNUAL STORM VOLUME (MG)
Vacant Light Residential	13%	4.23E+08	0.14	3.325	1.97E+08	1469
Vacant Heavy Residential	1%	3.25E+07	0.14	3.325	1.51E+07	113
Vacant Comericial	5%	1.63E+08	0.14	3.325	7.57E+07	565
Vacant Industrial	4%	1.30E+08	0.14	3.325	6.06E+07	452
Light Residential	34%	1.11E+09	0.37	3.325	1.36E+09	10157
Heavy Residential	4%	1.30E+08	0.59	3.325	2.55E+08	1905
Commercial	16%	5.21E+08	0.82	3.325	1.42E+09	10593
Industrial	3%	9.76E+07	0.68	3.325	2.21E+08	1647
Traffic Corridors	1%	3.25E+07	0.91	3.325	9.84E+07	735
Agricultural	15%	4.88E+08	0.05	3.325	8.11E+07	606
Parks and Open Spaces	4%	1.30E+08	0.14	3.325	6.06E+07	452
	Total	**3.25E+09**		**TOTAL**	**3.84E+09**	**28694**

Table 23. USA's Urban Storm Water Runoff Load (lb/year) Estimates by Parameter and Land Use Type

	Load (lbs/year)											
Parameter	Vacant Light Res.	Vacant Heavy Res.	Vacant Comm.	Vacant Ind.	Light Res.	Heavy Res.	Comm.	Ind.	Traffic Corridors	Ag.	Parks and Open Spaces	TOTAL
BOD5	2.45E+04	1.89E+03	9.43E+03	7.55E+03	1.53E+06	2.86E+05	7.07E+05	1.24E+05	1.23E+05	3.54E+04	7.55E+03	2.85E+06
COD	2.82E+05	2.17E+04	1.08E+05	8.68E+04	7.21E+06	1.35E+06	3.36E+06	5.36E+05	4.84E+05	4.04E+05	8.68E+04	1.39E+07
TSS	6.99E+05	5.38E+04	2.69E+05	2.15E+05	1.26E+07	2.37E+06	8.41E+06	1.14E+06	7.30E+05	1.01E+06	2.15E+05	2.77E+07
TDS	1.79E+06	1.38E+05	6.89E+05	5.51E+05	3.56E+06	6.68E+05	6.88E+06	8.93E+05	5.27E+05	5.05E+05	5.51E+05	1.68E+07
Chloride	na	na	na	na	1.86E+05	3.50E+04	8.70E+05	3.52E+04	na	na	na	1.13E+06
FCB (#/100ml)	na	na	na	na	5.31E+14	9.97E+13	4.26E+14	3.82E+13	na	na	na	1.09E+15
Cd	nd	nd	nd	nd	25.48	3.64	25.48	3.64	10.92	nd	nd	72.8
Zn	367.64	29.12	141.96	112.84	1.54E+04	2893.8	8572.2	990.08	185.64	152.88	112.84	2.90E+04
Cu	61.88	3.64	21.84	18.2	1696.24	316.68	971.88	218.4	240.24	25.48	18.2	3596.32
Pb	36.4	3.64	14.56	10.92	3982.16	746.2	1.15E+04	138.32	251.16	14.56	10.92	1.67E+04
Sb	na	na	na	na	36.4	7.28	21.84	3.64	na	na	na	69.16
As	na	na	na	na	149.24	29.12	69.16	18.2	na	na	na	265.72
Be	na	na	na	na	3.64	0.74256	7.28	0.50232	na	na	na	10.92
Cr	na	na	na	na	698.88	131.04	353.08	4.19E+04	na	na	na	4.31E+04
Hg	na	na	na	na	nd	nd	nd	nd	na	na	na	0
Ni	na	na	na	na	229.32	43.68	232.96	32.76	na	na	na	538.72
Se	na	na	na	na	nd	nd	nd	nd	na	na	na	0
Ag	na	na	na	na	1.97652	0.37128	nd	nd	na	na	na	2.34416
Th	na	na	na	na	1.1284	0.211484	1.59068	nd	na	na	na	2.9302
Cyanide	na	na	na	na	nd	nd	nd	nd	na	na	na	0
Total Phenols	na	na	na	na	637	120.12	516.88	91	na	na	na	1361.36
Total O&G	na	na	na	na	1.76E+05	3.31E+04	3.61E+05	4.47E+04	na	na	na	6.15E+05
TCA	na	na	na	na	189.28	36.4	265.72	nd	na	na	na	491.4
Toluene	na	na	na	na	931.84	174.72	nd	nd	na	na	na	1106.56
Benzene	na	na	na	na	211.12	40.04	nd	nd	na	na	na	251.16
Ethylbenzene	na	na	na	na	345.8	65.52	nd	nd	na	na	na	411.32
Total Xylenes	na	na	na	na	1525.16	287.56	nd	nd	na	na	na	1812.72
Disulfide	na	na	na	na	nd	nd	971.88	nd	na	na	na	971.88
TCE	na	na	na	na	nd	nd	265.72	nd	na	na	na	265.72
Chloroform	na	na	na	na	nd	nd	nd	7.28	na	na	na	7.28

Table 24. USA's % Urban Stormwater Runoff Load by Parameter and Land Use Type

Parameter	Vacant Light Res.	Vacant Heavy Res.	Vacant Comm.	Vacant Ind.	Light Res.	Heavy Res.	Comm.	Ind.	Traffic Corridors	Ag.	Parks and Open Spaces	TOTAL
BOD5	<1%	<1%	<1%	<1%	53.50%	10.04%	24.80%	4.34%	4.30%	1.24%	<1%	100.00%
COD	2.03%	<1%	<1%	<1%	51.74%	9.71%	24.12%	3.85%	3.48%	2.90%	<1%	100.00%
TSS	2.52%	<1%	<1%	<1%	45.55%	8.54%	30.29%	4.11%	2.63%	3.64%	<1%	100.00%
TDS	10.68%	<1%	4.11%	3.29%	21.23%	3.98%	41.12%	5.33%	3.14%	3.01%	3.29%	100.00%
Chloride	na	na	na	na	16.55%	3.11%	77.22%	3.12%	na	na	na	100.00%
FCB (#/100ml)	na	na	na	na	48.55%	9.11%	38.84%	3.51%	na	na	na	100.00%
Cd	na	na	na	na	35.76%	6.71%	37.29%	3.87%	16.38%	na	na	100.00%
Zn	1.27%	<1%	<1%	<1%	53.22%	9.98%	29.58%	3.41%	<1%	<1%	<1%	100.00%
Cu	1.70%	<1%	<1%	<1%	47.12%	8.84%	27.03%	6.11%	6.65%	<1%	<1%	100.00%
Pb	<1%	<1%	<1%	<1%	23.85%	4.47%	68.80%	<1%	1.50%	<1%	<1%	100.00%
Sb	na	na	na	na	53.09%	9.96%	31.05%	5.89%	na	na	na	100.00%
As	na	na	na	na	55.71%	10.45%	26.56%	7.28%	na	na	na	100.00%
Be	na	na	na	na	36.40%	6.83%	52.14%	4.64%	na	na	na	100.00%
Cr	na	na	na	na	1.62%	<1%	<1%	97.25%	na	na	na	100.00%
Hg	na	na	na	na	na	na	na	na	na	na	na	na
Ni	na	na	na	na	42.57%	7.99%	43.41%	6.03%	na	na	na	100.00%
Se	na	na	na	na	na	na	na	na	na	na	na	na
Ag	na	na	na	na	84.20%	15.80%	na	na	na	na	na	100.00%
Th	na	na	na	na	38.48%	7.22%	54.31%	na	na	na	na	100.00%
Cyanide	na	na	na	na	na	na	na	na	na	na	na	na
Total Phenols	na	na	na	na	46.68%	8.76%	37.84%	6.72%	na	na	na	100.00%
Total O&G	na	na	na	na	28.68%	5.38%	58.67%	7.27%	na	na	na	100.00%
TCA	na	na	na	na	38.79%	7.28%	53.94%	na	na	na	na	100.00%
Toluene	na	na	na	na	84.20%	15.80%	na	na	na	na	na	100.00%
Benzene	na	na	na	na	84.20%	15.80%	na	na	na	na	na	100.00%
Ethylbenzene	na	na	na	na	84.20%	15.80%	na	na	na	na	na	100.00%
Total Xylenes	na	na	na	na	84.20%	15.80%	na	na	na	na	na	100.00%
Carbon Disulfide	na	na	na	na	na	na	100.00%	na	na	na	na	100.00%
TCE	na	na	na	na	na	na	100.00%	na	na	na	na	100.00%
Chloroform	na	na	na	na	na	na	na	100.00%	na	na	na	100.00%

Table 25. USA's Dissolved Metals Urban Stormwater Runoff Load (lbs/year) Estimates by Parameter and Land Use Type.

	LOAD (lbs/year)				
Parameter	Light Res.	Heavy Res.	Comm.	Ind.	TOTAL
Sb	2.55	0.20	0.73	0.73	4.37
As	12.38	1.09	2.91	2.91	18.93
Be	0.35	0.03	nd	nd	0.37
Cd	1.82	0.14	0.52	0.29	2.91
Cr	28.76	2.18	4.00	4.00	39.31
Cu	91.36	6.92	16.74	24.39	139.05
Pb	196.20	14.92	17.47	0.73	229.32
Ni	17.84	1.46	1.09	5.10	25.48
Zn	907.45	69.89	282.83	943.12	2203.29
Th	nd	nd	nd	nd	0.00
Ag	nd	nd	nd	nd	0.00
Se	nd	nd	nd	nd	0.00
Hg	nd	nd	nd	nd	0.00

Table 26. USA's Percent Dissolved Metals Urban Stormwater Runoff by Parameter and Land Use Type

Parameter	Light Res.	Heavy Res.	Comm.	Ind.	TOTAL
Sb	60.09%	4.62%	15.44%	19.85%	100.00%
As	65.00%	5.00%	15.00%	15.00%	100.00%
Be	92.86%	7.14%	na	na	100.00%
Cd	66.21%	5.09%	18.43%	10.27%	100.00%
Cr	73.86%	5.68%	9.87%	10.59%	100.00%
Cu	65.53%	5.04%	11.92%	17.51%	100.00%
Pb	85.51%	6.58%	7.56%	0.35%	100.00%
Ni	70.45%	5.42%	4.08%	20.04%	100.00%
Zn	41.18%	3.17%	12.84%	42.81%	100.00%
Th	na	na	na	na	na
Ag	na	na	na	na	na
Se	na	na	na	na	na
Hg	na	na	na	na	na

Table 27. Portland Annual Urban Stormwater Runoff estimates by Land Use Type.

LAND USE TYPE	AREA (Acres)	AREA (ft^2)	PERCENT IMPERVIOUS	RUNOFF COEF.	ANNUAL RAINFALL (ft)	ANNUAL RUNOFF VOLUME (ft^3)	RUNOFF (MG)
Residential (light)	9040	3.94E+08	35	0.37	2.86	4.17E+08	3110.17
Residential (heavy)	655	2.85E+07	60	0.59	2.86	4.81E+07	359.34
Industrial	3058	1.33E+08	70	0.68	2.86	2.59E+08	1933.57
Commercial	5187	2.26E+08	85	0.82	2.86	5.30E+08	3954.98
Parks & Open Space	9426	4.11E+08	10	0.14	2.86	1.64E+08	1227.07
Vacant	15989	6.96E+08	10	0.14	2.86	2.79E+08	2081.44
Traffic Corridor	954	4.16E+07	95	0.91	2.86	1.08E+08	807.24
Total	**44309**	**1.61E+08**				**1.81E+09**	**13473.81**

Table 28. Portland Urban Stormwater Runoff Load (lbs/year) Estimates by Parameter and Land Use Type.

	Load (lbs/year)							
Parameter	**Light Res.**	**Heavy Res.**	**Ind.**	**Comm.**	**Parks and Open Space**	**Vacant**	**Traffic Corridors**	**Total**
TSS	4.88E+06	5.64E+05	2.49E+06	3.00E+06	5.82E+05	9.90E+05	8.01E+05	1.33E+07
TDS	1.95E+06	2.25E+05	1.61E+06	1.50E+07	1.50E+06	2.54E+06	5.79E+05	2.34E+07
BOD5	2.85E+05	3.30E+04	1.10E+06	5.61E+05	2.05E+04	3.47E+04	1.35E+05	2.17E+06
COD	1.95E+06	2.25E+05	2.19E+06	3.10E+06	2.36E+05	4.00E+05	5.31E+05	8.63E+06
Total Cd	12.96	1.50	72.44	23.11	0.00	0.00	12.81	123.03
Total Cu	259.53	29.99	982.80	1321.32	51.32	87.00	262.81	2995.72
Total Pb	728.00	84.08	953.68	2507.96	30.72	52.05	276.28	4622.80
Total Ag	5.21	0.60	8.08	23.11	1.02	1.74	1.35	41.13
Total Zn	3632.72	418.60	7243.60	6588.40	307.22	520.52	202.02	1.89E+04
O&G	9.61E+04	1.11E+04	8.55E+04	1.22E+05	6.15E+03	1.04E+04	6.01E+04	3.89E+05
FCB (#/100ml)	7.75E+14	8.95E+13	7.68E+14	1.78E+14	5.46E+14	9.25E+14	1.43E+14	3.42E+15
Total Sb	36.40	3.64	25.48	18.20	nd	nd	10.92	94.64
Total As	116.48	14.56	54.60	87.36	nd	nd	21.84	294.84
Total Be	14.56	0.00	3.64	3.64	nd	nd	0.00	21.84
Total Cr	247.52	29.12	822.64	214.76	112.84	189.28	18.20	1634.36
Total Hg	nd	nd	nd	21.84	nd	nd	nd	21.84
Total Ni	141.96	14.56	211.12	131.04	25.48	43.68	72.80	640.64
Total Se	29.12	3.64	18.20	0.00	10.92	21.84	7.28	91.00
Total Th	nd	nd	nd	32.76	nd	nd	7.28	40.04
Total Cyanide	nd	nd	nd	254.80	nd	nd	nd	254.80
Total Phenols	778.96	91.00	nd	na	na	na	236.60	1102.92
Petroleum Hydrocarbons	5.97E+04	6.90E+03	3.95E+04	1.29E+05	3.89E+03	6.60E+03	4.38E+04	2.89E+05
Methylene Chloride	50.96	7.28	na	na	na	na	14.56	72.80
Toluene	na	na	43.68	21.84	na	na	3367.00	3432.52
cis/trans-1,2-Dichloroethane	na	na	32.76	na	na	na	14.56	47.32
Tetrachloroethene	na	na	178.36	na	na	na	40.04	218.40
1,1,1-Trichloroethane	na	na	404.04	na	na	na	61.88	462.28
Trichloroethene	na	na	298.48	na	na	na	69.16	367.64
Total Xylenes	na	na	47.32	na	na	na	7.28	54.60
Fluoranthene	na	na	14.56	na	na	na	na	14.56
Phenanthrene	na	na	14.56	na	na	na	na	14.56
Pyrene	na	na	32.76	na	na	na	na	32.76
Naphthalene	na	na	25.48	na	na	na	na	25.48
DDE	1.09	0.00	na	na	na	na	na	1.09
DDT	2.18	0.36	na	na	na	na	na	2.55
Diazinon	52.05	5.82	na	65.88	na	na	na	123.76
Pentachlorophenol	5.10	0.73	na	28.76	na	na	4.00	40.04

Table 29. Portland % Urban Stormwater Runoff Load by Parameter and Land Use Type.

Parameter	Light Res.	Heavy Res.	Ind.	Comm.	Parks and Open Space	Vacant	Traffic Corridors	Total
TSS	36.67%	4.24%	18.67%	22.57%	4.39%	7.44%	6.02%	100.00%
TDS	8.33%	<1%	6.90%	64.09%	6.39%	10.85%	2.48%	100.00%
BOD5	13.18%	1.52%	50.64%	25.89%	<1%	1.60%	6.22%	100.00%
COD	22.54%	2.60%	25.41%	35.93%	2.73%	4.63%	6.16%	100.00%
Total Cd	10.55%	1.22%	59.04%	18.78%	<1%	<1%	10.41%	100.00%
Total Cu	8.67%	1.00%	32.87%	44.08%	1.71%	2.90%	8.77%	100.00%
Total Pb	15.70%	1.81%	20.56%	54.18%	<1%	1.13%	5.97%	100.00%
Total Ag	12.64%	1.46%	19.64%	56.25%	2.49%	4.23%	3.28%	100.00%
Total Zn	19.18%	2.22%	38.33%	34.84%	1.62%	2.75%	1.07%	100.00%
O&G	24.54%	2.84%	21.86%	31.21%	1.57%	2.66%	15.32%	100.00%
FCB (#/100ml)	22.63%	2.61%	22.43%	5.22%	15.92%	27.00%	4.20%	100.00%
Total Sb	39.61%	4.58%	25.30%	19.94%	na	na	10.56%	100.00%
Total As	39.22%	4.53%	19.04%	29.61%	na	na	7.61%	100.00%
Total Be	61.29%	7.08%	8.07%	19.12%	na	na	4.44%	100.00%
Total Cr	15.08%	1.74%	50.34%	13.12%	6.89%	11.69%	1.13%	100.00%
Total Hg	na	na	na	100.00%	na	na	na	100.00%
Total Ni	21.95%	2.54%	32.67%	20.56%	3.99%	6.76%	11.54%	100.00%
Total Se	31.28%	3.61%	20.16%	0.00%	13.58%	23.03%	8.34%	100.00%
Total Th	na	na	na	81.45%	na	na	18.55%	100.00%
Total Cyanide	na	na	na	100.00%	na	na	na	100.00%
Total Phenols	70.50%	8.15%	na	na	na	na	21.35%	100.00%
Petroleum Hydrocarbons	20.65%	2.39%	13.67%	44.52%	1.35%	2.28%	15.14%	100.00%
Methylene Chloride	72.72%	8.40%	na	na	na	na	18.88%	100.00%
Toluene	na	na	1.27%	<1%	na	na	98.11%	100.00%
cis/trans-1,2-Dichloroethane	na	na	70.55%	na	na	na	29.45%	100.00%
Tetrachloroethene	na	na	81.45%	na	na	na	18.55%	100.00%
1,1,1-Trichloroethane	na	na	86.93%	na	na	na	13.07%	100.00%
Trichloroethene	na	na	81.59%	na	na	na	18.41%	100.00%
Total Xylenes	na	na	87.78%	na	na	na	12.22%	100.00%
Fluoranthene	na	na	100.00%	na	na	na	na	100.00%
Phenanthrene	na	na	100.00%	na	na	na	na	100.00%
Pyrene	na	na	100.00%	na	na	na	na	100.00%
Naphthalene	na	na	100.00%	na	na	na	na	100.00%
DDE	89.64%	10.36%	na	na	na	na	na	100.00%
DDT	89.64%	10.36%	na	na	na	na	na	100.00%
Diazinon	41.89%	4.84%	na	53.27%	na	na	na	100.00%
Pentachlorophenol	13.43%	1.55%	na	74.30%	na	na	10.72%	100.00%

Table 30. Portland Dissolved Metals Urban Stormwater Runoff Load (lbs/year) Estimates by Parameter and Land Use Type.

	Load (lbs/year)							
Parameter	Light Res.	Heavy Res.	Ind.	Comm.	Parks and Open Space	Vacant	Traffic Corridors	Total
Sb	25.48	3.64	18.2	32.76	nd	nd	nd	83.72
As	50.96	7.28	32.76	65.52	nd	nd	14.56	167.44
Be	3.64	0	nd	3.64	nd	nd	nd	7.28
Cd	7.28	0	29.12	14.56	3.64	3.64	3.64	65.52
Cr	58.24	7.28	65.52	65.52	10.92	18.2	18.2	243.88
Cu	47.32	7.28	160.16	527.8	40.04	69.16	101.92	953.68
Fe	1.68E+04	1943.76	24297	5758.48	4084.08	6926.92	1612.52	6.15E+04
Pb	192.92	21.84	40.04	178.36	10.92	21.84	18.2	484.12
Mg	4.26E+04	4950.4	2.33E+04	1.15E+05	5.28E+04	8.95E+04	6115.2	3.35E+05
Hg	nd	nd	nd	nd	nd	nd	nd	nd
Ni	61.516	7.1344	257.348	93.548	20.4204	34.6528	40.404	513.24
Se	27.9552	3.22868	0.182	29.302	12.7764	21.658	6.916	101.92
Ag	4.1496	0.48048	3.31604	6.5884	2.33688	3.9676	1.4378	21.84
Th	nd	nd	nd	nd	nd	nd	nd	nd
Zn	1113.84	128.492	7098	4513.6	173.628	294.476	873.6	1.42E+04

Table 31. Portland % Dissolved Metals Urban Stormwater Runoff Load Estimates by Parameter and Land Use Type.

Parameter	Light Res.	Heavy Res.	Ind.	Comm.	Parks and Open Space	Vacant	Traffic Corridors	Total
Sb	32.33%	3.74%	23.22%	40.71%	nd	nd	nd	**100%**
As	30.23%	3.49%	19.75%	38.05%	nd	nd	8.48%	**100%**
Be	47.64%	5.50%	nd	46.85%	nd	nd	nd	**100%**
Cd	13.20%	1.53%	45.20%	22.73%	3.54%	6.01%	7.79%	**100%**
Cr	23.94%	2.77%	26.19%	27.46%	4.53%	7.69%	7.43%	**100%**
Cu	5.13%	0.59%	16.88%	55.26%	4.29%	7.27%	10.57%	**100%**
Fe	27.38%	3.16%	39.54%	9.37%	6.65%	11.28%	2.62%	**100%**
Pb	39.64%	4.58%	8.58%	36.58%	2.54%	4.31%	3.76%	**100%**
Mg	12.75%	1.47%	6.97%	34.40%	15.79%	26.79%	1.83%	**100%**
Hg	nd	nd	nd	nd	nd	nd	nd	**na**
Ni	11.96%	1.38%	49.99%	18.15%	3.97%	6.73%	7.83%	**100%**
Se	27.41%	3.17%	0.18%	28.72%	12.52%	21.23%	6.78%	**100%**
Ag	18.70%	2.16%	14.87%	29.53%	10.49%	17.80%	6.45%	**100%**
Th	nd	nd	nd	nd	nd	nd	nd	**na**
Zn	7.84%	<1%	50.07%	31.74%	1.22%	2.07%	6.15%	**100%**

Table 32. Clackamas Annual Urban Stormwater Rnuoff by Land Use Type.

LAND USE	TOTAL AREA (Acres)	TOTAL AREA (ft^2)	Percent Impervious	Runoff Coefficient	Annual Rainfall (ft)	Annual Runoff (ft^3)	Annual Runoff (mg)
Residential	5342.45	2.33E+08	24%	0.266	3.7	2.29E+08	1709.51
Commercial	928.47	4.04E+07	75%	0.725	3.7	1.08E+08	809.76
[illegible]dustrial	1477.64	6.44E+07	55%	0.545	3.7	1.30E+08	968.76
[illegible]rk/Open	415.23	1.81E+07	10%	0.14	3.7	9.37E+06	69.93
Total	**8163.79**	**3.56E+08**				**4.77E+08**	**3558**

Table 33. Clackamas Urban StormWater Runoff Load (lbs/year) Estimates by Parameter and Land Use Type.

	Load (lbs/year)				
Parameter	**Res.**	**Comm.**	**Ind.**	**Park/Open**	**TOTAL**
Cd	7.28	10.92	7.28		25.48
Cu	189.28	91	160.16		440.44
Pb	145.6	65.52	98.28		309.4
Zn	873.6	578.76	1317.68		2770.04
TSS	2.57E+05	2.91E+05	7.52E+05		1.30E+06
TDS	7.85E+05	3.85E+05	9.05E+05		2.07E+06
BOD	1.85E+05	1.01E+05	8.08E+04		3.68E+05
COD	4.85E+05	3.04E+05	3.48E+05		1.14E+06
O & G	6.85E+04	4.39E+04	3.09E+05		4.22E+05
FCB	1.43E+14	2.74E+13	8.15E+13		2.52E+14

Table 34. Clackamas % Urban StormWater Runoff Load Estimates by Parameter and Land Use Type.

Parameter	**Res.**	**Comm.**	**Ind.**	**Park/Open**	**TOTAL**
Cd	30.05%	42.70%	27.25%		**100.00%**
Cu	43.23%	20.48%	36.29%		**100.00%**
Pb	47.48%	21.18%	31.34%		**100.00%**
Zn	31.54%	20.87%	47.60%		**100.00%**
TSS	19.77%	22.37%	57.87%		**100.00%**
TDS	37.81%	18.56%	43.63%		**100.00%**
BOD	50.44%	27.57%	21.99%		**100.00%**
COD	42.67%	26.75%	30.58%		**100.00%**
O & G	16.26%	10.43%	73.32%		**100.00%**
FCB	56.81%	10.87%	32.32%		**100.00%**

Table 35. Gresham Urban Stormwater Runoff Load (lbs/year) estimates by Parameter.

Parameter	**AVERAGE CONC. (mg/l)**	**Qualifier**	**ANNUAL RUN-OFF VOLUME (ft3)**	**RUNOFF VOLUME (MGY)**	**LOAD (lbs/year)**
BOD5	12		1.82E+09	4.95E+06	1.36E+06
COD	93		1.82E+09	4.95E+06	1.06E+07
TSS	112		1.82E+09	4.95E+06	1.27E+07
TDS	40.5		1.82E+09	4.95E+06	4.59E+06
As	1.50E-03	*	1.82E+09	4.95E+06	171.08
Cr	0.01		1.82E+09	4.95E+06	1132.04
Cu	0.017		1.82E+09	4.95E+06	1925.56
Pb	0.041		1.82E+09	4.95E+06	4648.28
Zn	0.157		1.82E+09	4.95E+06	1.78E+04
Hg	1.25E-04	*	1.82E+09	4.95E+06	14.56
Oil & Grease	2.28		1.82E+09	4.95E+06	2.58E+05
Total Phenols	0.0334	*	1.82E+09	4.95E+06	3785.60
FCB(CFU/100ml)	7.38		1.82E+09	4.95E+06	3.79E+12
Methylene Chloride	3.50E-03		1.82E+09	4.95E+06	396.76

* Represents 1/2 the detection limit was used as one or more of the four values averaged.

Table 36. Lower Columbia River Non-Permitted Cities Annual LCR Urban Stormwater Runoff Load Estimates (lbs/year).

