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Spokane River Dissolved Metals Total Maximum Daily Load

Submittal Report

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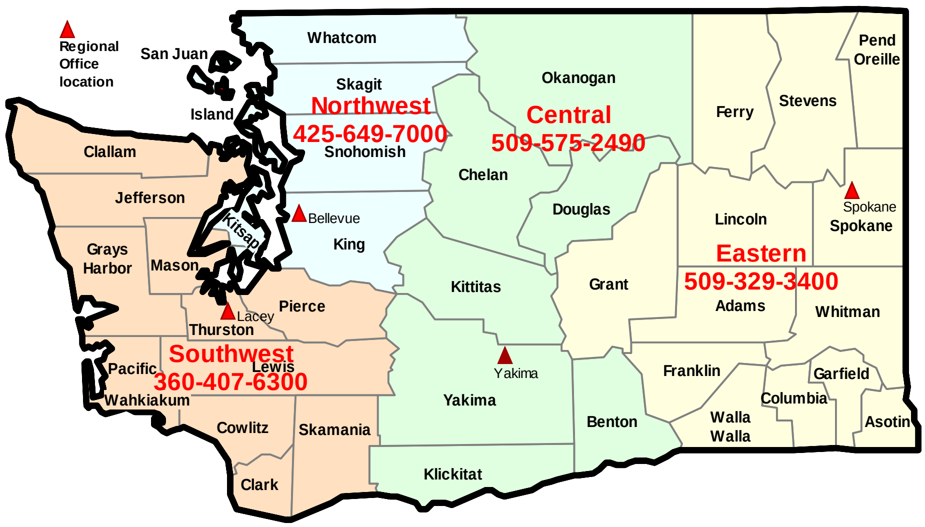

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Submittal Report

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Introduction

Section 303(d) of the federal Clean Water Act mandates that the State establish Total Maximum Daily Loads (TMDLs) for surface waters that do not meet standards after application of technology-based pollution controls. The U.S. Environmental Protection Agency (EPA) has established regulations (40 CFR 130) and developed guidance (EPA, 1991) for establishing TMDLs.

Under the Clean Water Act, every state has its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses, such as cold water biota and drinking water supply, and criteria, usually numeric criteria, to achieve those uses. When a lake, river or stream fails to meet water quality standards after application of required technology-based controls, the Clean Water Act requires that the state place the water body on a list of "impaired" water bodies and to prepare an analysis called a **Total Maximum Daily Load (TMDL)**.

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant which can be discharged to the water body and still meet standards, called the **loading capacity,** and allocates that load among the various sources. If the pollutant comes from a discrete source (referred to as a **point source**) such as an industrial facility's discharge pipe, that facility's share of the loading capacity is called a **wasteload allocation**. If it comes from a diffuse source (referred to as a **nonpoint source**) such as a farm, that facility's share is called a **load allocation**.

The TMDL must also consider seasonal variations and include a **margin of safety** that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. The sum of the individual allocations and the margin of safety must be equal to or less than the loading capacity.

The Washington State Department of Ecology (Ecology) is establishing a Total Maximum Daily Load (TMDL) for the Spokane River for dissolved cadmium, lead, and zinc. This TMDL will address impairments due to potential toxic effects on the five segments of the river listed in the 1988 Section 303(d) list of impaired surface waters.

The five elements of the Spokane River Dissolved Metals TMDL as required by the Clean Water Act are :

Loading Capacity

In the case of dissolved metals in the Spokane River, a concentration measure is appropriate because the relationship between the effluent-based criterion and the receiving water quality holds for all effluent flow rates and critical conditions in the Spokane River. The proposed concentration-based allocations assure that the in-river concentration of the metals of concern will always be further below the aquatic toxicity criterion downstream of each discharge than was present upstream.

Wasteload Allocation

The Spokane River dissolved metals waste load allocation is based on the most restrictive permit limits derived by either meeting aquatic life toxicity criteria at effluent hardness at the end-of-pipe, or based on maintaining existing concentrations of metals in effluent using performance-based limits with an added 10 percent compliance buffer. Whichever method results in the lower limit will be selected for the permit limit and established as the wasteload allocation. A minimum of ten representative low-level metals analyses will be required of dischargers where adequate metals data does not exist to develop performance-based limits.