	LOAD (lbs/year)				
	Urban Growth Boundary of				***City of***
City	**Camas**	**St. Helens**	**Vancouver**	**Washougal**	**Longview**
Impacted Segment	**4A**	**3A**	**4A**	**4B**	**2C**
Parameter					
BOD5	4.56E+05	2.00E+05	1.66E+06	1.56E+05	2.72E+05
COD	1.62E+06	6.56E+05	6.85E+06	6.85E+05	1.16E+06
TDS	2.52E+06	1.04E+06	1.06E+07	1.01E+06	2.06E+06
TSS	2.76E+06	1.08E+06	1.21E+07	1.25E+06	2.05E+06
FCB (#/100ml)	5.53E+14	2.08E+14	2.22E+15	2.48E+14	4.30E+14
Total O&G	1.71E+05	7.97E+04	5.46E+05	4.77E+04	8.85E+04
Ag	211.12	83.72	840.84	87.36	167.44
As	83.72	32.76	374.92	40.04	61.88
Be	43.68	14.56	200.2	21.84	32.76
Cd	21.84	10.92	72.8	7.28	10.92
Cr	422.24	160.16	1805.44	196.56	305.76
Cu	520.52	229.32	1921.92	178.36	323.96
Hg	214.76	105.56	1153.88	72.8	254.8
Ni	596.96	178.36	3192.28	382.2	531.44
Pb	797.16	331.24	3621.8	334.88	644.28
Sb	21.84	7.28	91	10.92	14.56
Se	145.6	40.04	793.52	94.64	134.68
Th	61.88	18.2	342.16	40.04	58.24
Zn	3887.52	1659.84	1.51E+04	1445.08	2493.4
TCA	116.48	54.6	389.48	36.4	61.88
TCE	50.96	25.48	167.44	14.56	29.12
Toluene	112.84	36.4	618.8	69.16	98.28
Total Phenols	2.10E+04	1.03E+04	6.46E+04	4808.44	1.12E+04
Total Xylenes	225.68	69.16	1266.72	145.6	200.2
Cyanide	65.52	21.84	360.36	40.04	65.52
Chloride	1.33E+05	4.11E+04	7.17E+05	8.31E+04	1.21E+05
Benzene	1.02E+05	3.53E+04	5.01E+05	5.61E+04	8.35E+04
Ethylbenzene	25.48	7.28	141.96	18.2	21.84
Disulfide	32.76	7.28	178.36	21.84	29.12
Chloroform	112.84	36.4	633.36	69.16	112.84
Trichloroethene	7.28	3.64	36.4	3.64	7.28
Petroleum HC	21.84	10.92	116.48	7.28	25.48
Methylene Chloride	83.72	21.84	473.2	58.24	76.44
cis/trans-1,2-Dichloroethane	14.56	7.28	47.32	3.64	7.28
Fluoranthene	76.44	29.12	338.52	40.04	54.6
Phenanthrene	76.44	29.12	338.52	40.04	54.6
Pyrene	80.08	29.12	345.8	40.04	54.6
Naphthalene	76.44	29.12	342.16	40.04	54.6
DDE	1.092	0.364	6.552	0.728	1.092
DDT	1.456	0.364	7.644	1.092	1.092
Diazinon	10.92	3.64	65.52	7.28	10.92
Pentachlorophenol	160.16	47.32	895.44	105.56	149.24

Bold text represents parameters that were not commonly detected and thus their load estimates should be viewed cautiously.

Table 37. Lower Columbia River Non permitted City Dissolved Metals Urban Stormwater Runoff Load Estimates (lbs/year).

	Dissolved Load (lbs/year)				
PARAMETER	**Camas**	**St. Helens**	**Vancouver**	**Washougal**	**Longview**
DISSOLVED Ag	2.912	1.092	13.468	1.456	2.548
DISSOLVED As	25.844	10.556	110.656	10.92	18.2
DISSOLVED Be	1.092	0.364	6.188	0.728	1.092
DISSOLVED Cd	11.648	5.46	37.492	3.276	6.188
DISSOLVED Cr	41.496	16.744	165.984	17.108	29.12
DISSOLVED Cu	109.928	47.684	418.964	38.584	81.9
DISSOLVED Fe	19124.56	7698.6	80545.92	8095.36	14094.08
DISSOLVED Mg	70743.4	26273.52	301202.7	32912.88	60795.28
DISSOLVED Ni	101.556	46.956	309.036	28.028	52.416
DISSOLVED Pb	81.536	27.664	418.6	46.228	72.072
DISSOLVED Sb	13.468	5.46	57.148	5.46	9.464
DISSOLVED Se	13.104	3.64	70.252	8.372	14.196
DISSOLVED Zn	2922.92	1419.6	8302.84	673.4	1346.8

Bold text represents parameters that were not commonly detected and thus their load estimates should be viewed cautiously.

Table 38. Total Urban Storm Water Runoff and Point Source Lower Columbia River Load Comparison.

	Load (lbs/year)		(Difference)
PARAMETER	**SWR**	**POINT**	**SWR - POINT**
BOD, 5-DAY (20 DEG. C)	1.52E+07	3.26E+07	-1.74E+07
COD (CHEMICAL OXYGEN DEMAND)	3.97E+07	1.40E+05	3.97E+07
COLIFORM, FECAL	8.23E+15	1.18E+14	8.12E+15
SOLIDS, TOTAL SUSPENDED	7.46E+07	5.68E+07	1.81E+07
SOLIDS TOTAL DISSOLVED	6.44E+07	1.79E+07	4.66E+07
OIL & GREASE	2.63E+06	1.51E+06	1.12E+06
PHENOLS	1.19E+05	1.54E+04	1.03E+05
ARSENIC, TOTAL (AS AS)	1328.60	1972.88	-644.28
CADMIUM, TOTAL (AS CD)	345.80	1488.76	-1142.96
CHROMIUM, TOTAL (AS CR)	6923.28	3559.92	3363.36
COPPER, TOTAL (AS CU)	1.22E+04	1.55E+04	-3286.92
CYANIDE, TOTAL (AS CN)	808.08	1.03E+04	-9522.24
LEAD, TOTAL (AS PB)	3.23E+04	4233.32	2.80E+04
MERCURY, TOTAL (AS HG)	1845.48	604.24	1241.24
NICKEL, TOTAL (AS NI)	6097.00	4244.24	1852.76
SILVER TOTAL	1441.44	1441.44	0
TIN, TOTAL (AS SN)	309.40	0	309.40
ZINC, DISSOLVED (AS ZN)	3.12E+04	1.32E+04	1.80E+04
ZINC, TOTAL (AS ZN)	9.36E+04	3.19E+04	6.17E+04
BENZENE	7.83E+05	0	7.83E+05
CHLOROFORM	979.16	3.48E+05	-3.47E+05
1,2-DICHLOROETHANE, TOTAL	123.76	0	123.76
ETHYLBENZENE	633.36	0	633.36
FLUORANTHENE	553.28	0.47	553.28
METHYLENE CHLORIDE	1186.64	0	1186.64
NAPHTHALENE	567.84	0	567.84
PENTACHLOROPHENOL	1405.04	0	1405.04
PHENANTHRENE	553.28	0.44	553.28
PYRENE	582.40	0.36	582.40
TETRACHLOROETHENE	218.40	0.07	218.40
TOLUENE	5510.96	1.64E+05	-1.58E+05
1,1,1-TRICHLOROETHANE	1627.08	0	1627.08
TRICHLOROETHENE	425.88	0.18	425.88
TRICHLOROETHYLENE	556.92	0	556.92

Table 39. Five LCR tributary mouth stations and two LCR mainstem monitoring stations inventoried for various metals, pesticides, and other conventional parameters (1993, 1994 data).

[illegible]ite Name	USGS Station	River Mile (River Segment)		Load Code
		Tributary	Columbia	
Willamette R. (at Portland)	14211720	12.8	101.5 (3B)	LCR_Trib
Sandy R. (nr Troutdale)	453056122243701	3.1	120.5 (4A)	LCR_Trib
Cowlitz R. (at Kelso)	14244200	4.8	68 (2C)	LCR_Trib
Kalama R. (near Kalama)	14223600	2.8	73.1 (3A)	LCR_Trib
Lewis R. (at Woodland)	455417122441000	5.7	87 (3A)	LCR_Trib
Columbia R. (at Warrendale)	14128910	NA	141.0 (4B)	UCR_Tot
Columbia R. (at Beaver Army Terminal)	14246900	NA	53.8 (2B)	CR_Tot

Table 40. 1994 Sampling dates: underlined bold dates represent the monthly sampling dates used for between-tributary comparisons. All other comparisons utilized values averaged over all dates within that month.

USGS Monitoring Station Sampling Dates (month/day)						
Warrendale	Sandy	Willamette	Lewis	Kalama	Cowlitz	Beaver A.T.
		1/11				
2/16		**2/14** 2/25				**2/17**
3/16		**3/14**				**3/17**
4/13		**4/11**	**4/20**		**4/18**	**4/14** 4/21 4/29
5/11	**5/3**	**5/10**		**5/16**		5/5 5/12 **5/20** 5/25
6/15		**6/14**	**6/29**		**6/22**	6/10 **6/16**
7/27	**7/7**	**7/25**	**7/29**		**7/14**	**7/28**
8/10	**8/15**	**8/8**			**8/31**	**8/11**
9/15	**9/19**	**9/13**	**9/7**	**9/6**		**9/12**
10/24		**10/25** 10/29				**10/27**
11/8		**11/3**				**11/10**
12/20		**12/2**				**12/8**

Table 45. Point Source and Urban Storm Water Runoff % Flow and Suspended Solids Load Contribution by Tributary.

	% FLOW DISHARGE		*% SUSPENDED SOLIDS*	
TRIBUTARY	**Pt. Source**	**Urban Storm**	**Pt. Source**	**Urban Storm**
Sandy	**0.1 - 0.3**	**NA**	**0.1 - .7**	**NA**
Willamette	**0.3 - 4**	**1 - 4**	**0.1 - 15**	**0.4 - 20**
Lewis	**0.01 - 0.04**	**NA**	**0.1 - 0.4**	**NA**
Kalama	**NA**	**NA**	**NA**	**NA**
Cowlitz	**0.05 - 0.08**	**NA**	**.01 - 0.06**	**NA**
Beaver	**0.3 - 1**	**0.1 - 0.5**	**1 - 6**	**0.5 - 4**

Table 46. 1993 monthly Willamette River point source pollutant loading as a percent contribution of the total tributary pollutant loading observed at Willamette River Mile 12.8 (USGS Station 14211720; 1993, 1994 ambient water quality data).

	PS pollutant percent load of the total Willamette R. load by month					
Parameter	**0%-5%**	**5%-10%**	**10%-30%**	**30%-50%**	**50%-100%**	**> 100%**
Ag (total)			11		4	6,9
As (total)	11	4				6,9
Ba (total)	4,6,9,11					
[illegible]d (total)				11		4,6,9
Cr (total)	4,10,11		6	9		
Cu (total)	10,11	4	6,9			
Fe (total)	4,6,9,11					
Fecal Col	1-7,9,10	11				
Hg (total)	6	4,11		9		
Mn (total)	4,6,9,11					
Mo (total)	4,9,11		6			
Ni (total)	4,10,11		6,9			
Pb (total)	4,11		6,9			
Se (total)	4,11			6		
Sus Sed	1-4, 8,10-12	5-7	9			
Zn (total)	11		4	6	9	
Zn (diss)		11	4,10,	6,9		10

Table 47. Monthly Willamette River urban storm water runoff pollutant loading as a percent contribution of the total tributary pollutant loading observed at Willamette River Mile 12.8 (USGS Station 14211720; 1993,1994 ambient water quality data)

	Storm Water pollutant percent load of total Willamette River load by month.					
Parameter	**0%-5%**	**5%-10%**	**10%-30%**	**30%-50%**	**50%-100%**	**> 100%**
Ag (total)	4,6,9,11					
As (total)	11		4,6,9			
Be (total)	4,6,11	9				
Cd (total)	11		4,6			9
Cr (total)	4,6,10, 11		9			
Cu (total)	4,10,11	6	9			
Cu (diss)	4,6,9, 10,11					
Fecal Col	1,4,12	3,6,9	7	2	5,10	11
Hg (total)	4,6,9, 11					
Ni (total)	4,6,9-11					
Ni (diss)	1,4-7, 9-11					
Pb (total)		11	4		6,9	
Pb (diss)	4,6,9-11					
Sb (total)	11	4		6	9	
Se (total)	4,6,11					
Sus Sed	1,2,4, 7,8,10-12	3,5,6	9,10			
Zn (total)	11	4	6	9		
Zn (diss)	4,6,9, 11		10			

Table 48. Total 1993 monthly Columbia River point source pollutant loading as a percent contribution of the total Columbia River pollutant loading observed at River mile 53.8 (USGS Beaver Army Terminal Station 14246900; 1993, 1994 ambient water quality data).

	P.S. pollutant % loads of total Columbia River load by month.					
Parameter	**0%-5%**	**5%-10%**	**10%-30%**	**30%-50%**	**50%-100%**	**> 100%**
Ag(tot rec)	4,5,10		8			
Ag (total)				5	4	8,10
Al (total)	4,5,8,10					
As (total)	4,5,8,10					
Ba (total)	4,5,8,10					
Cd(tot rec)	4,10					
Cd (total)			5,10		4	8
Cr(tot rec)	4,5,8,10					
Cr (total)	4,5,8,10					
Cu(tot rec)	4,5,8,10					
Cu (total)	5,8,10	4				
Fe (total)	4,5,8, 10					
F.C.B.	2-12					
Hg (total)	4,5,8,10					
Mg (total)	4,10					
Mn (total)	4,5,8,10					
Mo (total)				5	4	8,10
Ni (total)	4,5,8,10					
Pb(tot rec)	4,5,8,10					
Pb (tot)	5,10	4	8			
Sb (total)	4,5,10	8				
Sb(tot rec)	4,10					
Se (total)	4,5,8					
Sus Sed	2-12					
Zn (total)	4,5,10	8				
Zn (diss)	4,8,10	5				
Zn(tot rec)	4,5,8,10					

Table 49. Monthly Columbia River urban storm water runoff pollutant loading as a percent contribution of the total Columbia River pollutant loading observed at River mile 53.8 (USGS Beaver Army Terminal Station 14246900; 1993, 1994 ambient water quality data).

	Storm water pollutant percent loads of the total Columbia River load by month.					
Parameter	**0%-5%**	**5%-10%**	**10%-30%**	**30%-50%**	**50%-100%**	**> 100%**
Ag (total)			5	4	8,10	
As (diss)	4,5,8,10					
As (total)	4,5,8,10					
Be (total)	5,10	4,8				
Cd (total)	5,10	4,8				
Cr (total)	4,5,8,10					
Cu (diss)	4,5,8,10					
Cu (total)	4,5,8,10					
Fe (diss)	3-5, 7,12					
F.C.B.	10	11	3,9,12	4,7,8		2
Hg (total)	4, 5,8,10					
Mg (diss)	2-12					
Ni (diss)	3-5, 7-11					
Ni (total)	4,5,8,10					
Pb (tot)			4,5,8,10			
Sb (total)	4,5	8,10				
Se (total)			5	8	4	
Sus Sed	3-12	2				
Zn (total)	4,5,8,10					
Zn (diss)	4,8,10	5				

ble 50. Results of the Warrendale and Beaver Army Terminal USGS Tributary Stations, Point Sources and rban Storm Water Runoff monthly load comparisons (lbs/day).

MONTH	TYPE	PARAM TYPE	PARAM	BEAVER LOAD	% WARRENDALE LOAD	% POINT LOAD	% SWR LOAD	% UNIDENTIFIED LOAD
5	DRY	Total	Ag	10.46	82.37	45.38	24.60	-52.35
8	DRY	Total	Ag	1.18	68.87	404.11	77.97	-450.95
5	DRY	Total	As	1374.38	97.36	<1%	<1%	1.99
8	DRY	Total	As	523.78	100.83	1.25	*0.16*	-2.25
5	DRY	Total	Cd	23.92	138.15	33.39	2.59	-74.13
8	DRY	Total	Cd	3.92	103.30	203.86	5.66	-212.83
5	DRY	Total	Cr	1460.09	137.10	<1%	<1%	-38.74
8	DRY	Total	Cr	713.00	87.41	1.60	<1%	10.36
5	DRY	Total	Cu	1873.70	93.04	1.79	1.17	4.00
8	DRY	Total	Cu	677.74	92.26	4.95	1.17	1.62
5	DRY	Total	Hg	63.78	1.80	2.79	*5.17*	-316.80
5	DRY	Total	Ni	1041.50	37.25	1.08	*1.05*	60.63
8	DRY	Total	Ni	358.46	17.50	3.14	*1.08*	78.27
5	DRY	Total	Pb	328.89	117.51	4.18	17.60	-39.30
8	DRY	Total	Pb	97.94	76.44	14.05	21.28	-11.77
5	DRY	Total	Se	8.67	96.10	0.66	*26.93*	-23.69
2	WET		SUS SED	6.61E+06	33.06	2.53	5.02	59.39
3	WET		SUS SED	8.11E+06	43.55	2.06	2.99	51.39
4	WET		SUS SED	1.46E+07	41.62	1.15	1.17	56.06
5	DRY		SUS SED	2.18E+07	66.05	<1%	<1%	32.67
6	DRY		SUS SED	2.16E+07	64.08	<1%	<1%	34.72
7	DRY		SUS SED	6.69E+06	69.68	2.18	<1%	27.53
8	DRY		SUS SED	3.92E+06	51.65	3.72	1.24	43.39
9	DRY		SUS SED	2.51E+06	62.37	5.81	4.58	27.25
10	WET		SUS SED	7.18E+06	39.41	2.33	2.20	56.05
11	WET		SUS SED	1.62E+07	28.04	1.04	2.32	68.60
12	WET		SUS SED	3.98E+07	6.95	0.42	1.01	91.62
5	DRY	DISS	Zn	622.90	96.10	6.46	8.96	-11.52
5	DRY	Total	Zn	3762.34	103.74	3.12	4.47	-11.34
8	DRY	DISS	Zn	979.39	51.65	4.11	2.03	42.21
8	DRY	Total	Zn	1723.72	64.56	6.81	3.53	25.09

Table 51. Inventory of industrial types potentially discharging chlorinated Dioxin/Furans to the Lower Columbia River, Lower Columbia River and the Willamette River.

SIC Code	Industrial Category	Upper Columbia	Lower Columbia	Willamette	Total
2421	Saw mills & planning mills	3	2		5
2491	Wood preserving	2	2		4
2499	Wood products, not elsewhere classified			1	1
2611	Pulp mills	1	1		2
2621	Paper mills	1	5	7	13
2631	Paperboard mills				0
2812	Alkalies and chlorine			1	1
2865	Cyclic organic crudes and intermediates, and organic dyes and pigments		1	1	2
2879	Pesticides and agricultural chemicals	1		1	2
2911	Petroleum refining			1	1
3111	Leather tanning and finishing				0
3324	Steel investment foundries			1	1
3334	Primary aluminum products	2	3		5
3339	Primary smelting	1	1	2	4
3353	Aluminum sheet				0
3355	Aluminum rolling				0
3471	Electroplating			1	1
3612	Power, distribution and speciality transformers			1	1
3721	Aircraft (transportation equipment)				0
3724	Aircraft parts and auxiliary equipment				0
3728	Aircraft parts			1	1
3731	Ship building and repair			2	2
3732	Boat building and repair	2	1		3
3743	Railroad equipment	1			1
4952	Sewage treatment plants	35	41	21	97
	Total	**49**	**57**	**41**	**147**

Table 52. Type and amount of PCB waste generated in Region X in 1985.

Contaminant	Waste Generated (tons)
PCB oil over 500ppm	450 - 550
PCB contaminated mineral oil	1200 - 1600
Soil and miscellaneous materials	2000 - 3000
Capacitors with oil	800 - 1200
Transformer carcasses	2000 - 4000

TABLE 53. Solid Waste Disposal sites Located in the Oregon Counties of Clackamas, Clatsop, Columbia, Multnomah, and Washington.

SITE_ID	COMMON_NAME	STATE	COUNTY_NAME	SW_CLASS	SW_TYPE
[illegible]04380	HILLSBORO LANDFILL	OR	WASHINGTON	MUNICIPAL	DEMOLITION
104183	RIEDEL WASTE DISPOSAL SYSTEM	OR	MULTNOMAH	MUNICIPAL	DEMOLITION
104091	LAKESIDE RECLAMATION	OR	WASHINGTON	MUNICIPAL	DEMOLITION
104372	VERNONIA LANDFILL	OR	COLUMBIA	MUNICIPAL	LANDFILL
104268	MALARKEY LANDFILL	OR	MULTNOMAH	INDUSTRIAL	LANDFILL
104094	H. G. LAVELLE LANDFILL	OR	MULTNOMAH	MUNICIPAL	LANDFILL
104048	WARRENTON LANDFILL	OR	CLATSOP	MUNICIPAL	LANDFILL
103984	CANNON BEACH DISPOSAL SITE	OR	CLATSOP	MUNICIPAL	LANDFILL
105912	ROSSMAN'S LANDFILL, INC.	OR	CLACKAMAS	MUNICIPAL	LANDFILL
55966	ST. JOHNS LANDFILL	OR	MULTNOMAH	MUNICIPAL	LANDFILL
108782	OREGON STEEL MILLS LANDFILL	OR	MULTNOMAH	INDUSTRIAL	LANDFILL
104049	ASTORIA LANDFILL	OR	CLATSOP	MUNICIPAL	LANDFILL
104077	SANTOSH DISPOSAL SITE	OR	COLUMBIA	MUNICIPAL	LANDFILL
104092	OBRIST TROUTDALE LANDFILL	OR	MULTNOMAH	MUNICIPAL	LANDFILL
104367	WAUNA MILL	OR	CLATSOP	INDUSTRIAL	PULP/PAPER
104352	WAUNA MILL LANDFILL	OR	CLATSOP	INDUSTRIAL	PULP/PAPER
104323	CLARIFIER SOLIDS LANDFILL	OR	COLUMBIA	INDUSTRIAL	PULP/PAPER

TABLE 54. Sum of Criteria Pollutants (lbs/year) by City.

CITY	PARTICULATE TOTAL	PARTICULATE < PM10	CARBON MONOXIDE	NITROGEN DIOXIDE	SULFUR DIOXIDE	VOLITILE ORGANICS	LEAD
Beaverton	87.5	31.97	7.87	32.96	2.66	40.95	0
Boring	1.8	0.27	0	0	0	0	0
[illegible]nby	2.96	2.96	0	0	0	0	1.11
[illegible]kamas	7.57	1.21	0	0	0	0	0
Eagle Creek	15.25	15.16	0	0	0	3.15	0
Forest Grove	211.94	182.54	253.09	16.33	3.81	112.12	0
Gladstone	0	0	0	0	0	0.92	0
Gresham	0.62	0.61	1.58	6.32	0.4	16.97	0
Hillsboro	21.57	11.66	2.79	12.02	0.36	289.34	0
Molalla	5.26	1.59	0.32	1.6	0.03	0.03	0
Oregon City	156.26	62.66	88.84	504.15	47.14	14.66	0
Portland	1250.22	879.21	1635.63	3625.15	606.15	3540.92	0.06
Scappoose	36.9	6.38	0.07	0.34	0.01	0.18	0
St. Helens	375.49	334.42	6412.13	1555.33	1301.79	591.97	0
Tangent	85.7	17.37	0.46	2.18	0.06	2.61	0
Tigard	0	0	0	0	0	13.01	0
Troutdale	1.42	1.3	2.27	9.48	0.44	0.5	0
Tualatin	0	0	0	0	0	10.41	0
West Linn	157.52	153.4	39.83	545.06	55.41	0.35	0
Wilsonville	0	0	0	0	0	10.67	0

FIGURES

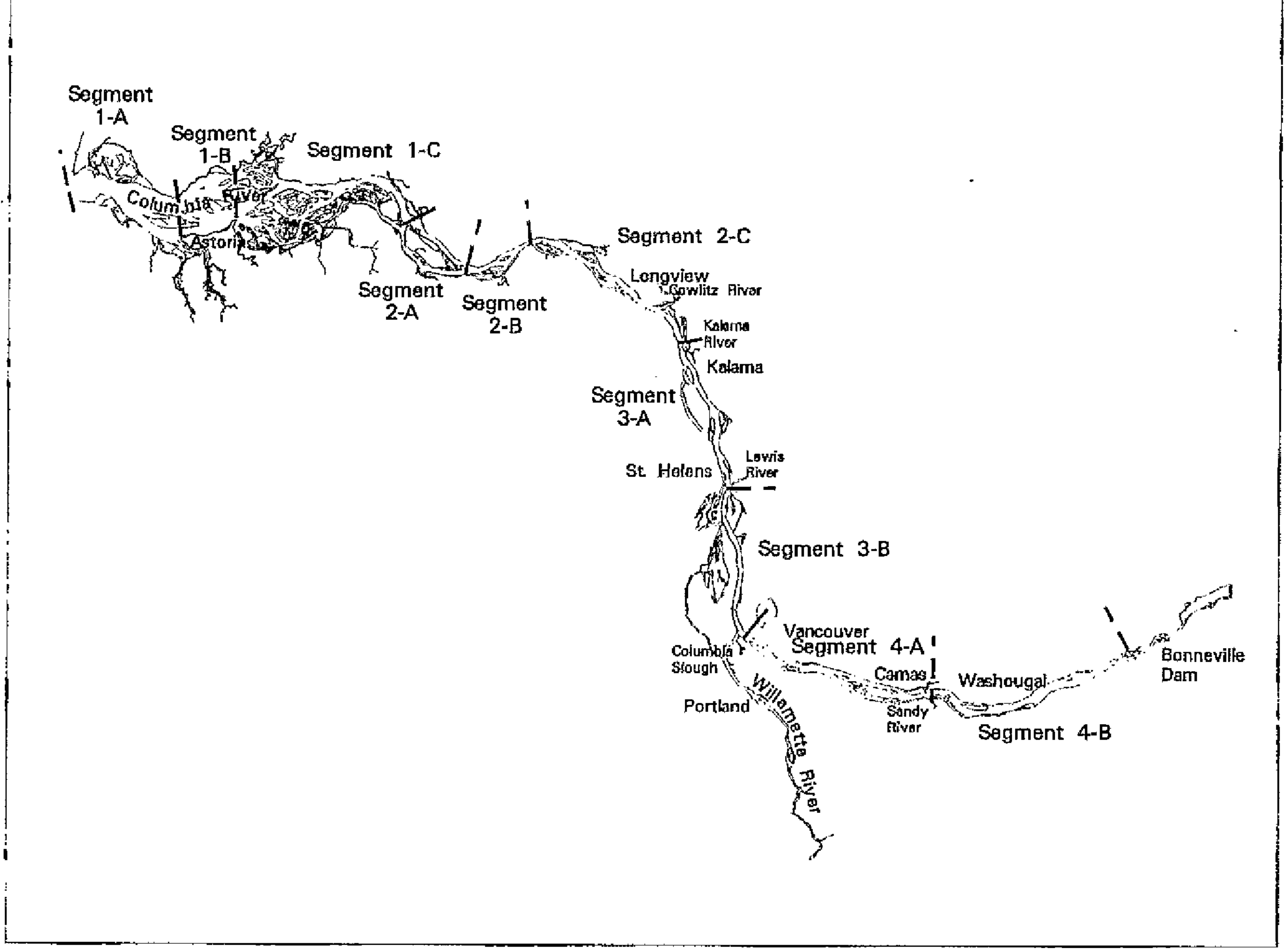


Figure 1a. Lower Columbia River Segment Designations (Tetra-Tech).

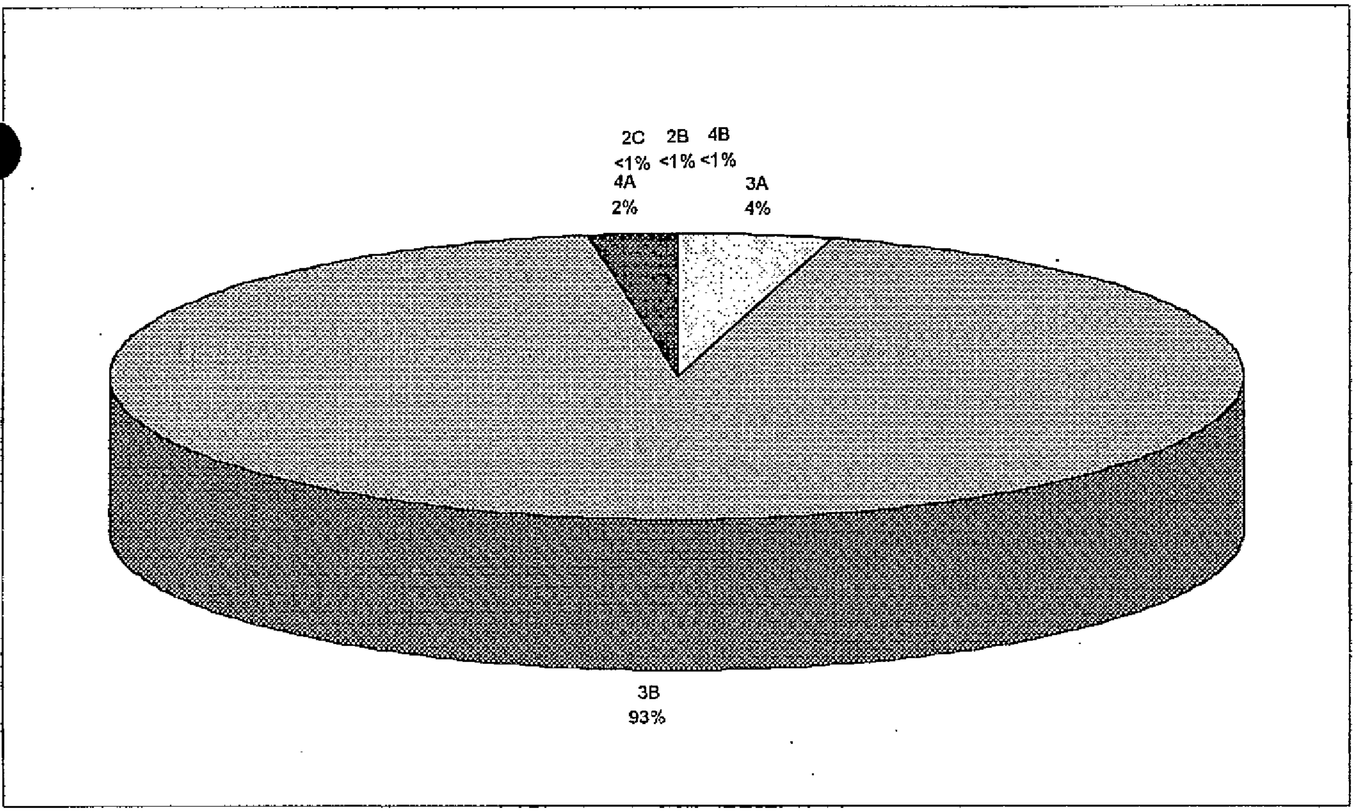


Figure 2. % Organic Load by River Segment (See Table 7a)

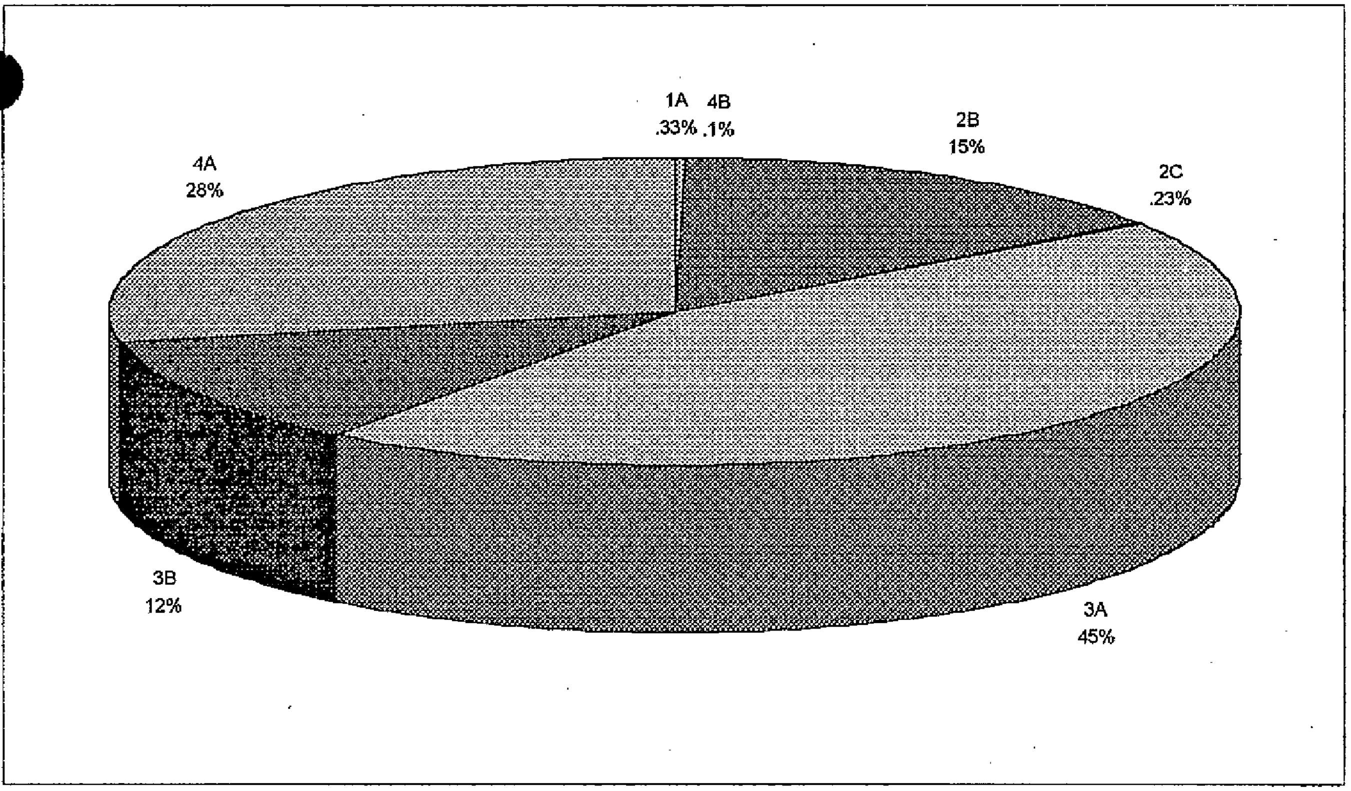


Figure 3. % General Organic Load by River Segment (See Table 8a).

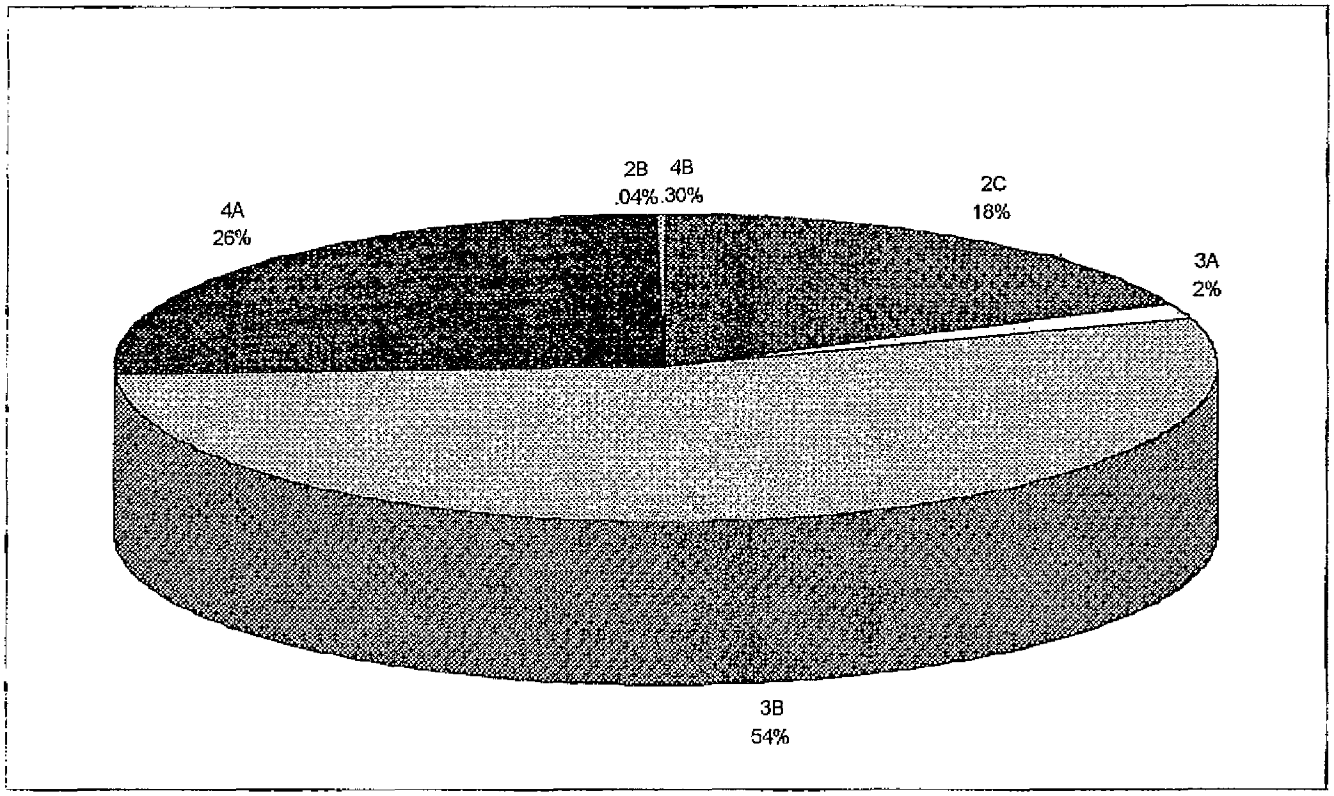


Figure 4. % Metal Load by River Segment (See Table 9a).

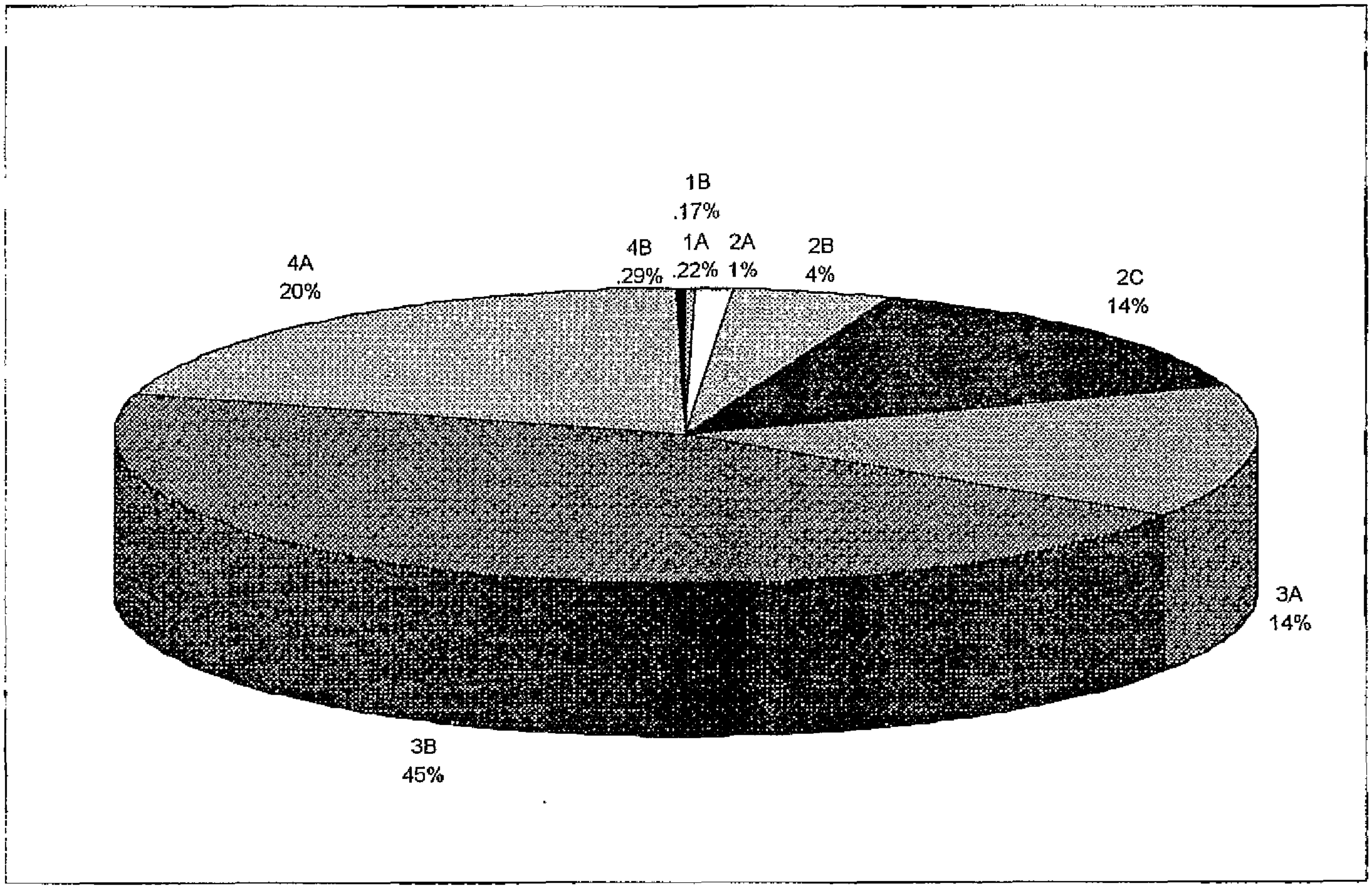


Figure 5. % Conventional Loading by River Segment (See Table 10a)

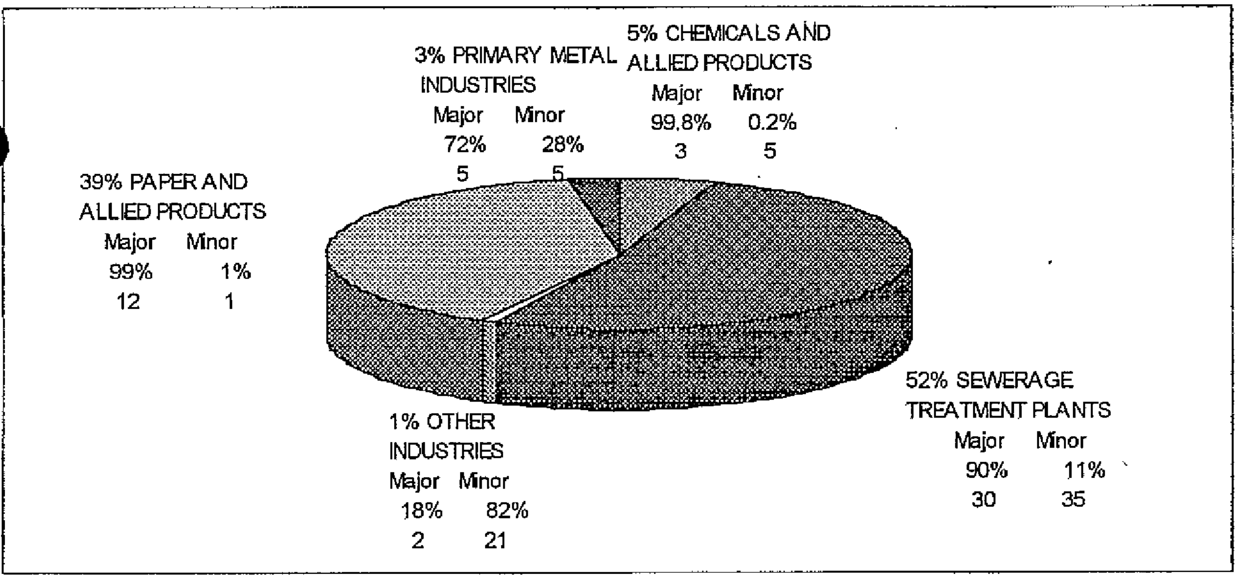


Figure 5a. % of Discharge Flow by General Industrial Category and Size Including Count.

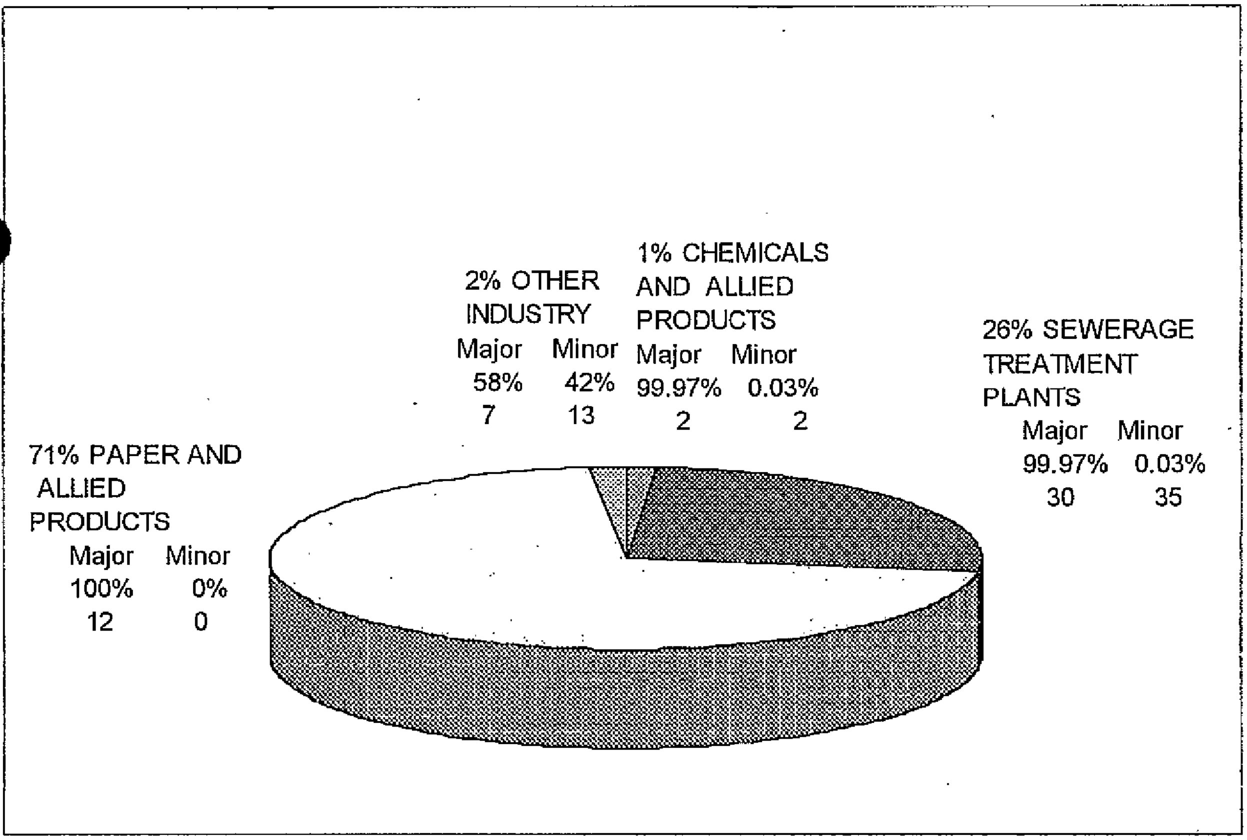


Figure 5b. Percentage of Suspended Solid Load by General Industrial Category and Size Including Count.

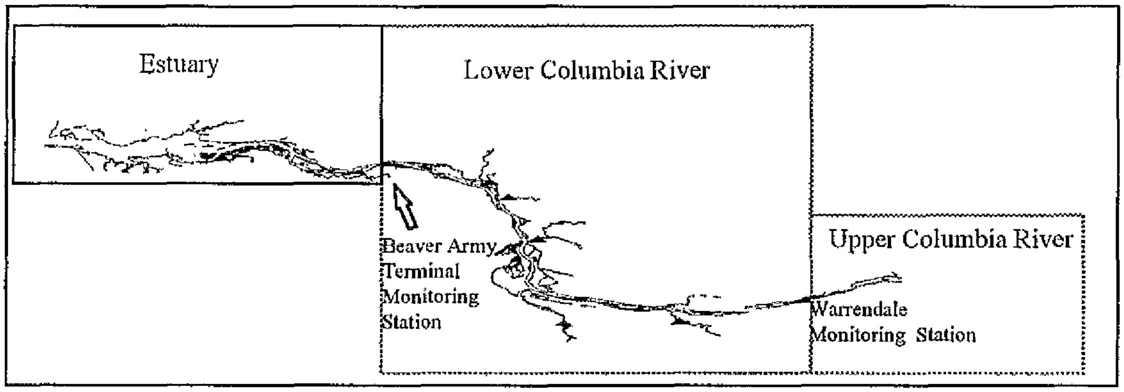


Figure 6. Upper Columbia River (Warendale) and Lower Columbia River (Warendale) USGS Monitoring Stations.

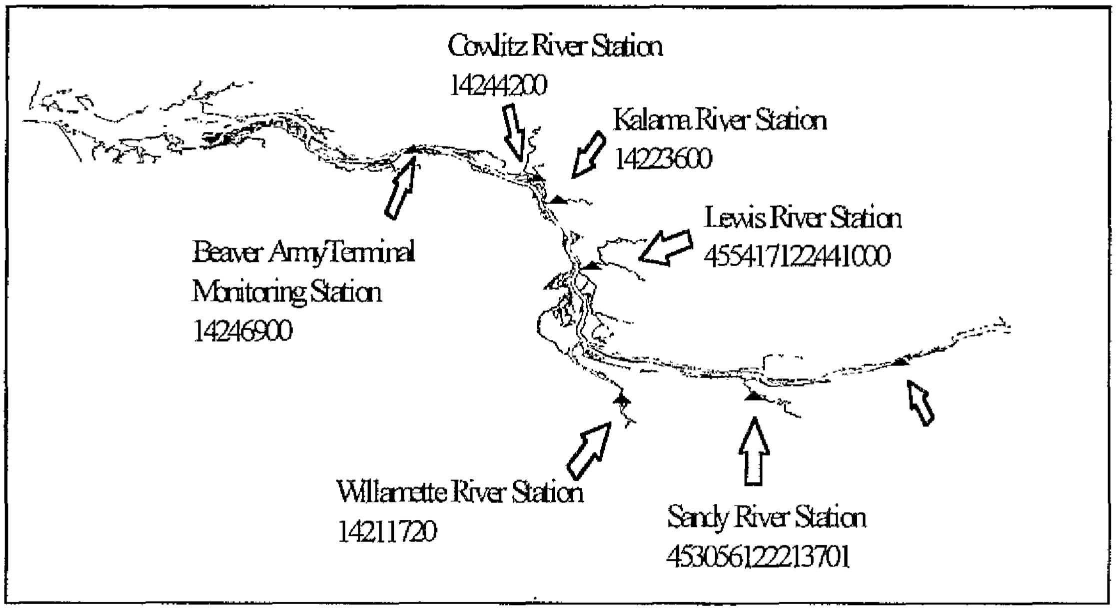
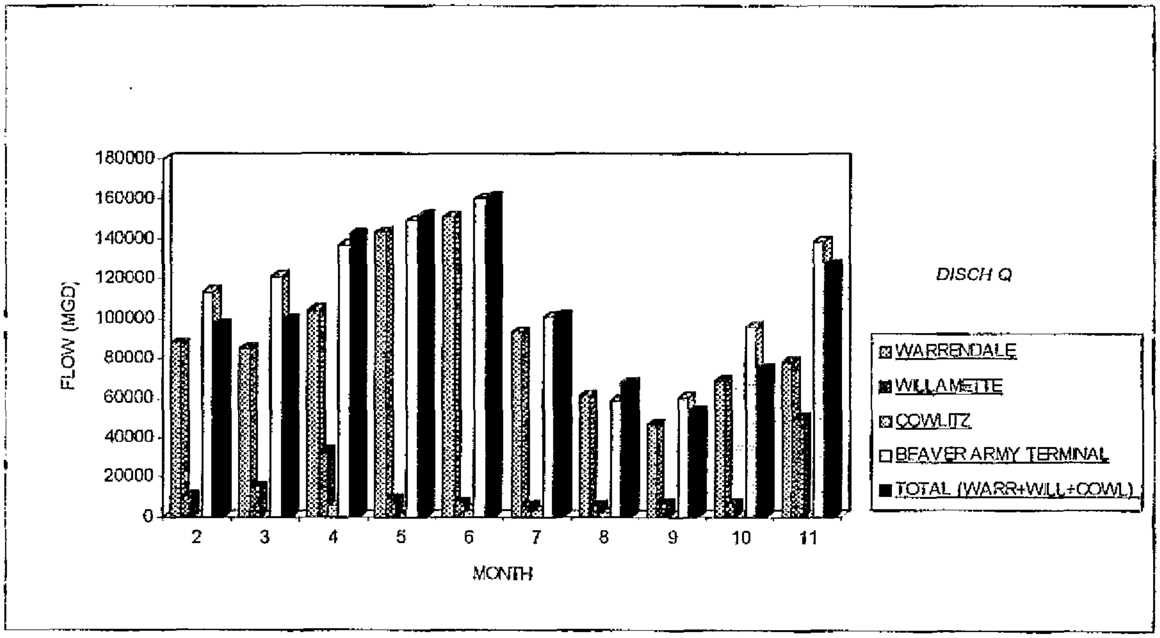


Figure 7. Location of USGS Columbia River and Tributary Monitoring Stations



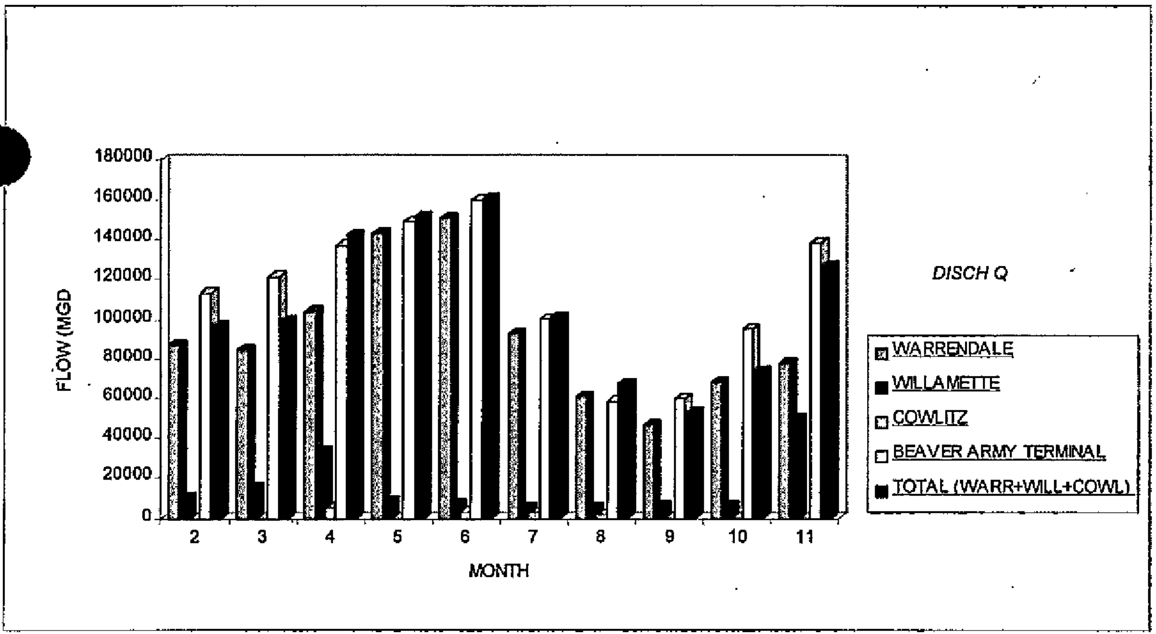


Figure 8. LCR major tributaries and main-stem USGS monitoring stations monthly discharge Q comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

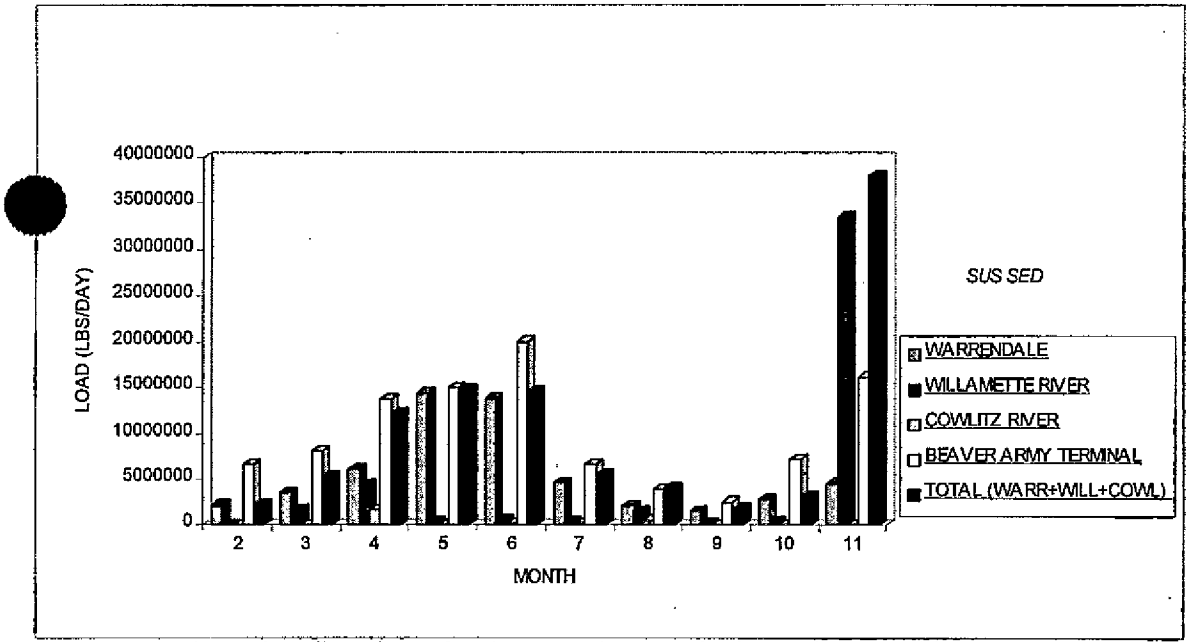


Figure 9. LCR major tributaries and main-stem USGS monitoring stations monthly suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

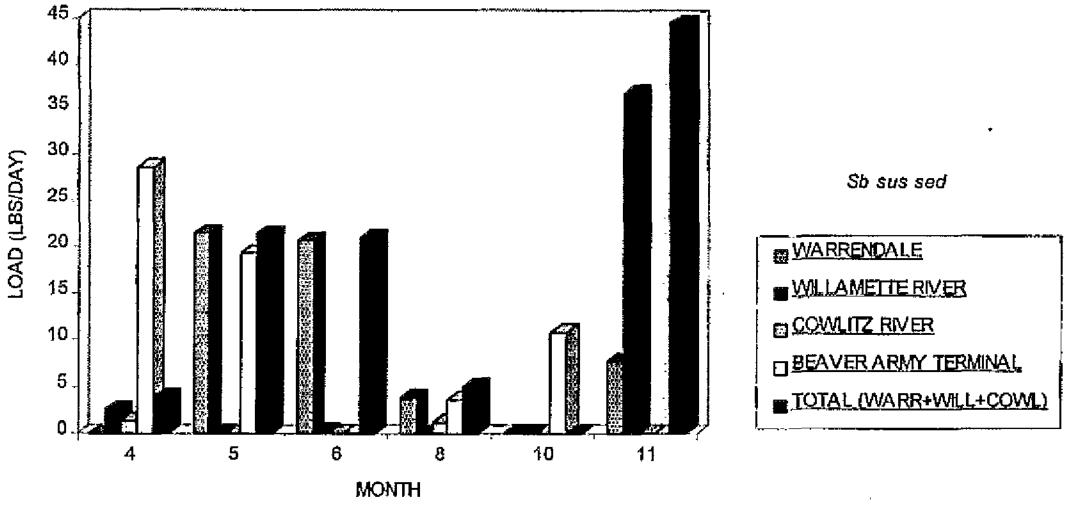


Figure 10. LCR major tributaries and main-stem USGS monitoring stations monthly <u>Antimony suspended sediment</u> load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

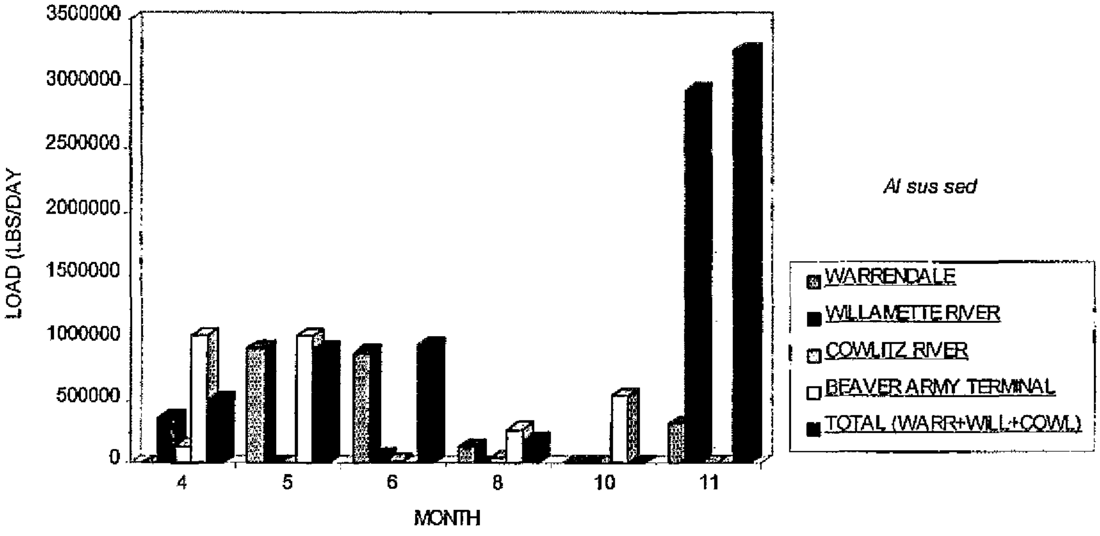


Figure 11. LCR major tributaries and main-stem USGS monitoring stations monthly <u>Aluminum suspended sediment</u> load comparisons (1994). Note: Completely flat columns signify no sampling took place and do not represent zero load values.

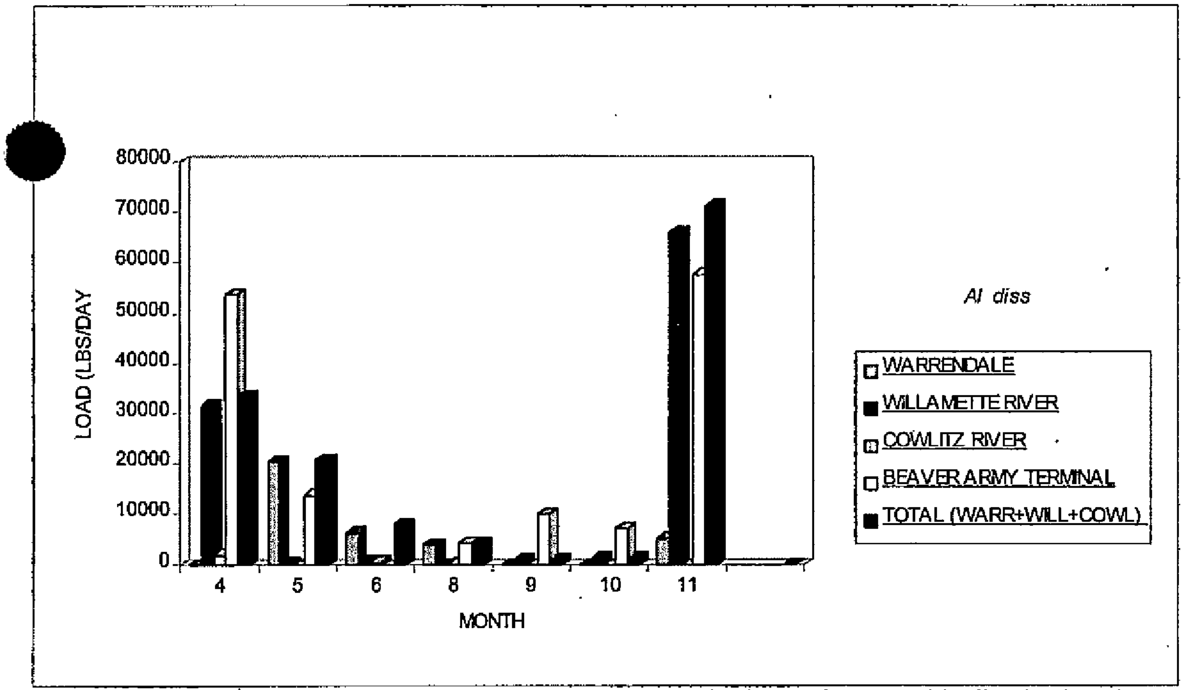


Figure 12. LCR major tributaries and main-stem USGS monitoring stations monthly dissolved Antimony load comparisons (1994). [1/2 the detection limit was used to calculate the load in May for the Willamette River; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

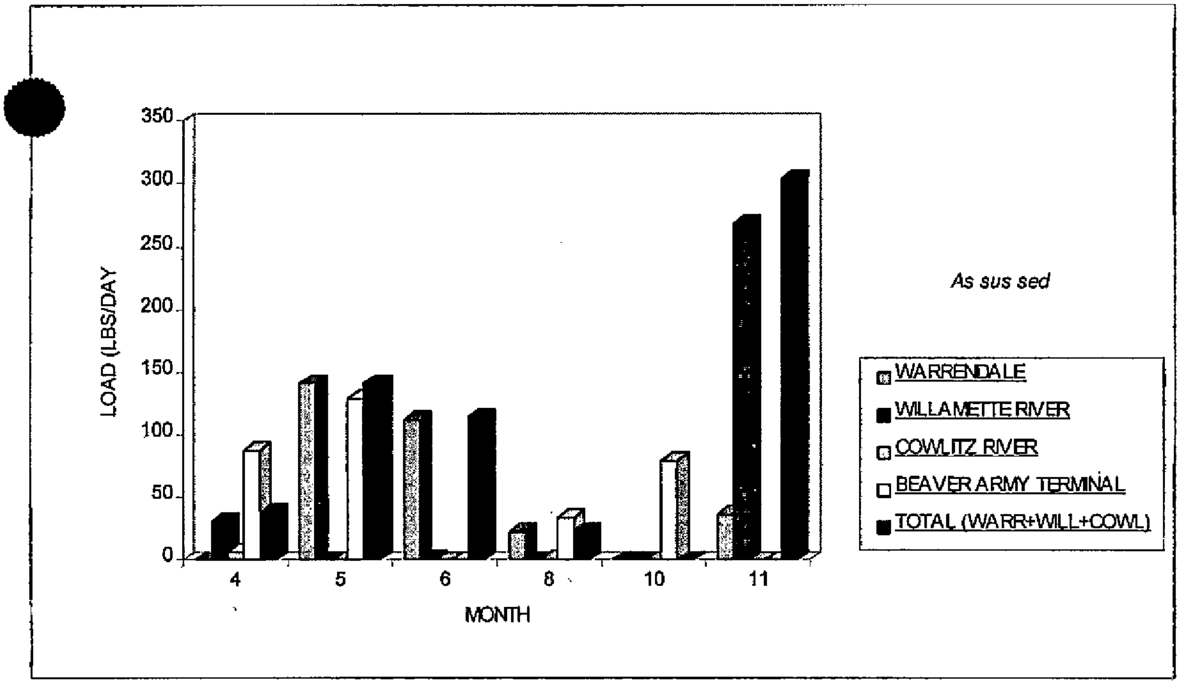


Figure 13. LCR major tributaries and main-stem USGS monitoring stations monthly Arsenic suspended sediment load comparisons. [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

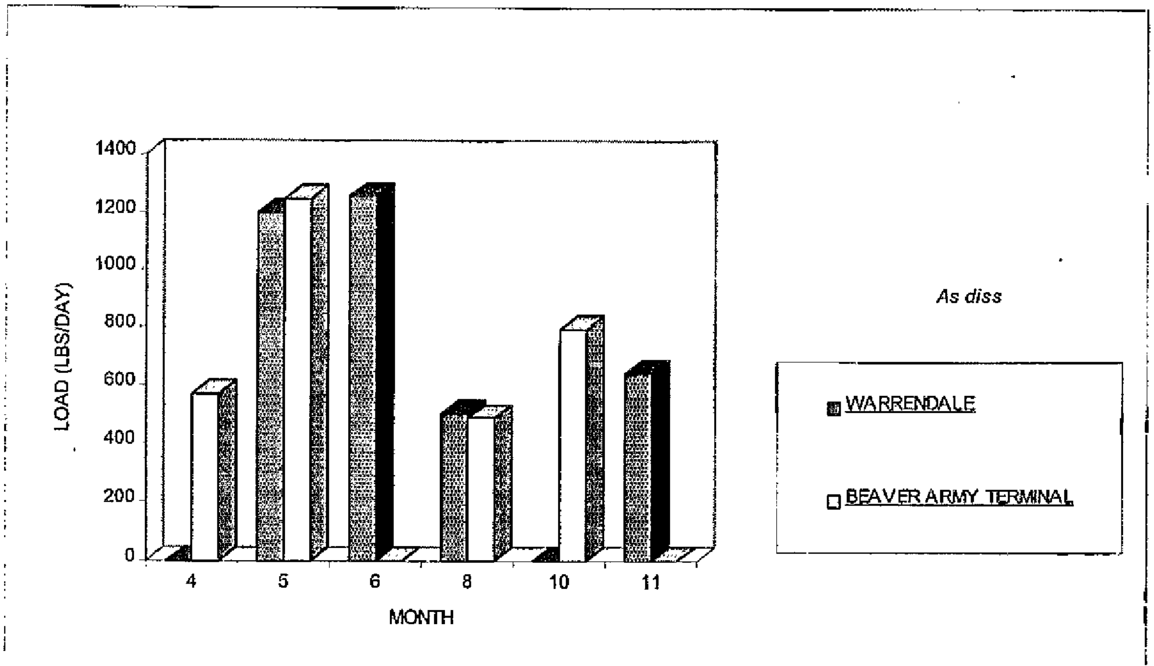


Figure 14. LCR major tributaries and main-stem USGS monitoring stations monthly dissolved Arsenic load comparisons (1994). [1/2 the detection limit was used to calculate the load in April for Beaver Army Terminal; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

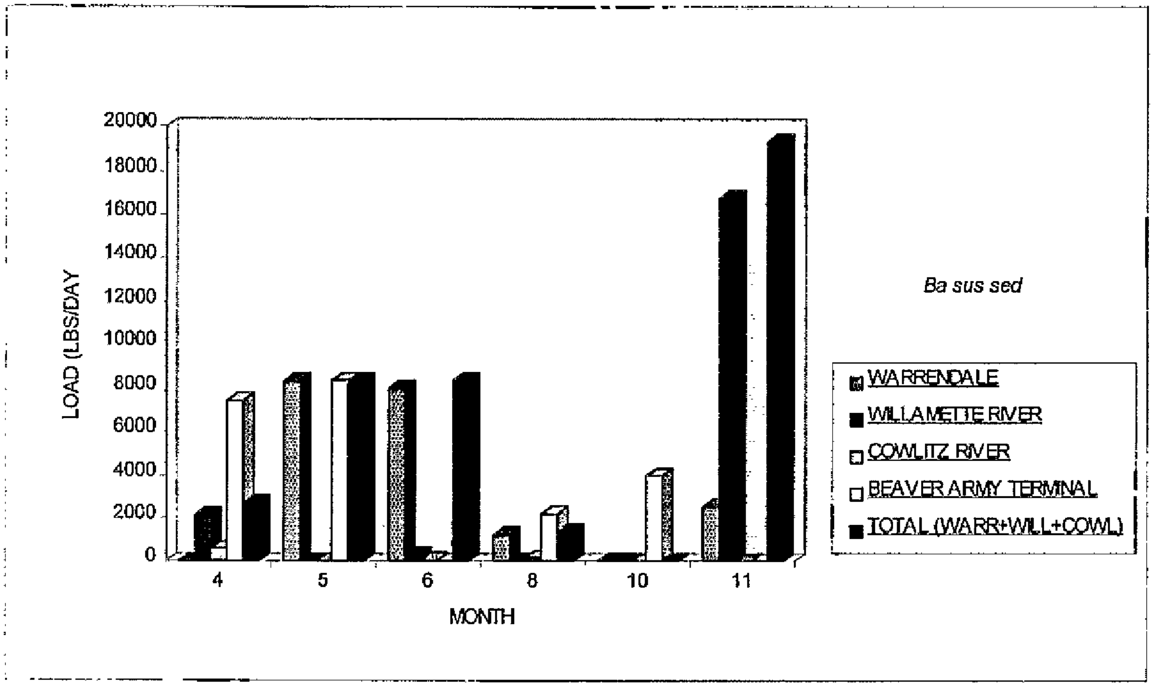


Figure 15. LCR major tributaries and main-stem USGS monitoring stations monthly Barium suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

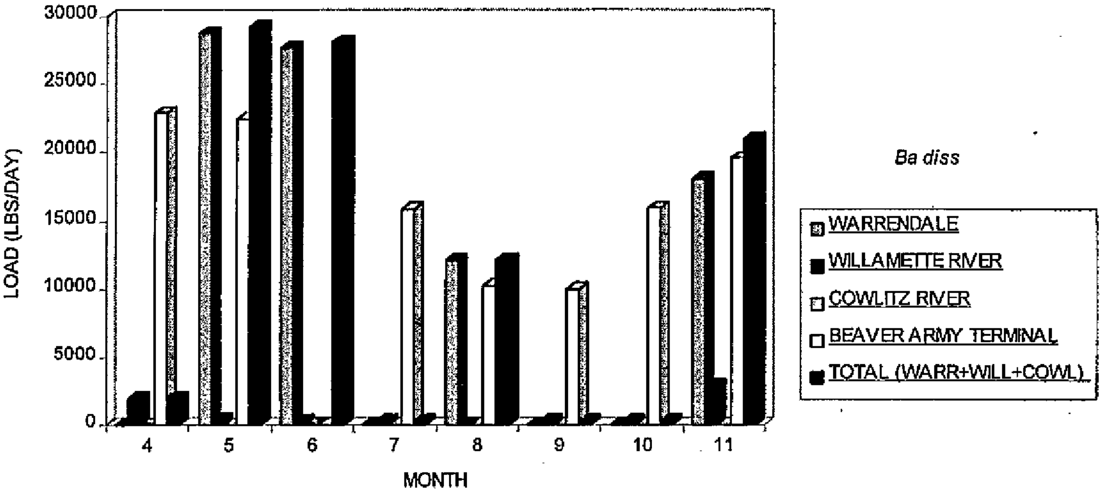


Figure 16. LCR major tributaries and main-stem USGS monitoring stations monthly dissolved Barium load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

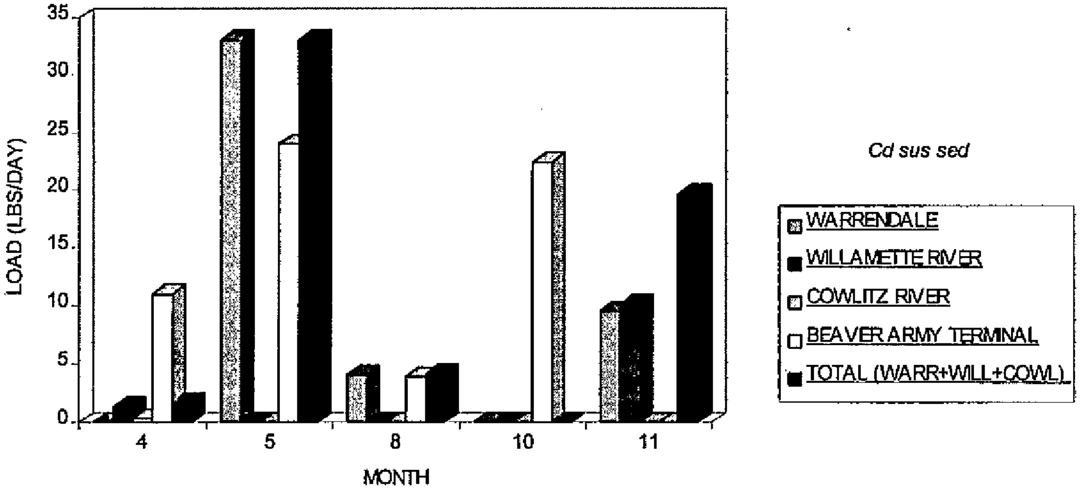


Figure 17. LCR major tributaries and main-stem USGS monitoring stations monthly Cadmium suspended sediment load comparisons. [1/2 the detection limit was used to calculate the load in August for the Cowlitz River and Beaver Army Terminal; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

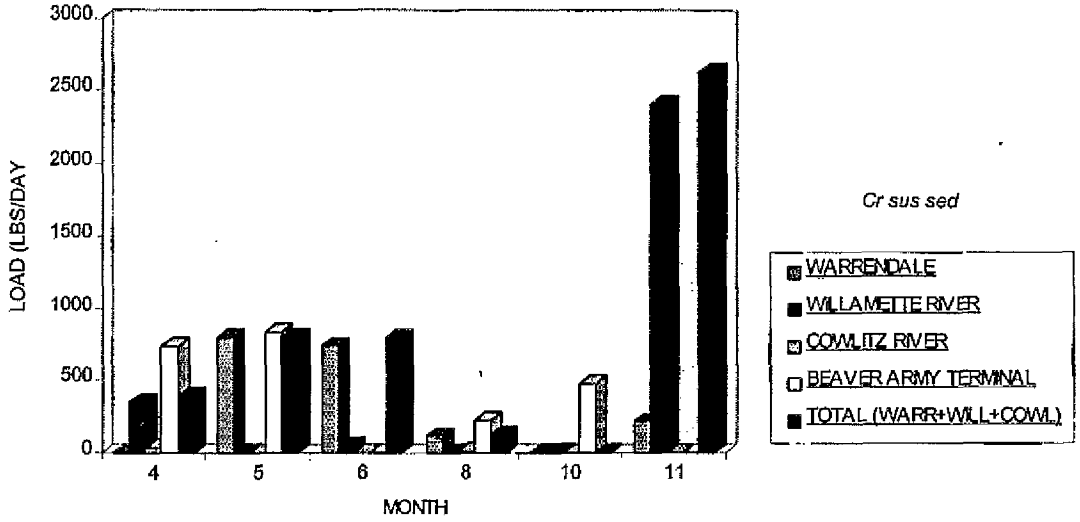


Figure 18. LCR major tributaries and main-stem USGS monitoring stations monthly Chromium suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

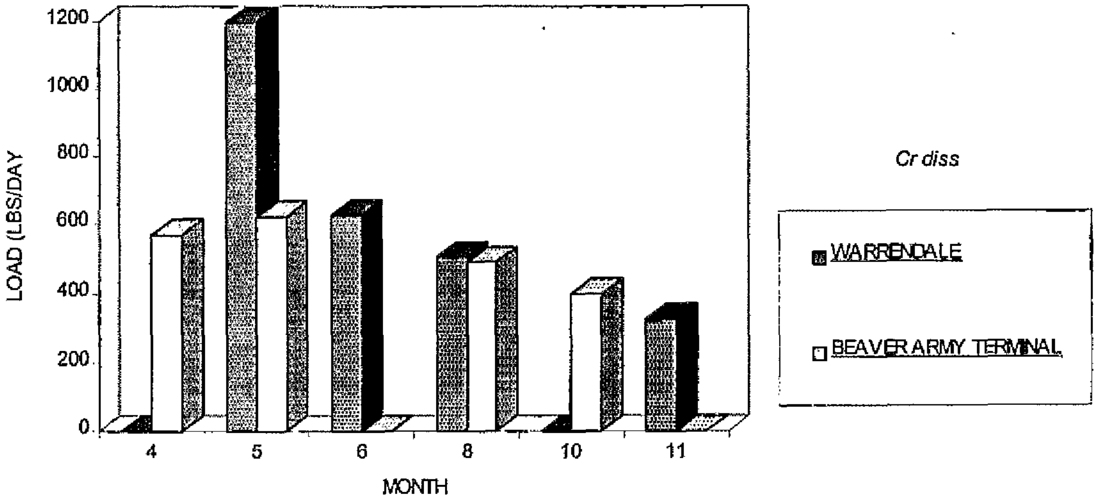


Figure 19. LCR major tributaries and main-stem USGS monitoring stations monthly dissolved Chromium load comparisons. [1/2 the detection limit was used to calculate the load in April and May for Beaver Army Terminal and June for Warrendale; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

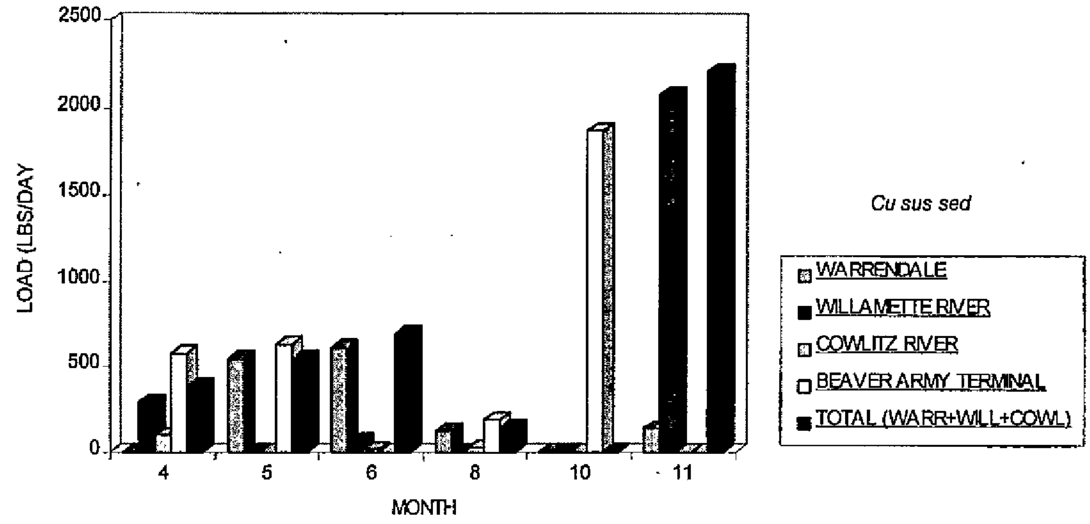


Figure 20. LCR major tributaries and main-stem USGS monitoring stations monthly Copper suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

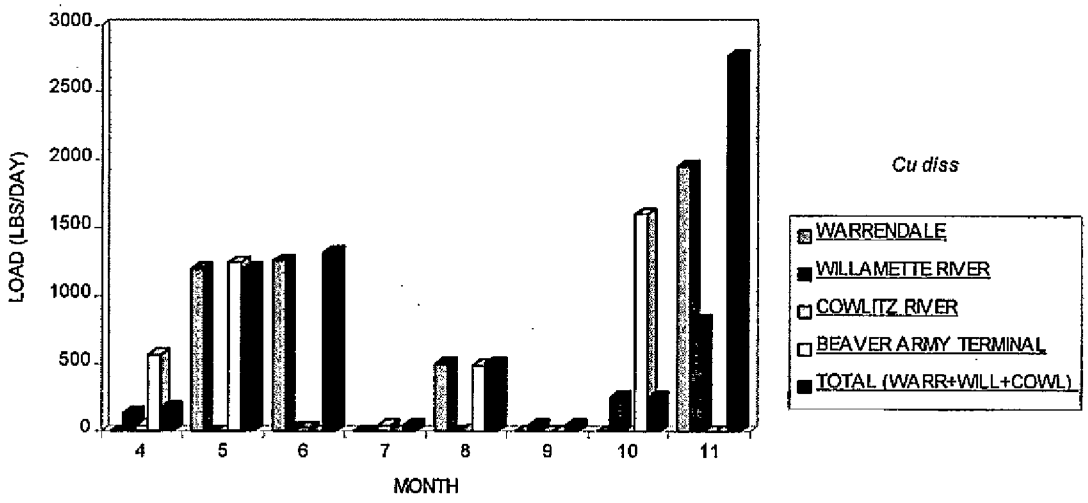


Figure 21. LCR major tributaries and main-stem USGS monitoring stations monthly Copper suspended sediment load comparisons (1994). [1/2 the detection limit was used to calculate the load in April for the Willamette River and Beaver Army Terminal, in June for the Willamette River, and in August for the Cowlitz River; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

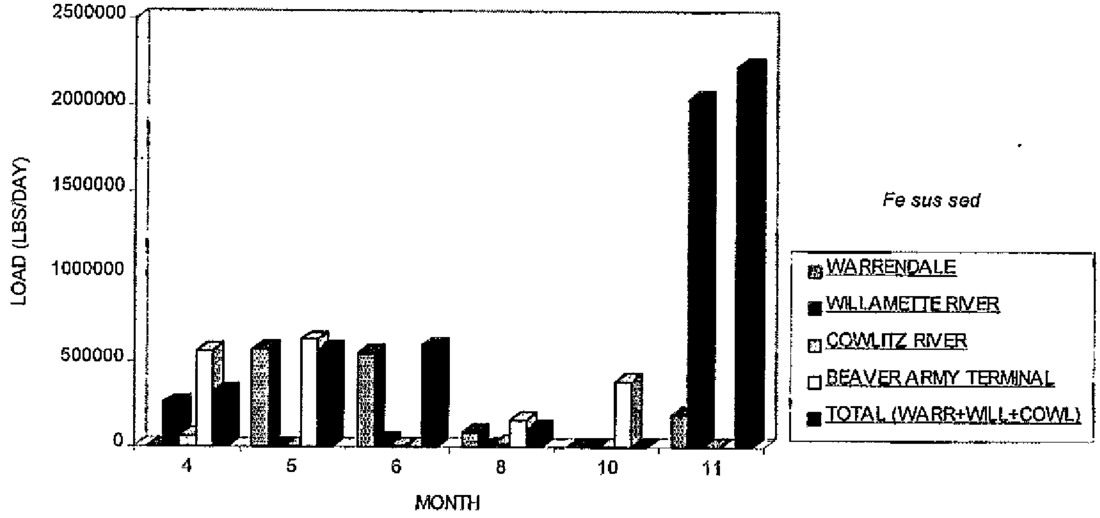


Figure 22. LCR major tributaries and main-stem USGS monitoring stations monthly Iron suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

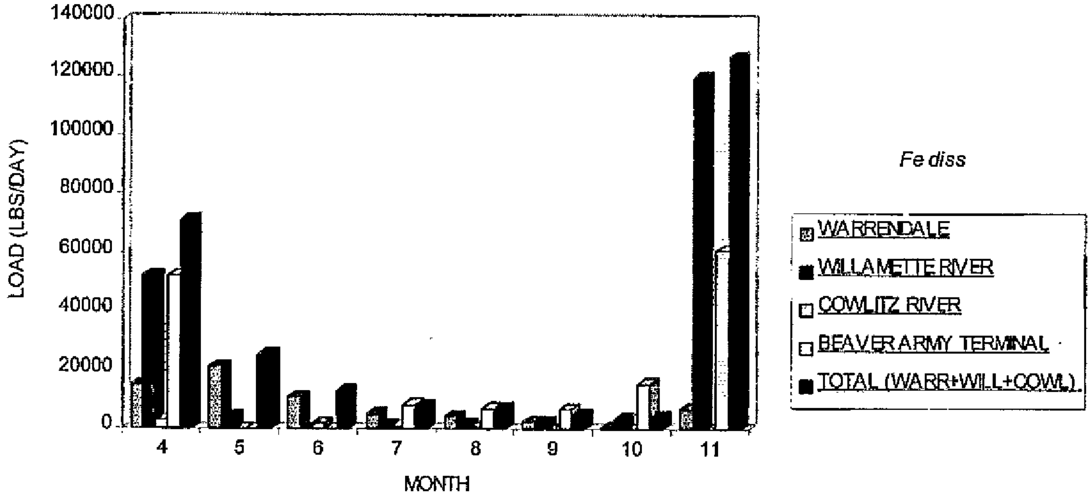


Figure 23. LCR major tributaries and main-stem USGS monitoring stations monthly dissolved Iron load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

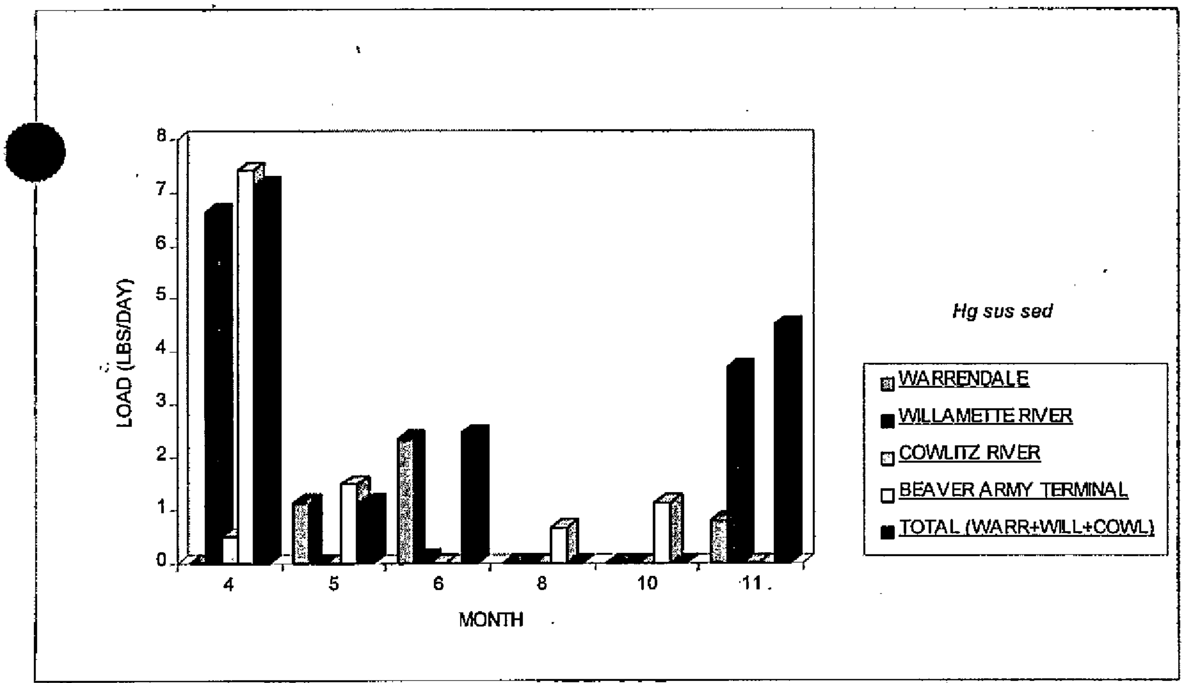


Figure 24. LCR major tributaries and main-stem USGS monitoring stations monthly Mercury suspended sediment load comparisons (1994). [1/2 the detection limit was used to calculate the load in August for the Cowlitz River; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

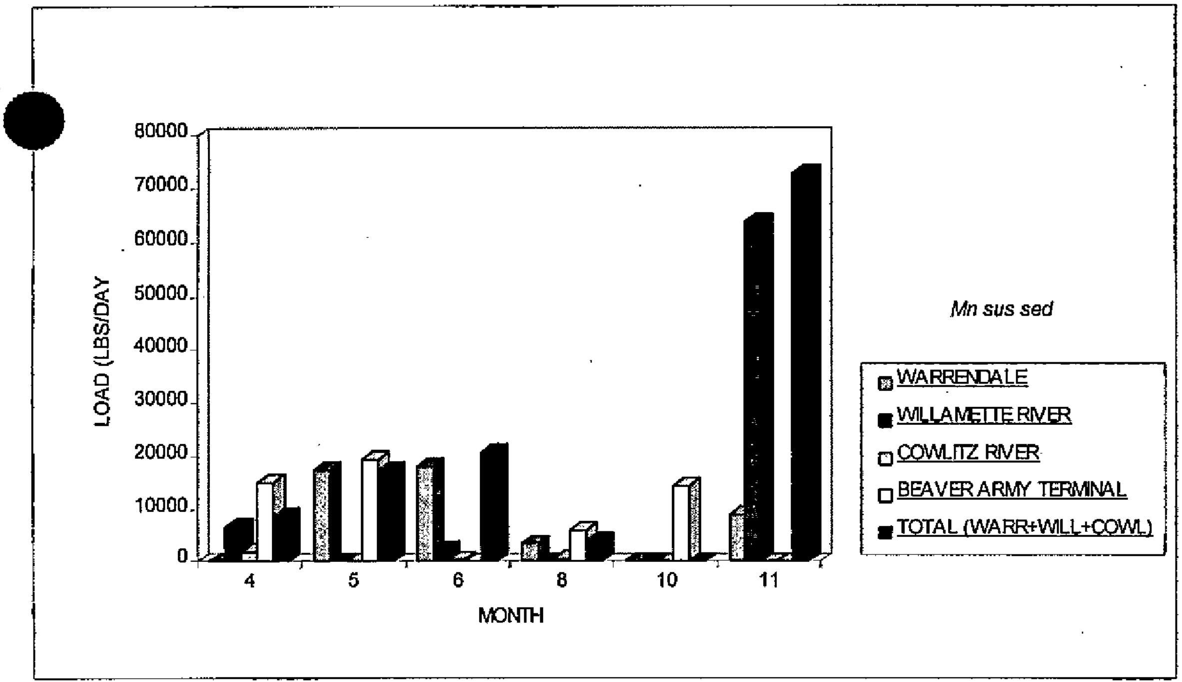


Figure 25. LCR major tributaries and main-stem USGS monitoring stations monthly Manganese suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

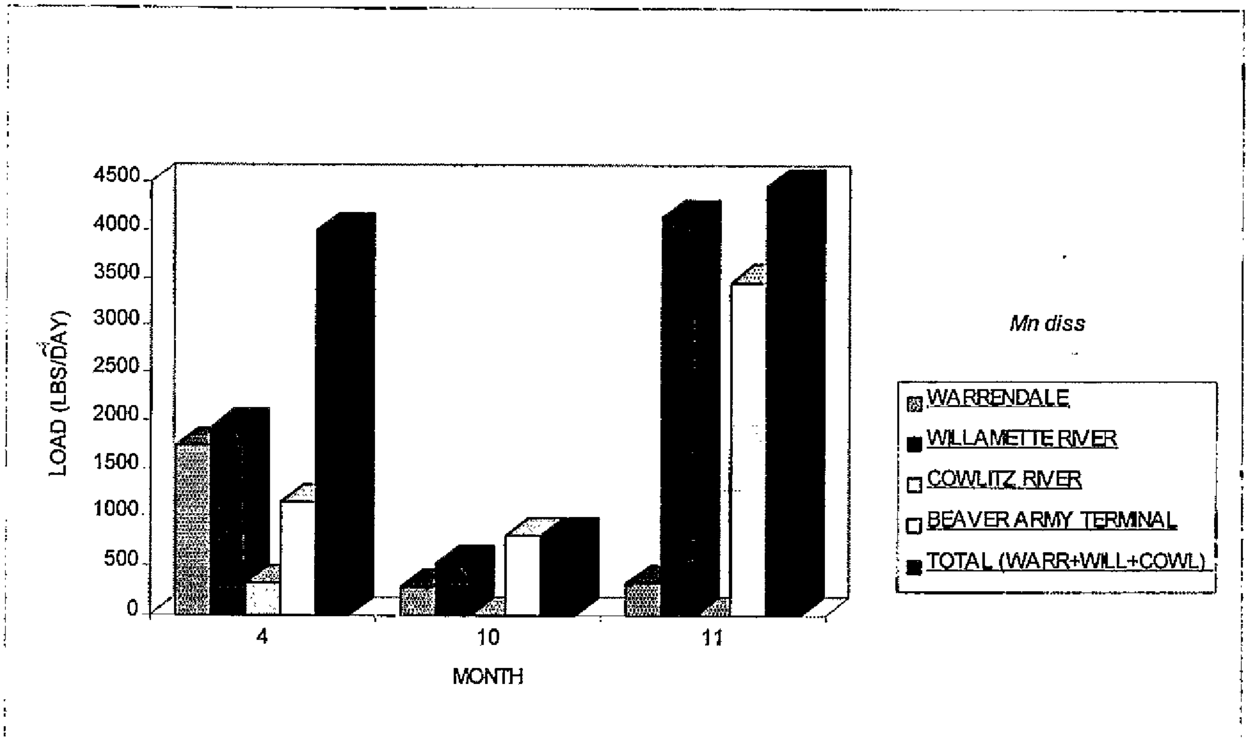


Figure 26. LCR major tributaries and main-stem USGS monitoring stations monthly dissolved Manganese load comparisons (1994). [1/2 the detection limit was used to calculate the load in October and November for Warrendale; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

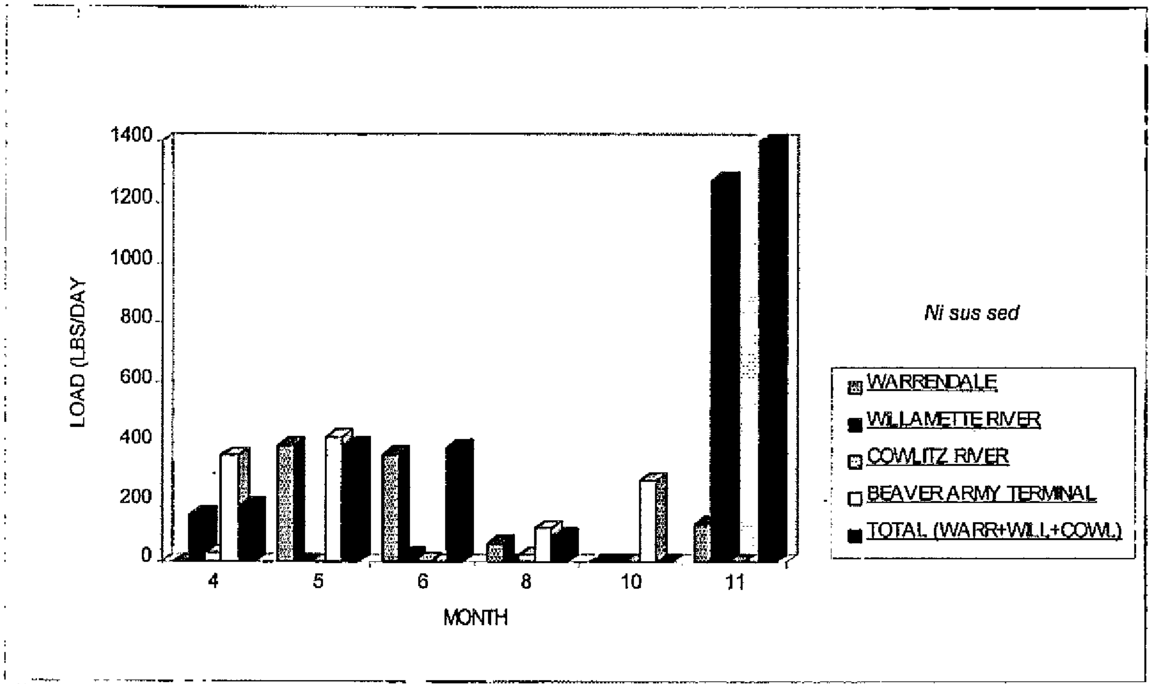


Figure 27. LCR major tributaries and main-stem USGS monitoring stations monthly Nickel suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

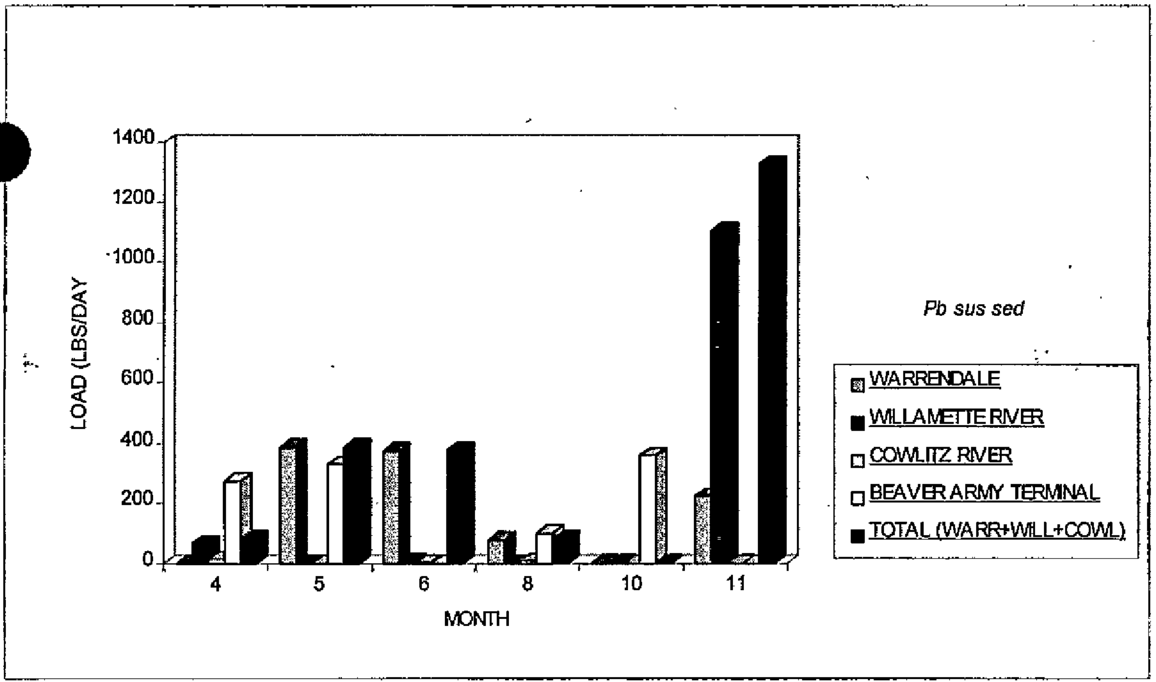


Figure 28. LCR major tributaries and main-stem USGS monitoring stations monthly Lead suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

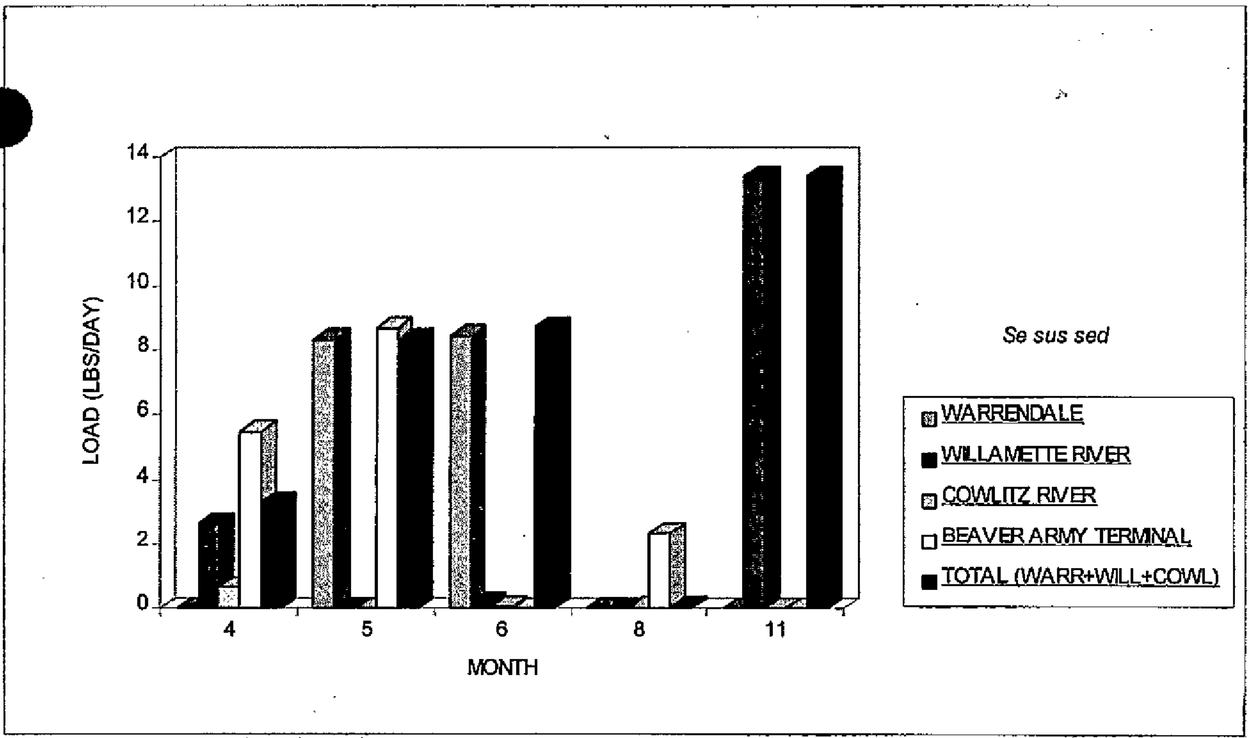


Figure 29. LCR major tributaries and main-stem USGS monitoring stations monthly Selenium suspended sediment load comparisons (1994). [1/2 the detection limit was used to calculate the load in August for the Cowlitz River; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

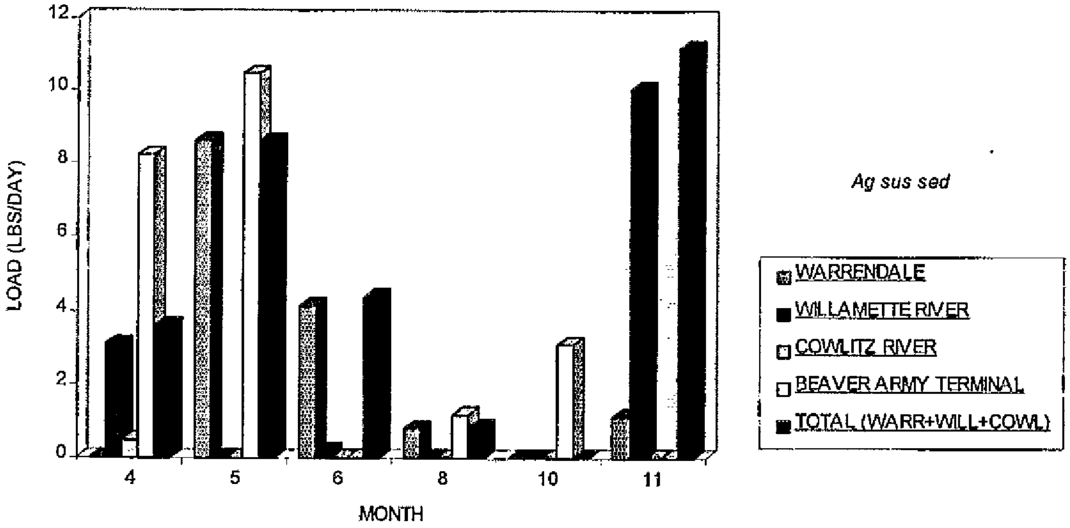


Figure 30. LCR major tributaries and main-stem USGS monitoring stations monthly Silver suspended sediment load comparisons (1994). [1/2 the detection limit was used to calculate the load in June and August for the Cowlitz River; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

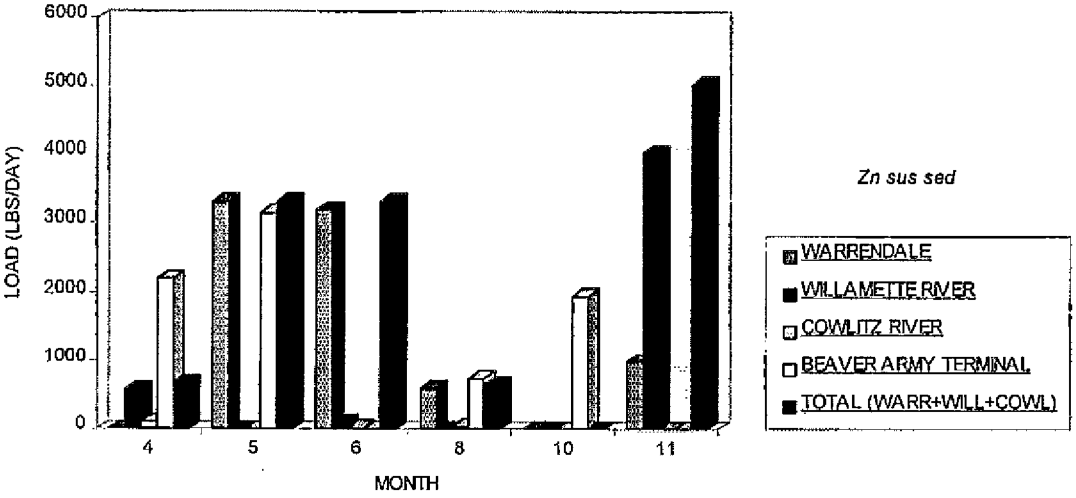


Figure 31. LCR major tributaries and main-stem USGS monitoring stations monthly Zinc suspended sediment load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

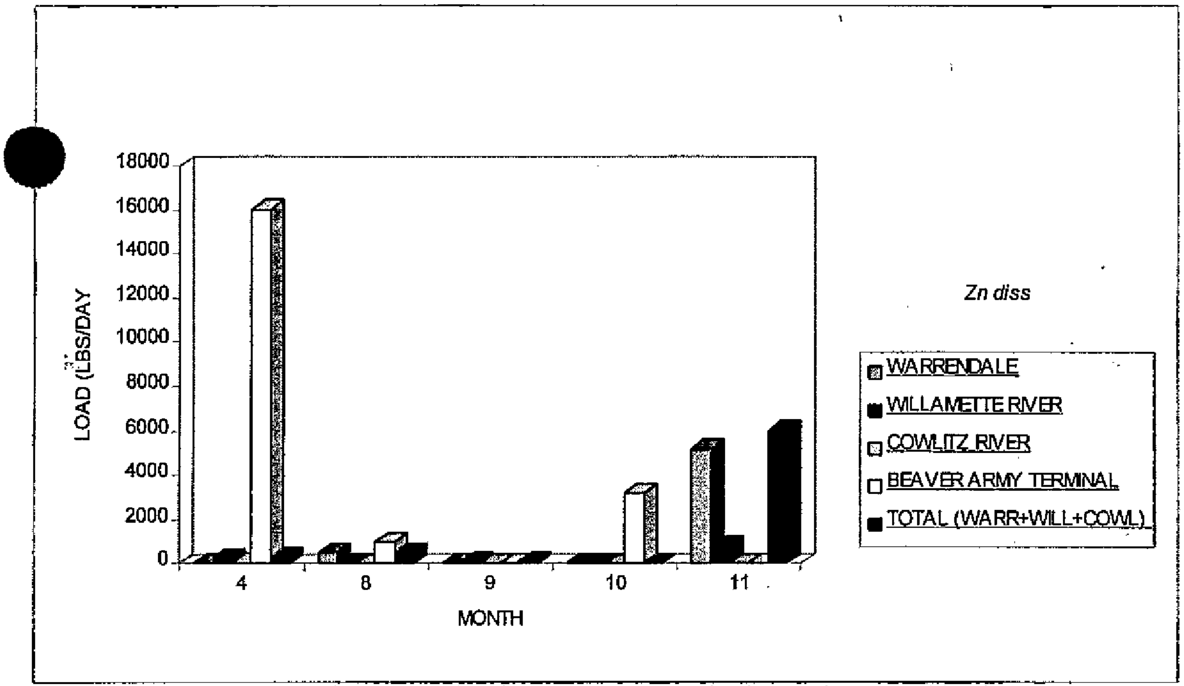


Figure 32. LCR major tributaries and main-stem USGS monitoring stations monthly dissolved Zinc load comparisons (1994). [1/2 the detection limit was used to calculate the load in October for the Willamette River; Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

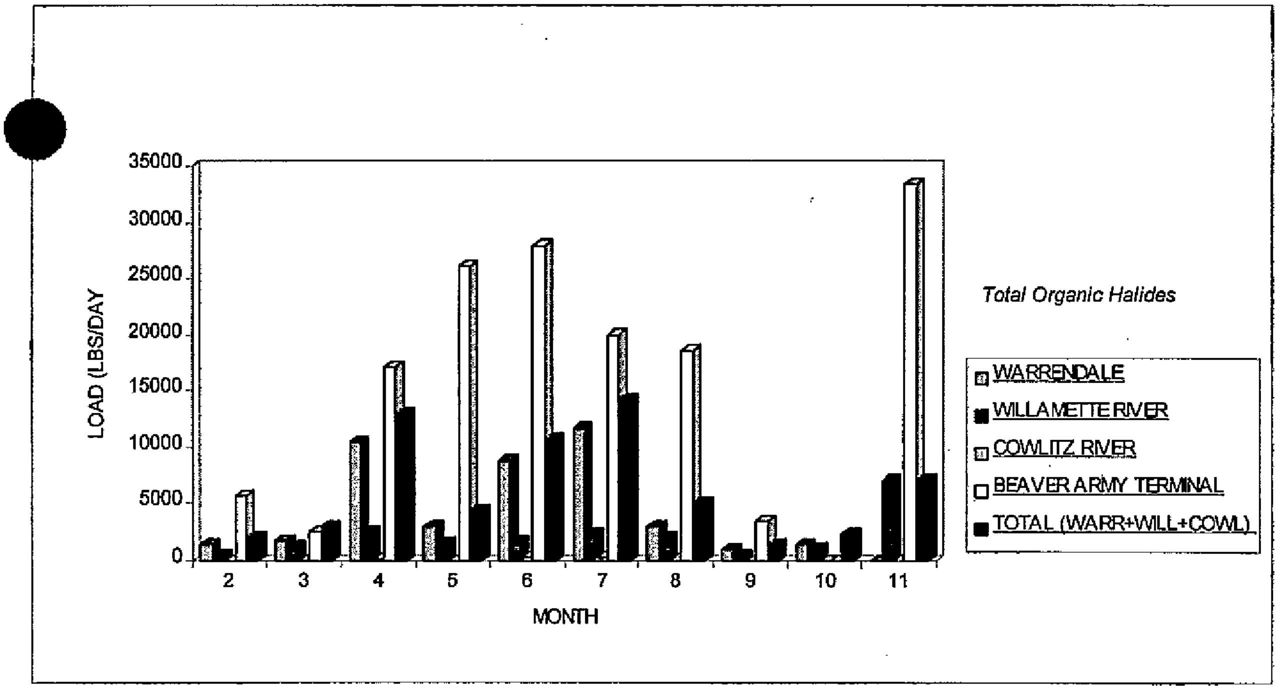


Figure 33. LCR major tributaries and main-stem USGS monitoring stations monthly total Organic Halide load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

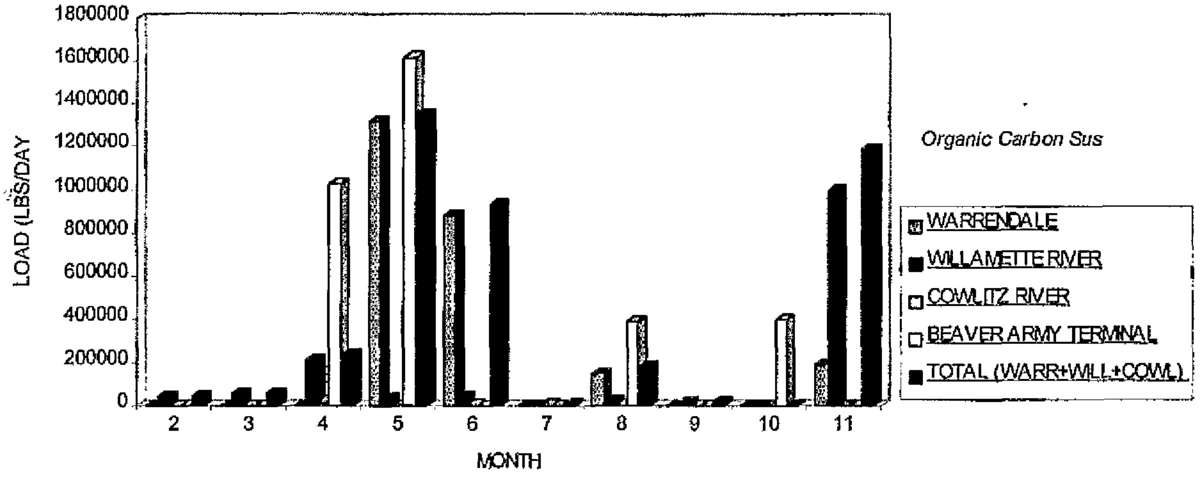


Figure 34. LCR major tributaries and main-stem USGS monitoring stations monthly total Organic Carbon load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

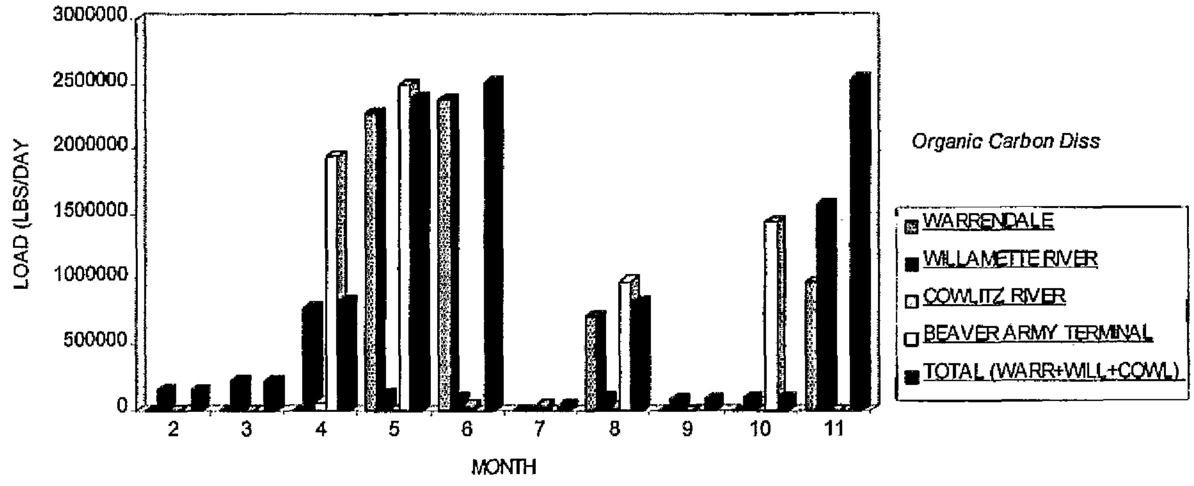


Figure 35. LCR major tributaries and main-stem USGS monitoring stations monthly dissolved Organic Carbon load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

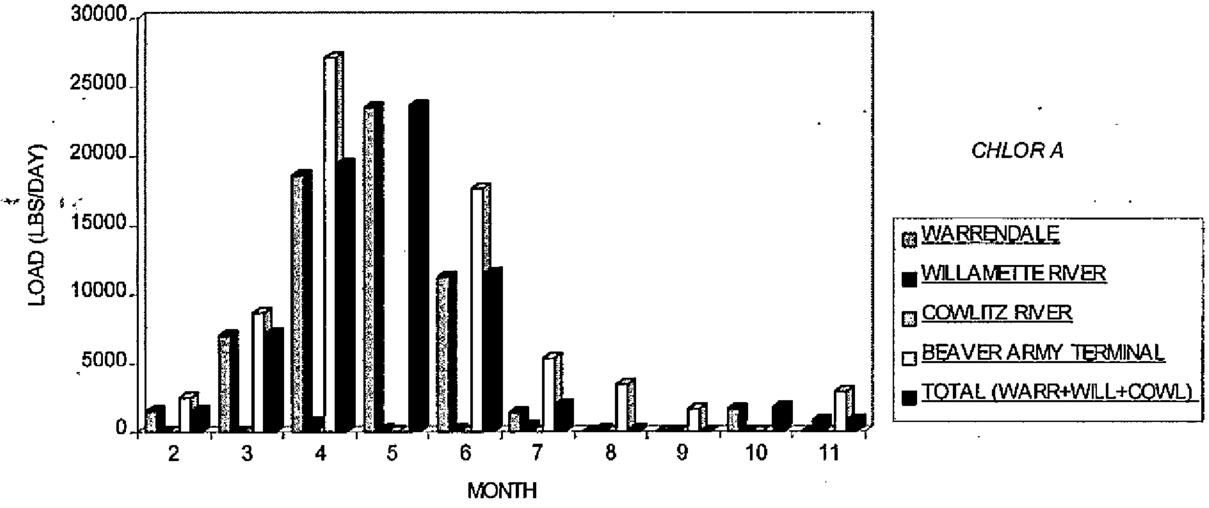


Figure 36. LCR major tributaries and main-stem USGS monitoring stations monthly total Chlorophyll *a* load comparisons (1994). [Note: Completely flat columns signify no sampling took place and do not represent zero load values.]

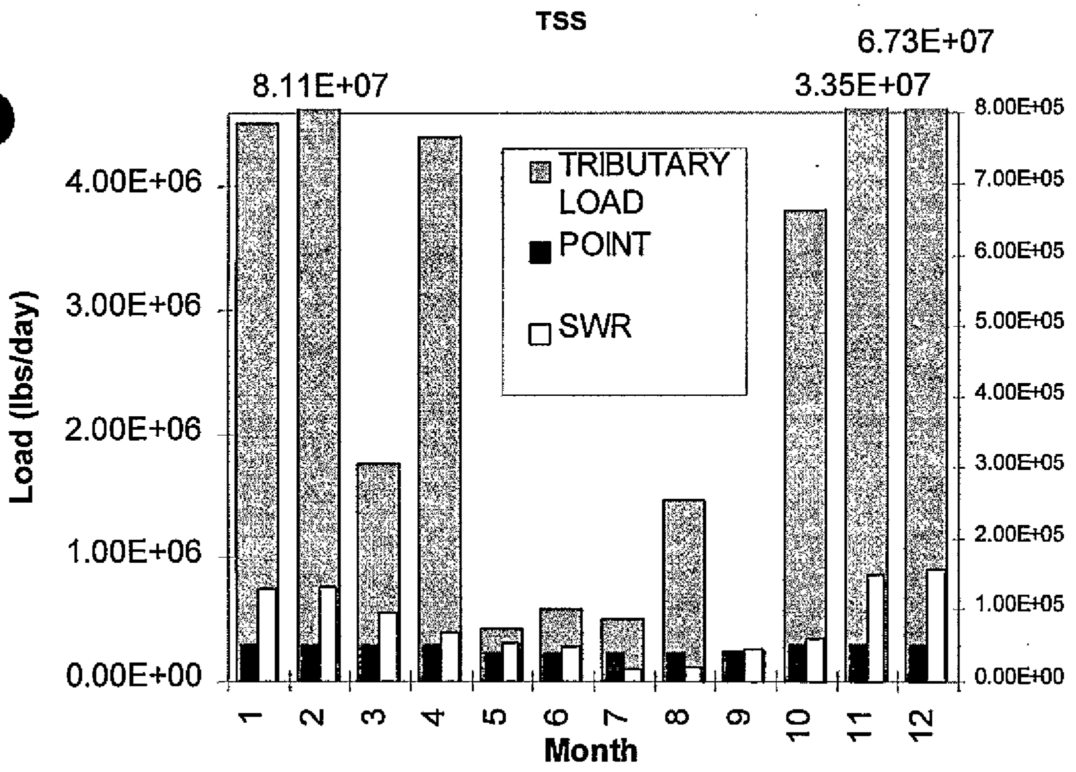


Figure 37. Total Suspended Solids; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

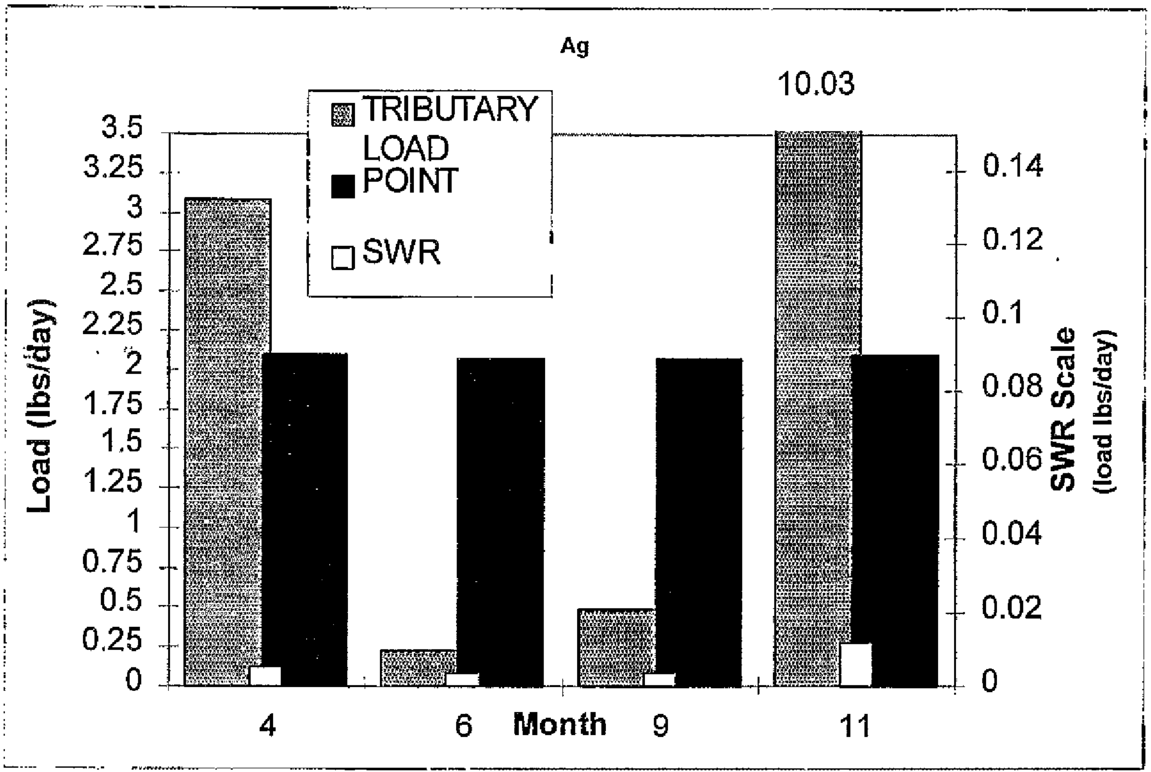


Figure 38. Total Silver; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

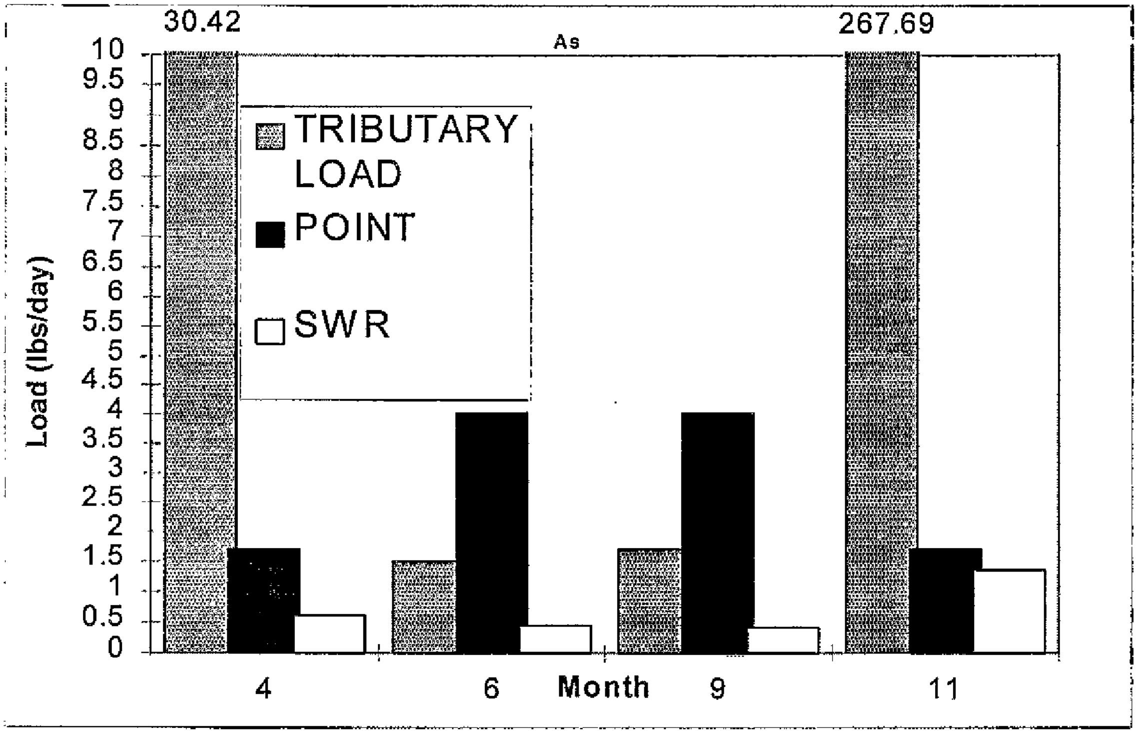


Figure 39. Total Arsenic; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

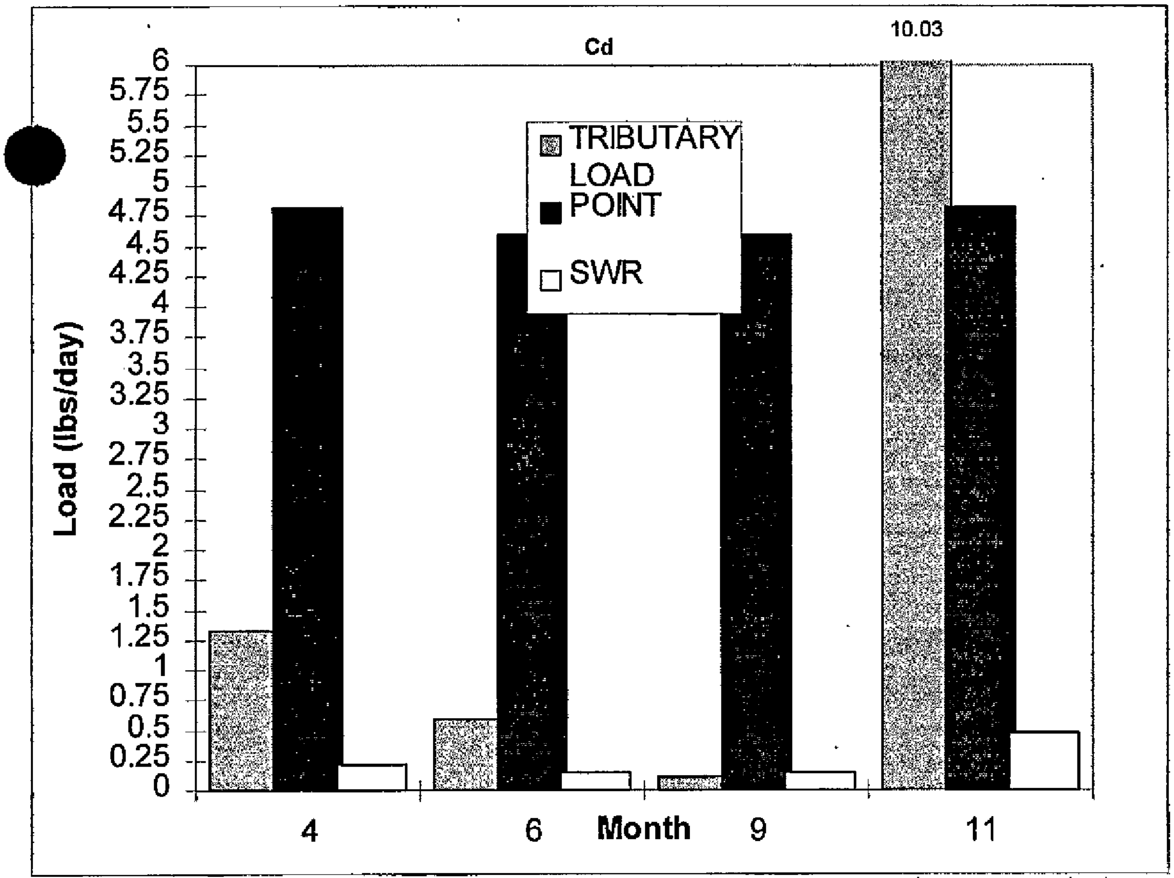


Figure 40. Total Cadmium; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

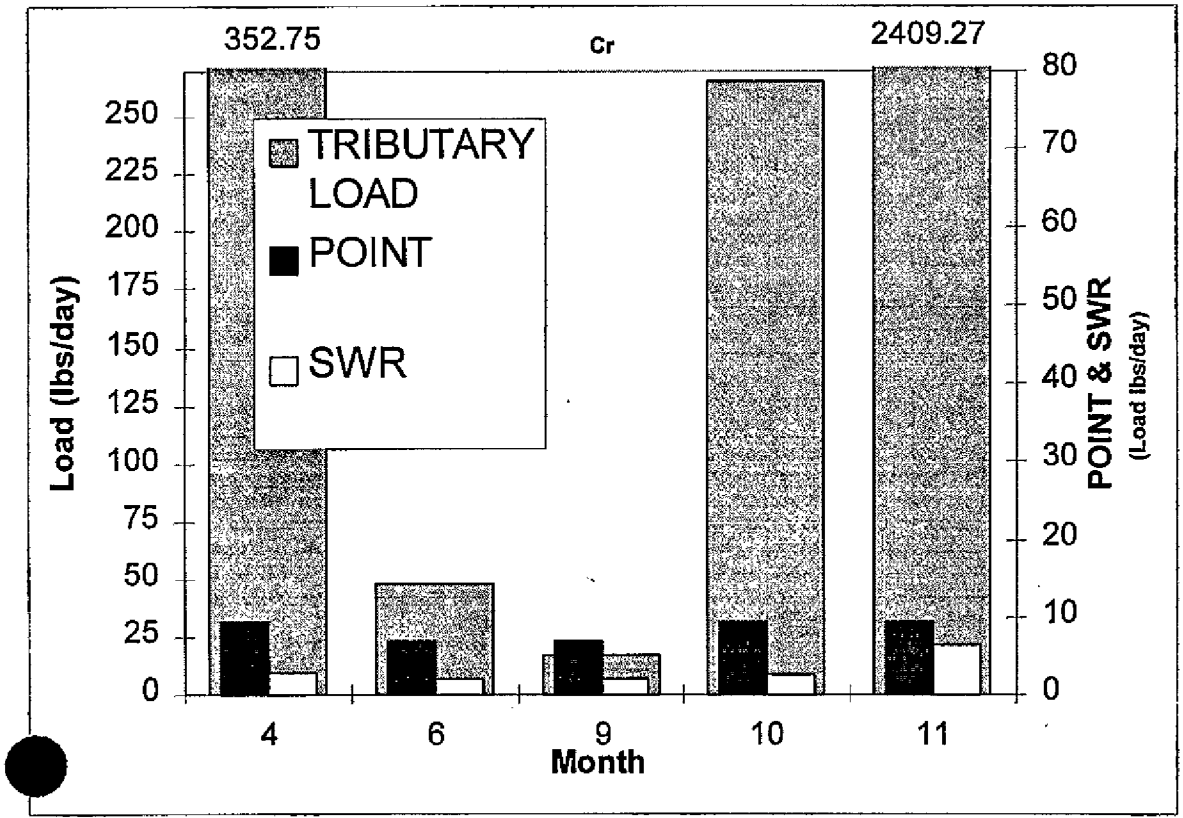


Figure 41. Total Chromium; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

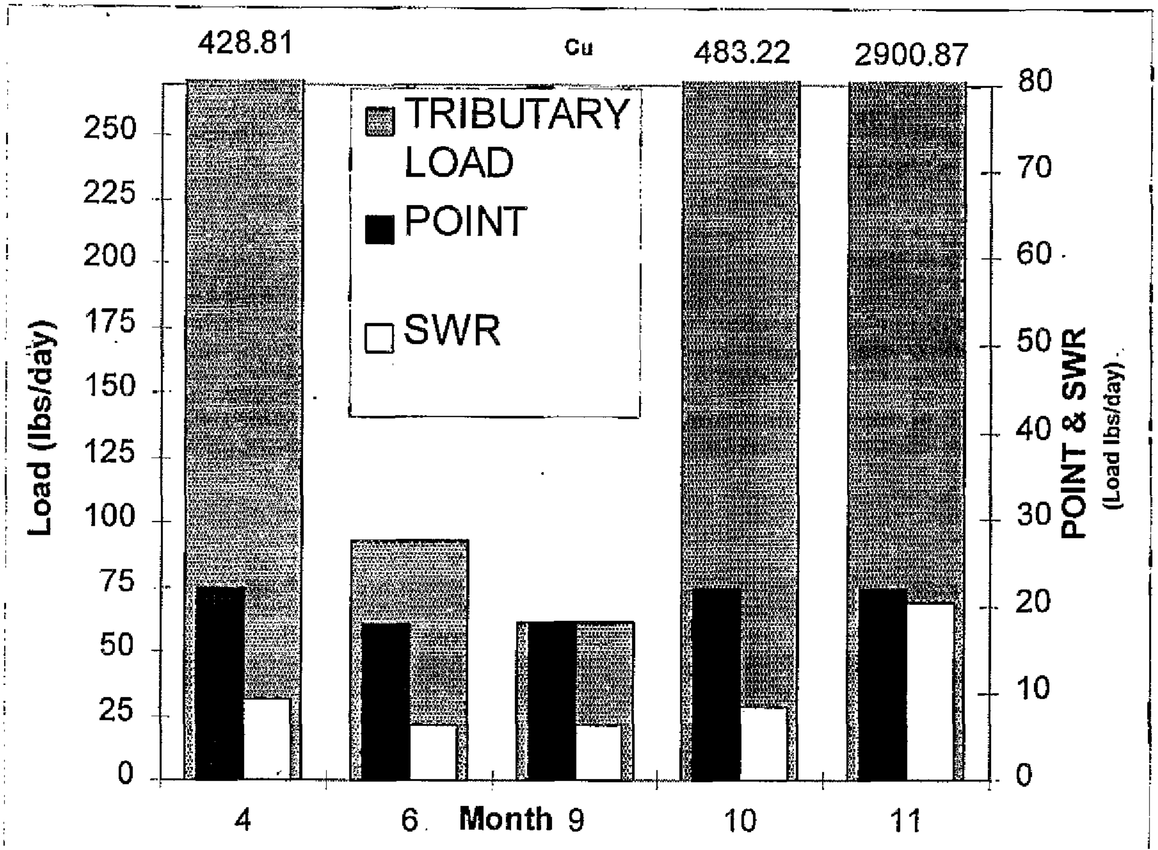


Figure 42. Total Copper; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

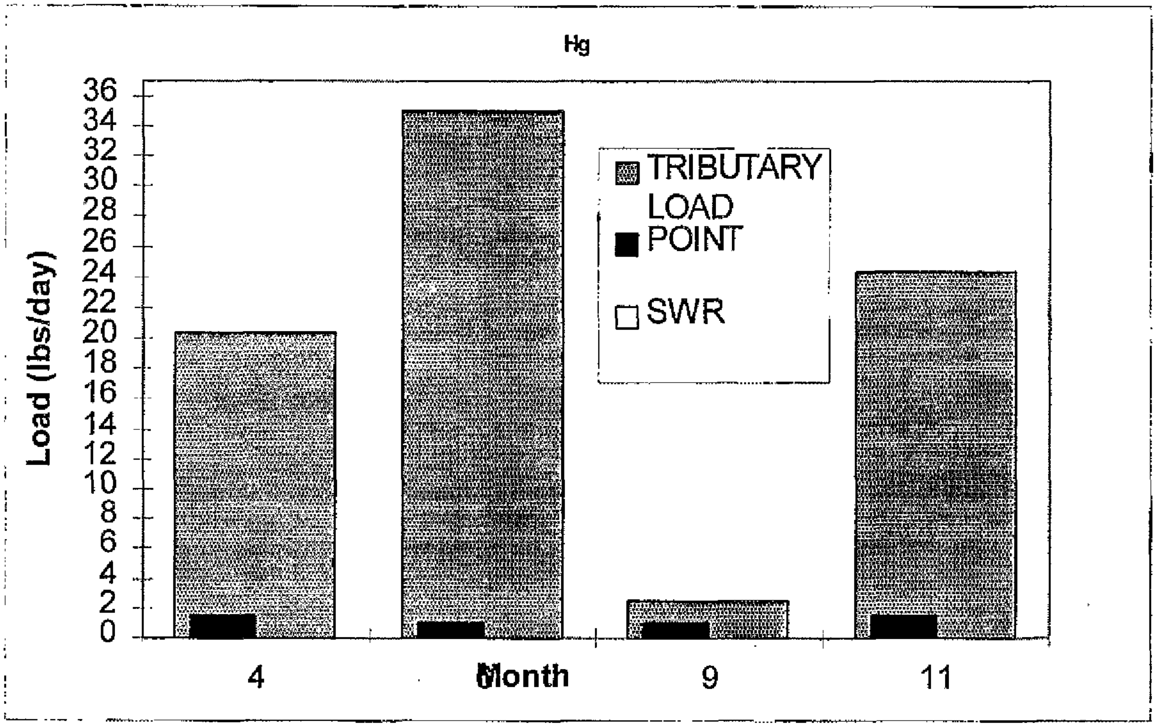


Figure 43. Total Mercury; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

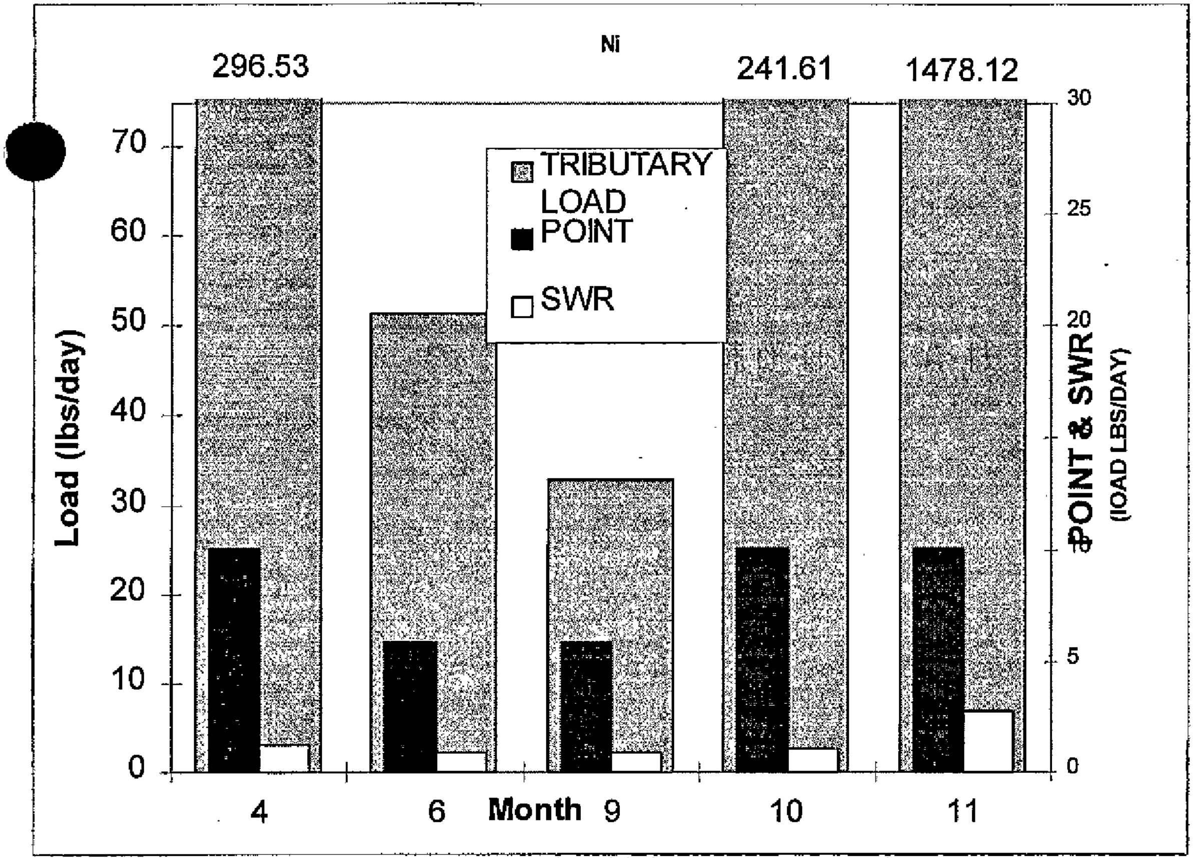


Figure 44. Total Nickel; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

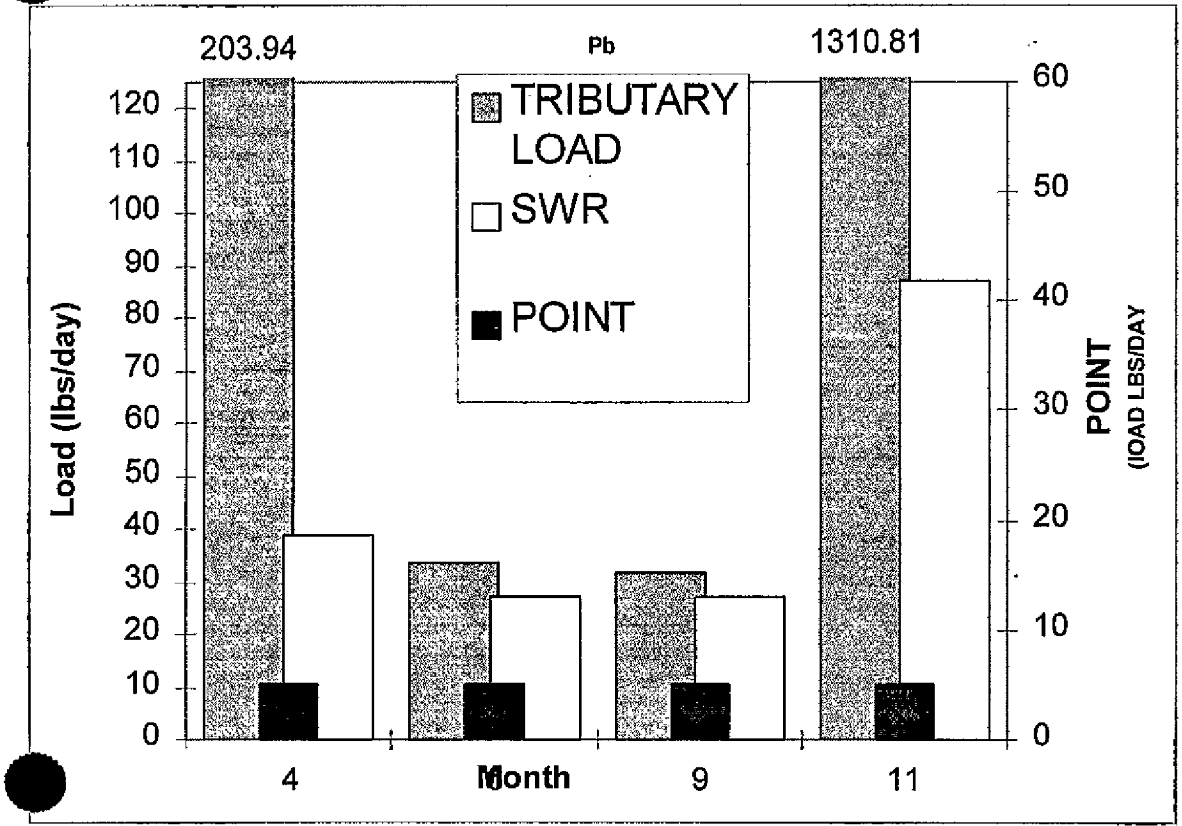


Figure 45. Total Lead; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

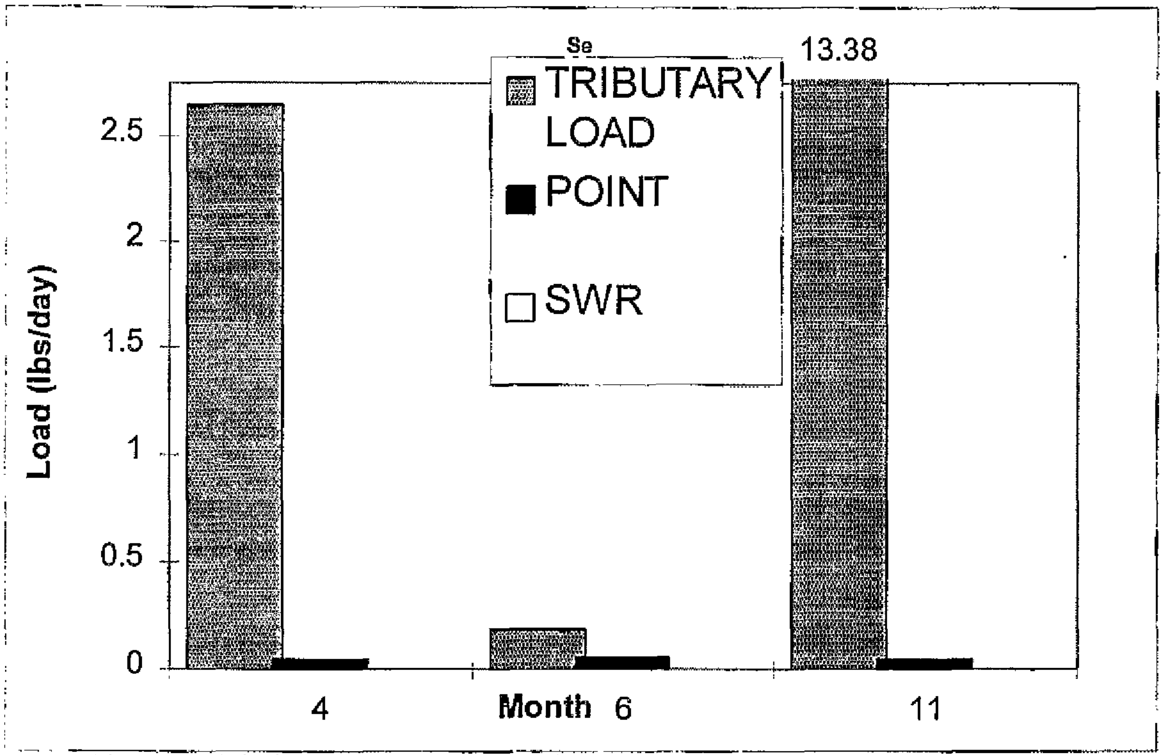


Figure 46. Total Selenium; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

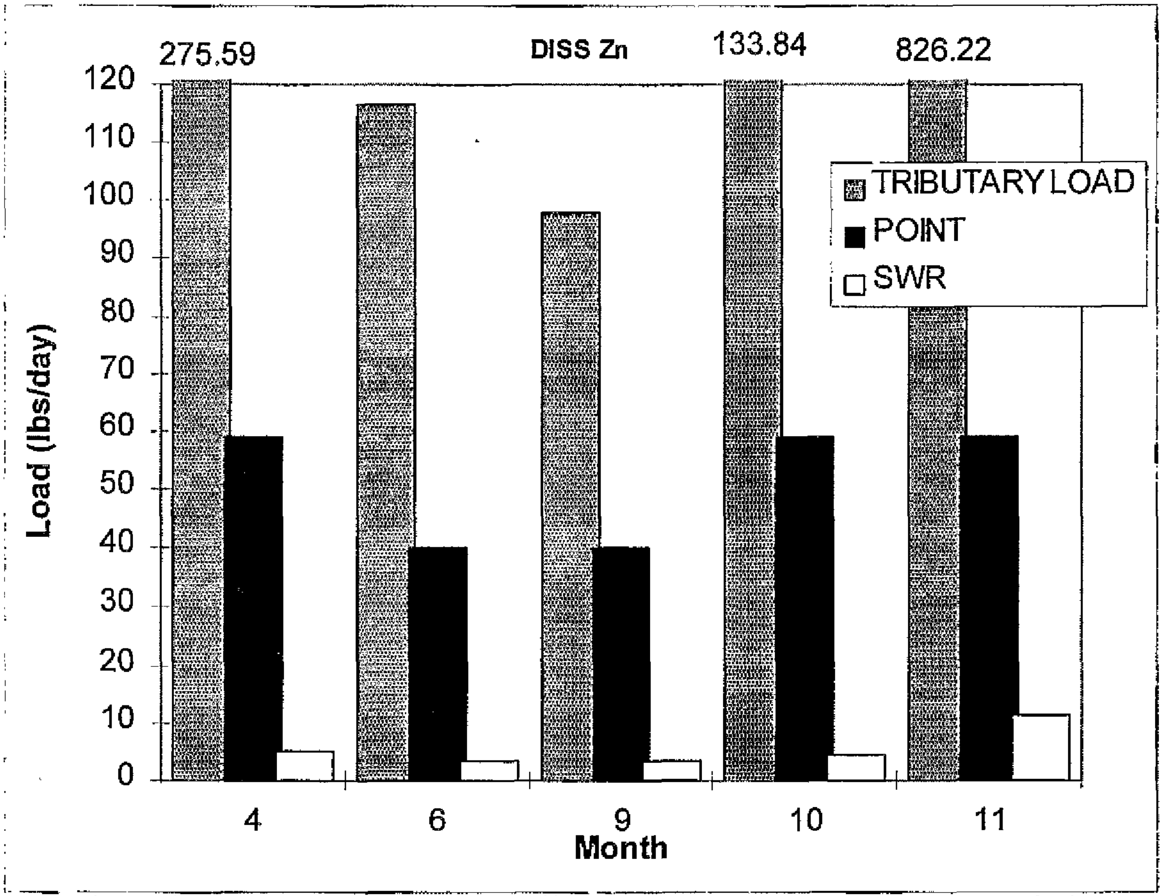


Figure 47. Dissolved Zinc; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

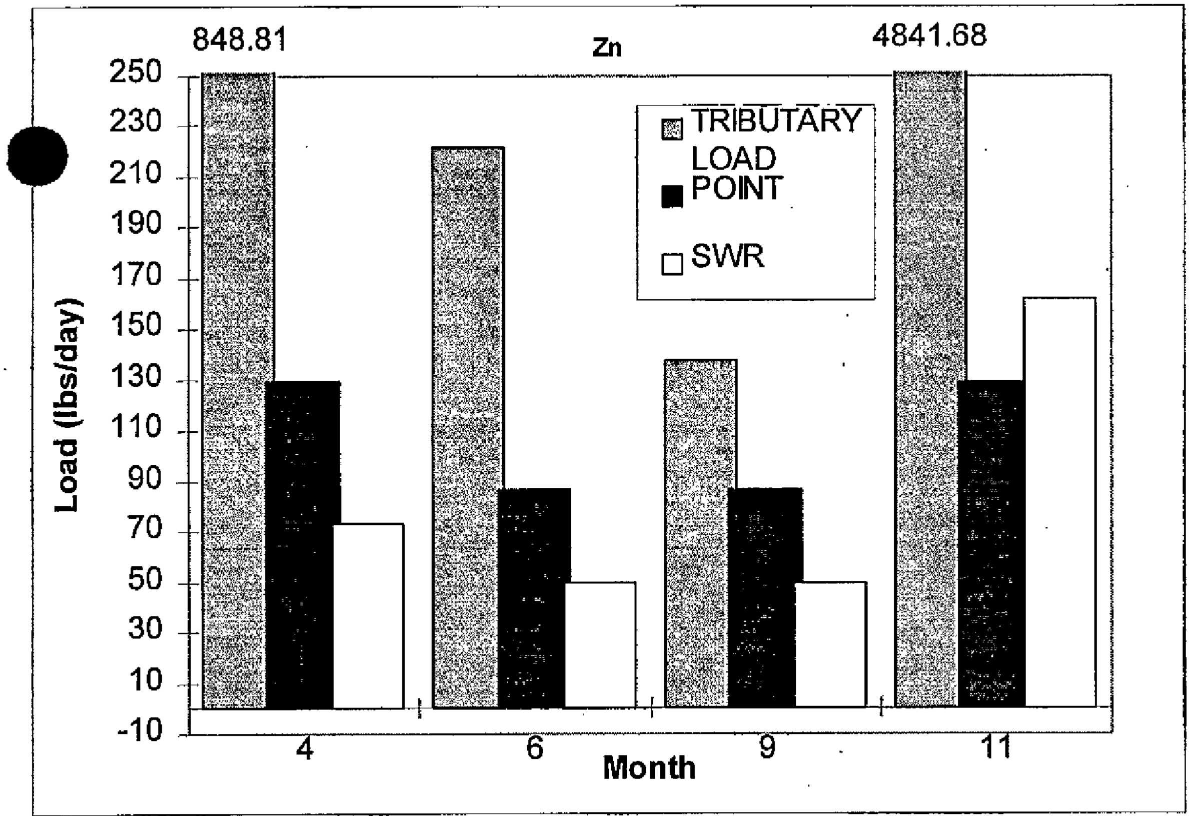


Figure 48. Total Zinc; 1994 Comparison of identified upstream NPDES point sources and urban stormwater runoff loads to the load found in Willamette River at the USGS monitoring station (RM 12.8).

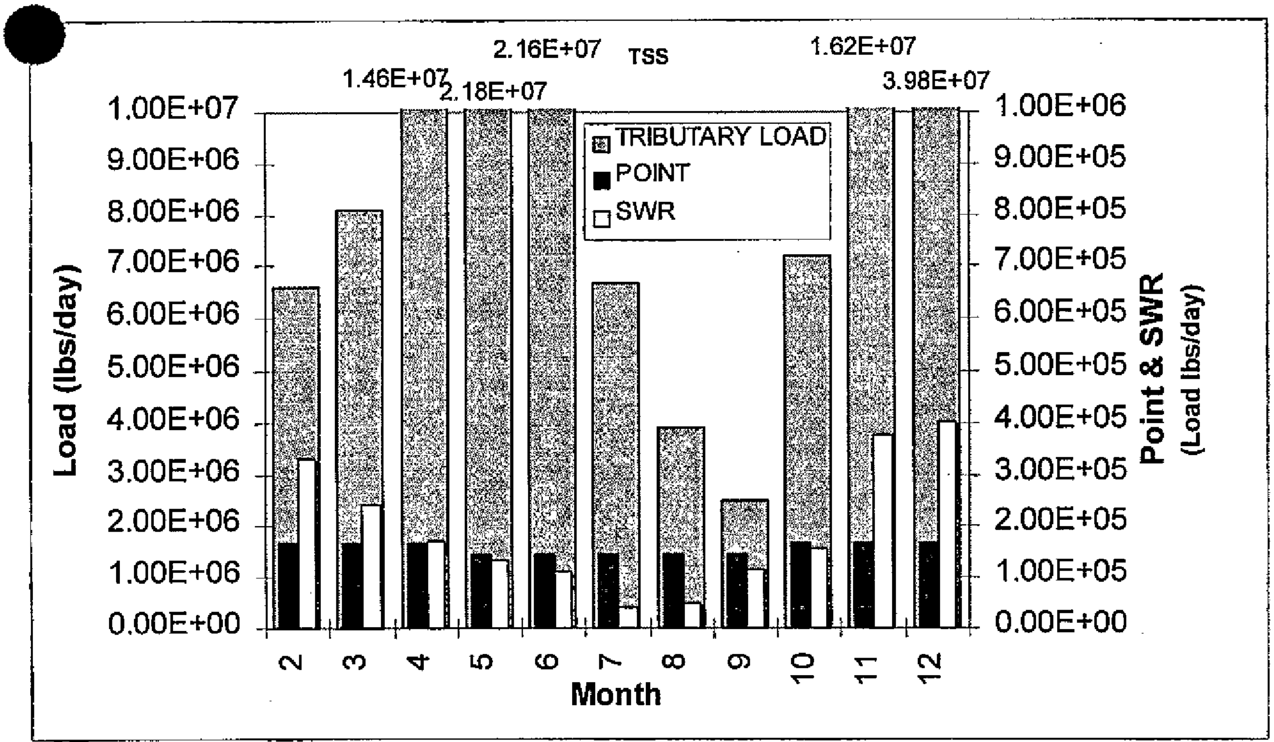


Figure 49. Total Suspended Solids; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

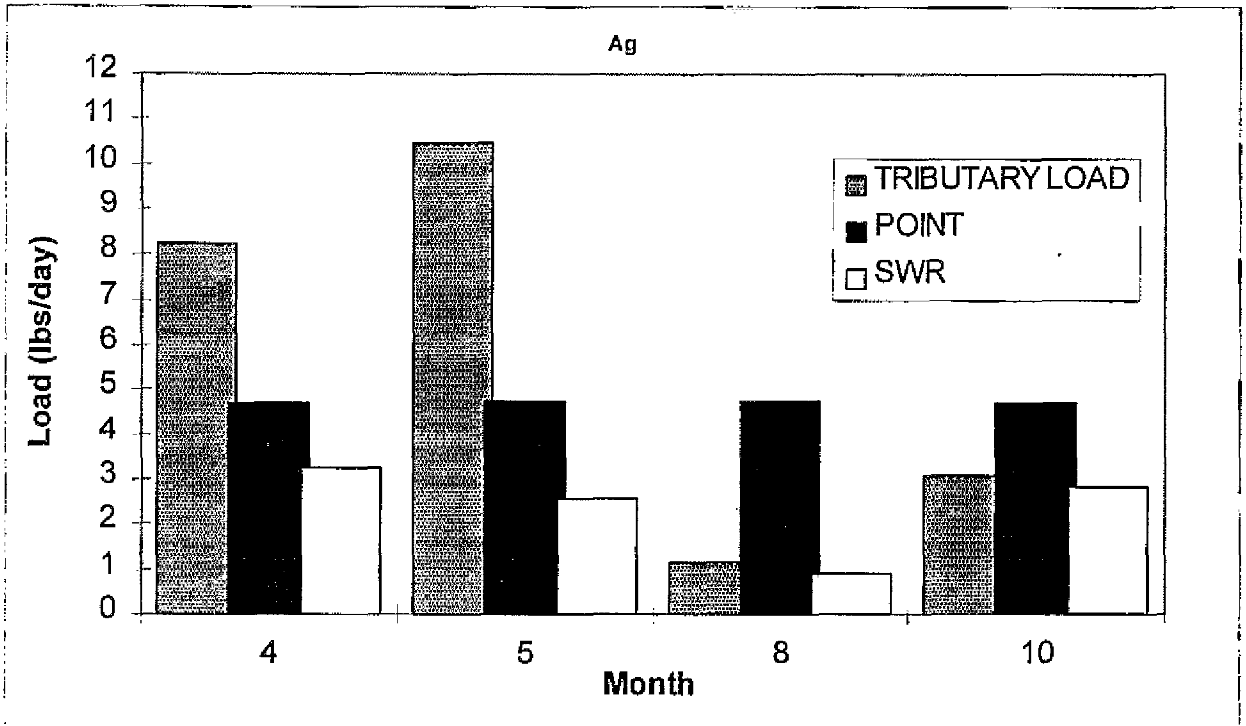


Figure 50. Total Silver; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

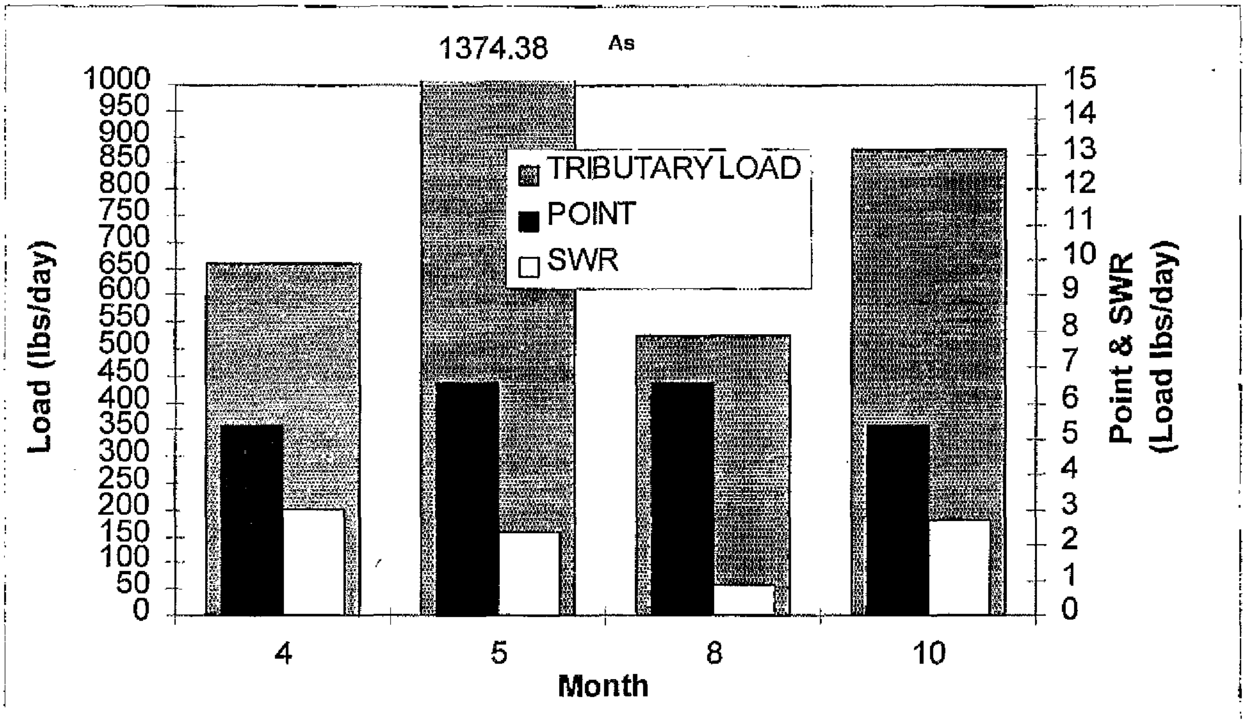


Figure 51. Total Arsenic; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

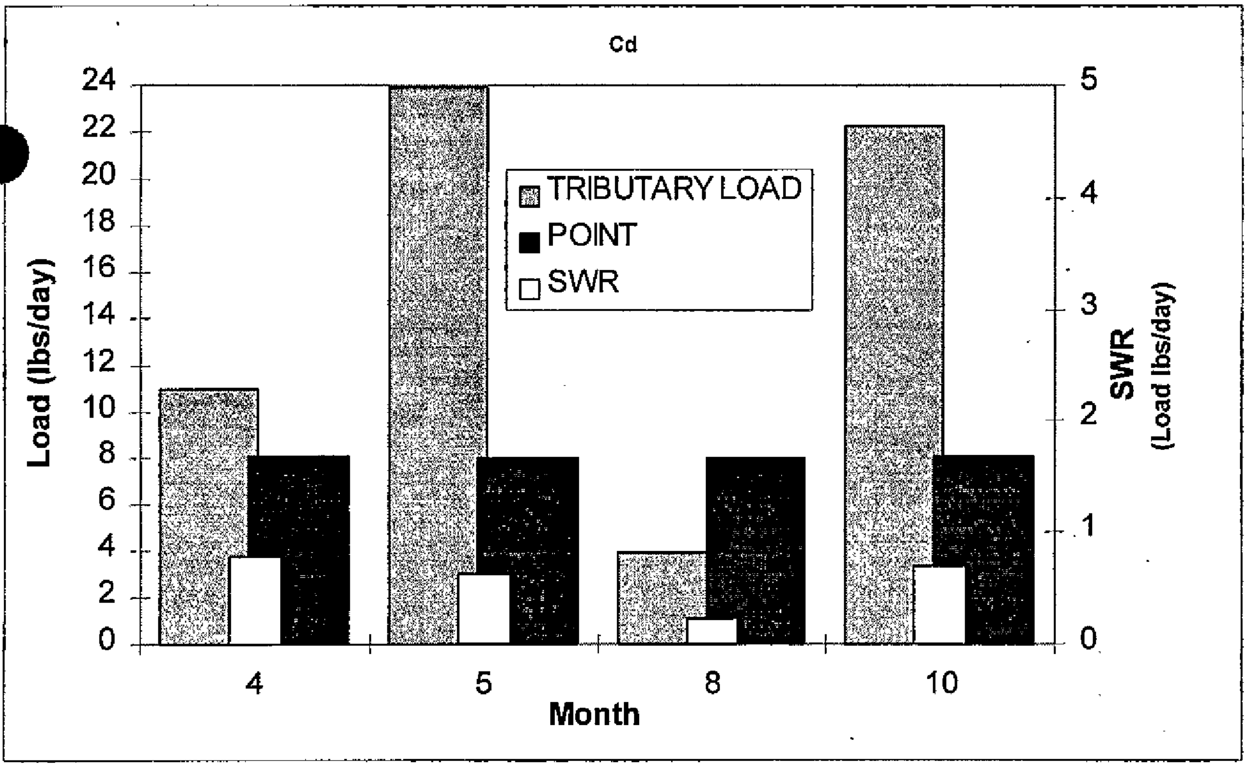


Figure 52. Total Cadmium; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

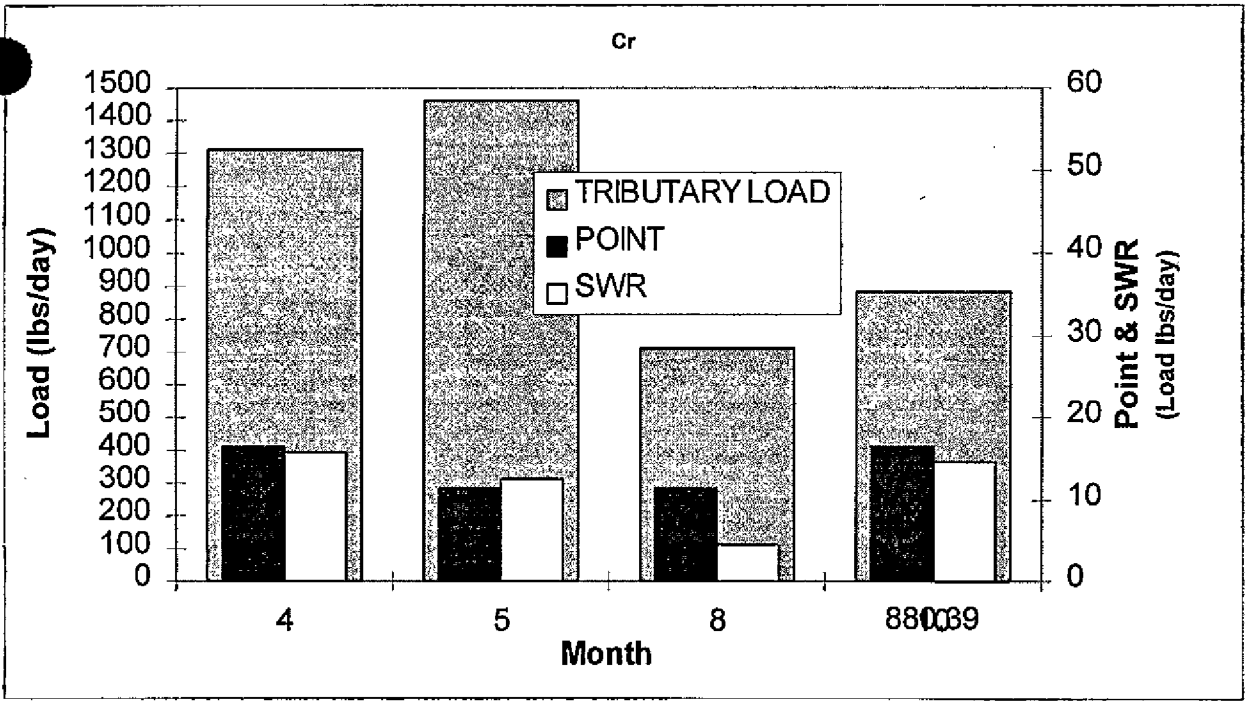


Figure 53. Total Chromium; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

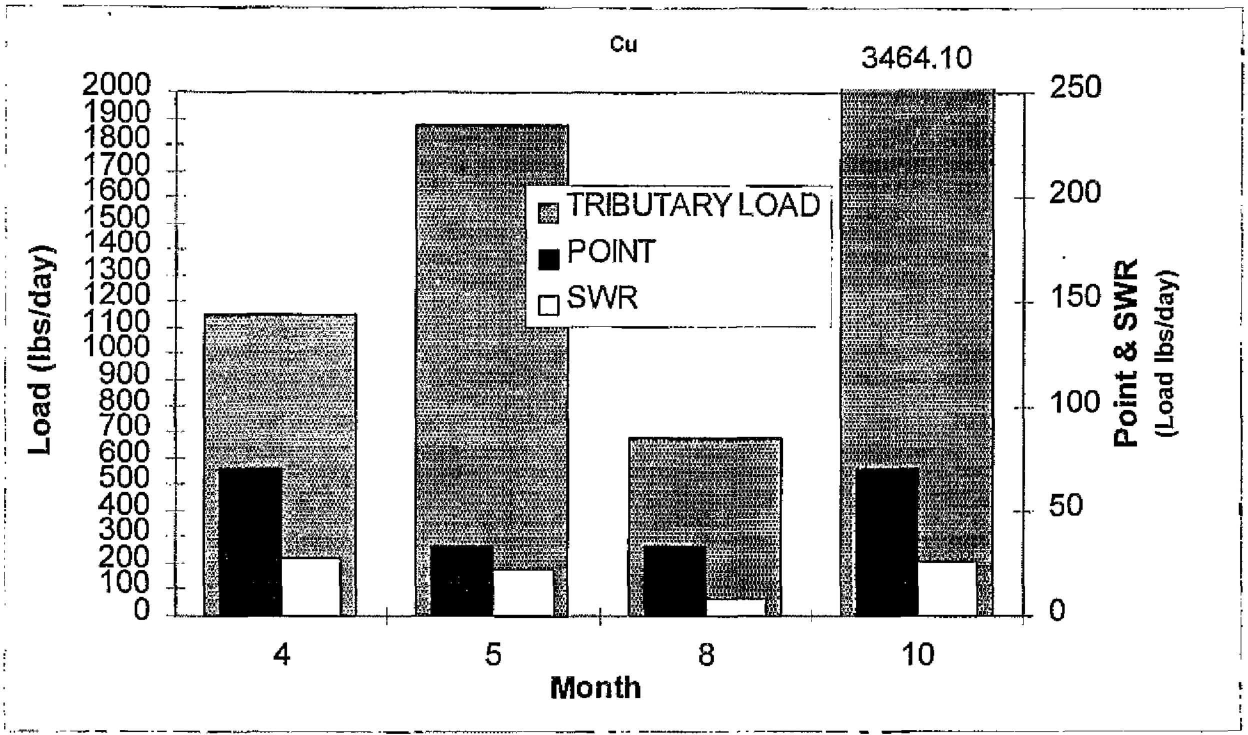


Figure 54. Total Copper; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

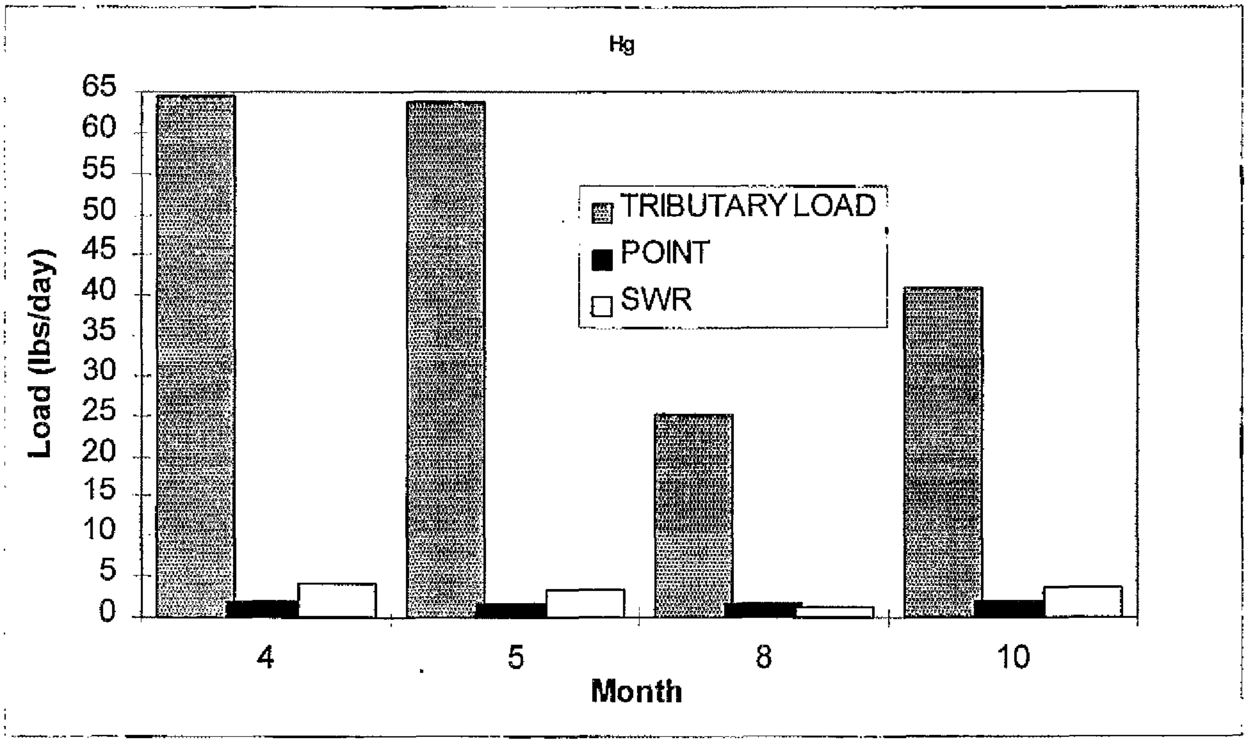


Figure 55. Total Mercury; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

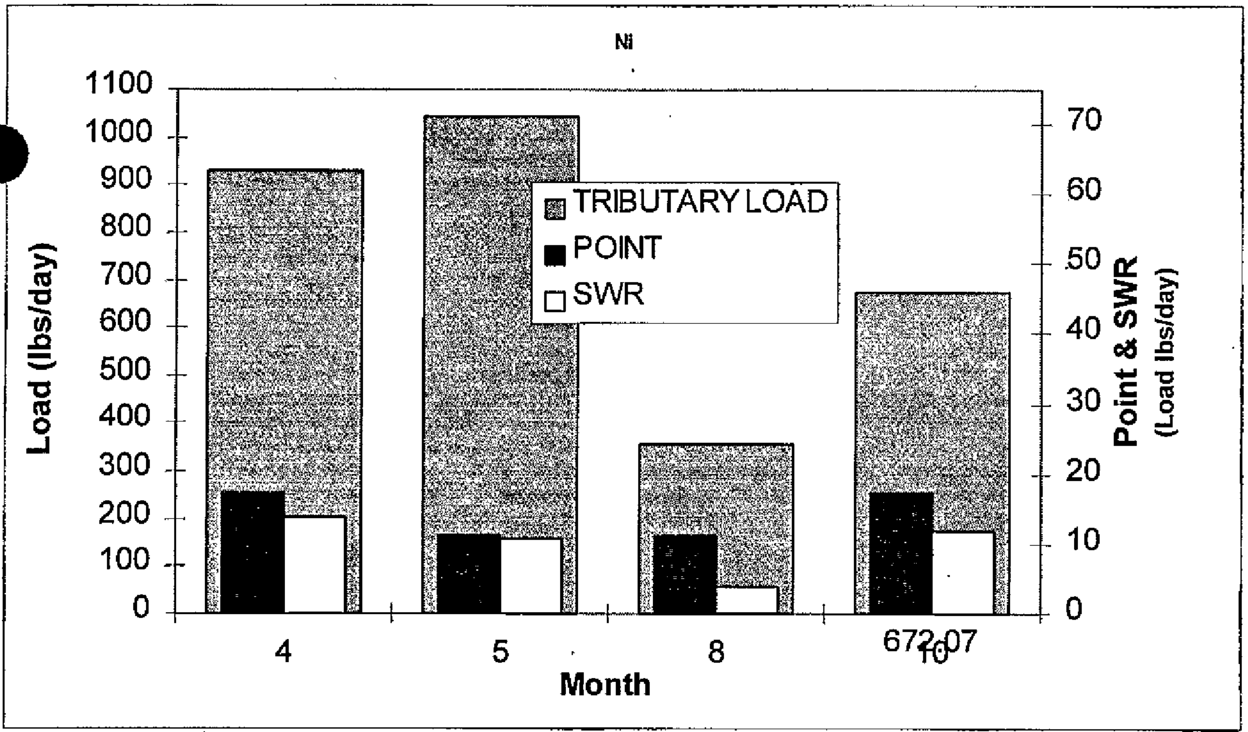


Figure 56. Total Nickel; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

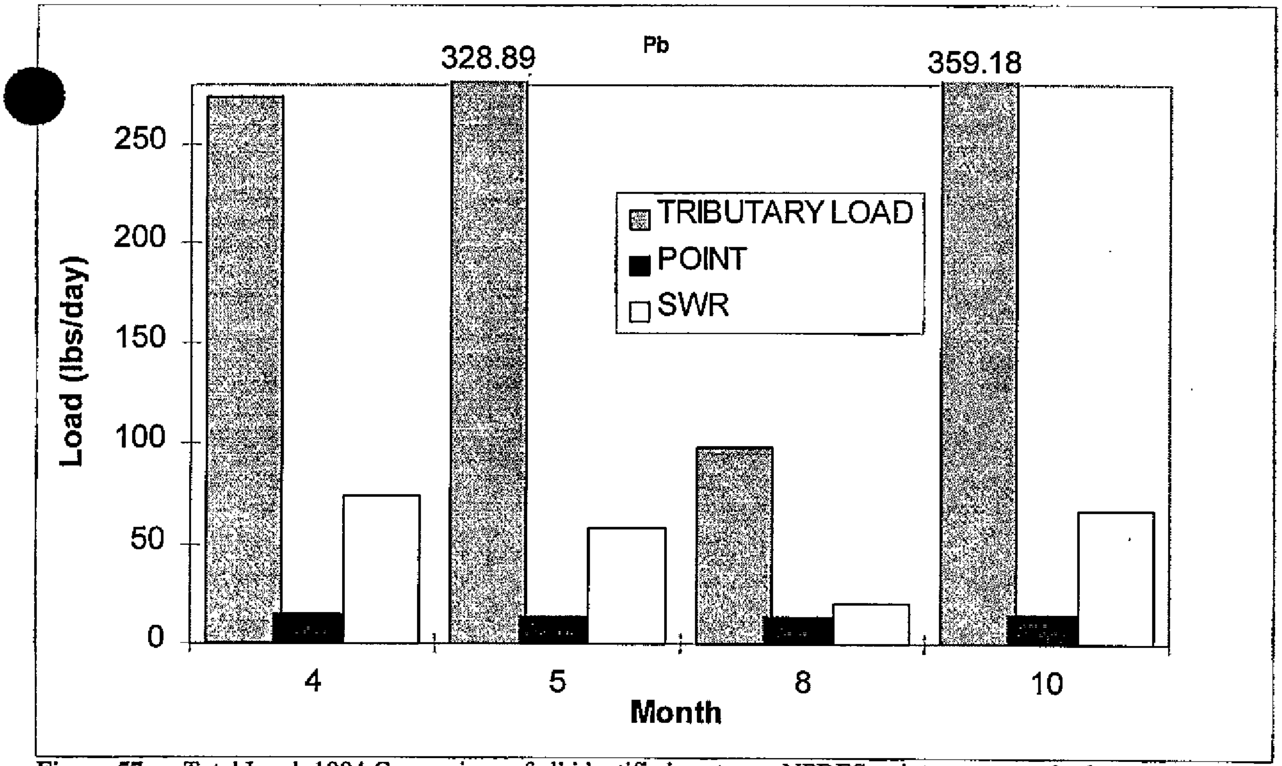


Figure 57. Total Lead; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

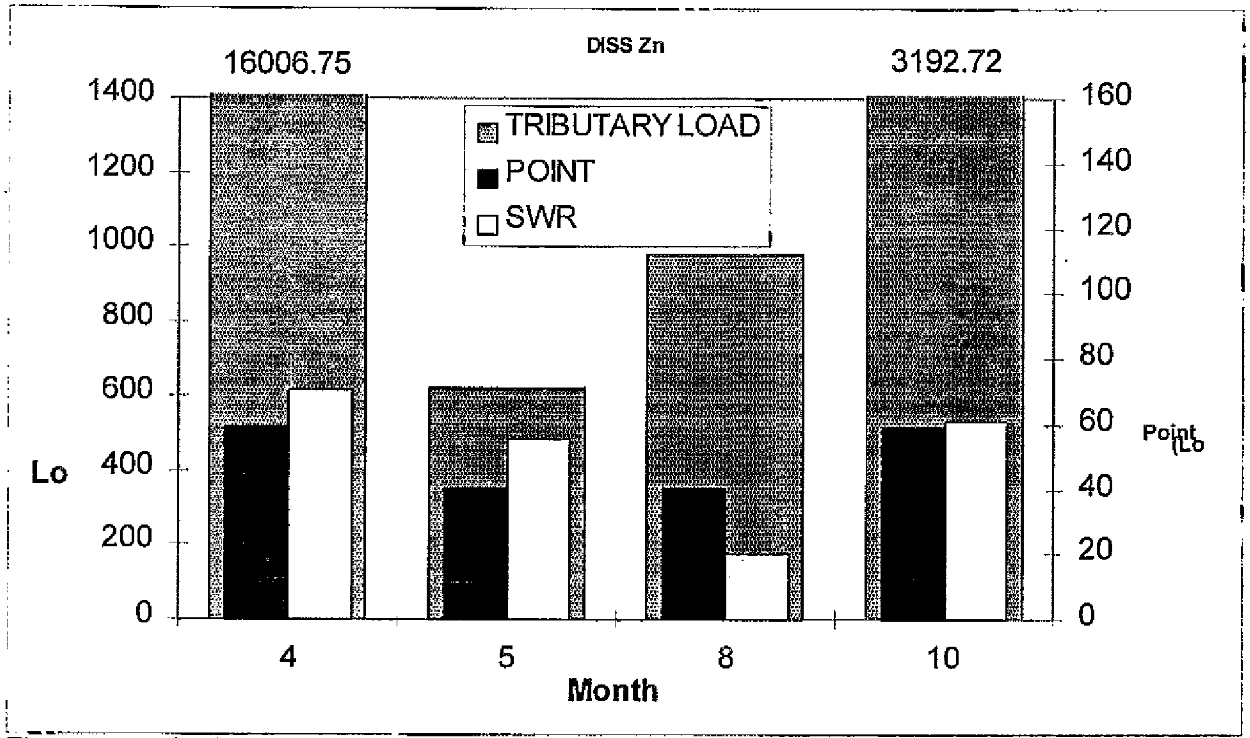


Figure 58. Dissolved Zinc; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

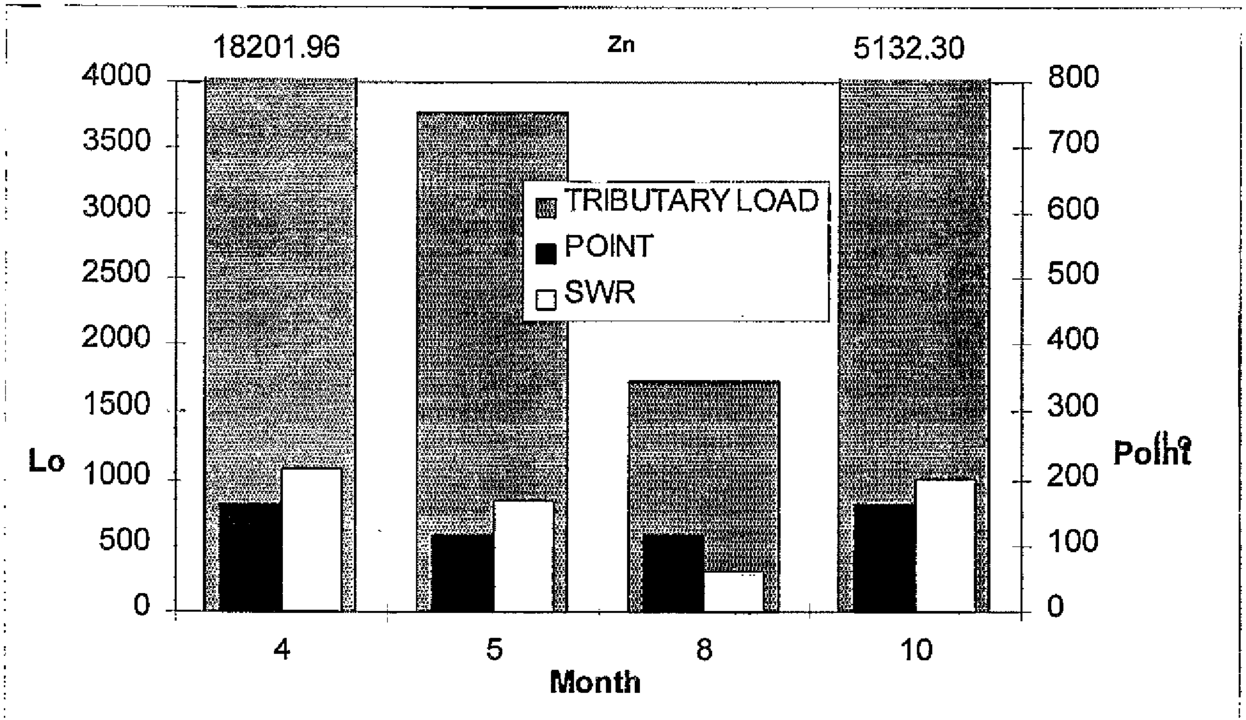


Figure 59. Total Zinc; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8).

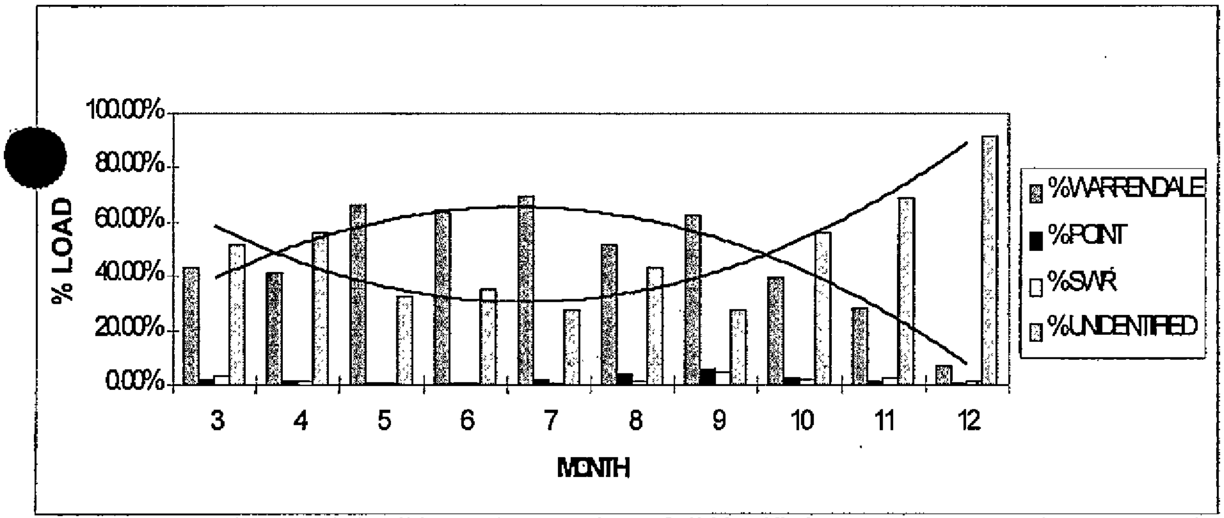


Figure 60. Total Suspended Solids; 1994 Comparison of all identified upstream NPDES point sources and urban stormwater runoff loads to the load found in the Lower Columbia River at Beaver Army Terminal USGS monitoring station (RM 53.8). Trend lines included.