Load Allocations

The load allocation is the concentration required to meet the chronic criterion at the outlet of Lake Coeur d'Alene. However, the concentration-based wasteload allocation approach will assure compliance with Washington State water quality standards even if the Spokane River only meets the standards at the Washington-Idaho border.

Margin of Safety

Numerous conservative assumptions were made in model development to provide an inherent margin of safety. Extreme values of either 90^{th} or 10^{th} percentile values were used to estimate critical variables in the model application. In the worst-case scenario, the highest allowable effluent concentration as derived from the end-of-pipe, aquatic life criteria method will assure that downstream metals concentrations will be further below the aquatic life criteria than present upstream of each discharge. It is anticipated that wasteload allocations using the performance-based method will, in many cases, be much less than allocations using the end-of-pipe, aquatic life criteria method, and therefore will provide a greater margin of safety.

Seasonal Variation

Water quality data on metals and hardness collected in the Spokane River show seasonal variation at the Washington-Idaho border. The metals data show increasing trends as river flows increase. Significant variation in hardness also occurs during the lower river flows when groundwater inflow significantly affects river hardness moving progressively downstream in the Spokane Valley. The modeling approach used the conservative approach for critical conditions when river hardness is low.

Background

Geographic Setting

The source of the Spokane River is Lake Coeur d'Alene located in Idaho (Figure 1). The river flows in a westerly direction from the lake, across the state boundary line, to the city of Spokane. From Spokane, the river flows in a northwesterly direction to its confluence with the Columbia River. The Spokane River is approximately 111 miles long with a watershed covering 6,580 square miles. Major tributaries to the Spokane River include the Little Spokane River and Hangman (Latah) Creek. There are six hydroelectric dams located on the Spokane River.

Forested lands comprise a majority of the land use in Washington (55%), with agriculture (33%), urban (6%) and rangeland (3%) following in areas covered. Agricultural lands lie mainly in the Lower Spokane River, Little Spokane River, and Hangman Creek watersheds. Urban land use occurs mainly in the Middle Spokane River watershed, primarily due to the location of the City of Spokane. The population of the greater Spokane is 400,000. Other urban areas include Cheney (population 7,700), Medical Lake (population 3,700), Deer Park (population 2,300), and Airway Heights (population 2,000). The Spokane Indian Tribe's reservation is located in the lower river watershed, covering 155,000 acres of land (Knight, 1998).

The Spokane River has a complex geological history (Crosby et al., 1971). The basin is composed of highly porous, poorly sorted glacial deposits. The upper and lower river substrate is composed of granitic rock cobble. From River mile 90 to 85 the substrate is composed of rocks and boulders. The river does not exhibit typical riffle-pool morphology (Bailey and Saltes, 1982). Below the river lies the Spokane-Rathdrum Aquifer, which is the sole source of drinking water for the region.

The climate in the watershed is temperate. The region lies on the edge of a rain shadow created by the Cascade Mountain Range. Annual rainfall varies from 14 inches in the lower watershed to 35 inches in the upper watershed. The precipitation near the City of Spokane is 17 inches per year. The average temperature range is 21°F to 85°F, with extreme temperatures from below minus 30°F to over 100°F (Knight, 1998).

The annual average flow in the Spokane River is approximately 6,300 cfs. The lowest 7-day average flow with a 10-year recurrence at the upstream end near Post Falls is approximately 187 cubic feet per second (cfs). The highest 7-day average flow with a 10-year recurrence is approximately 36,000 cfs. Substantial inflows of groundwater enter the river beginning downstream from the Liberty Lake outfall. These groundwater inflows significantly increase the river flow rate, especially when surface water flows are low. The total net aquifer inflows range between 500 to 800 cfs. For comparison, the combined effluent flow from all permitted discharges is about 128 cfs (Pelletier and Merrill, 1998).

Description of Pollutant Sources

Seven wastewater treatment facilities legally discharge to the river. In Idaho, EPA permits the following discharges (proceeding downstream from the river source):

- City of Coeur d'Alene Advanced Wastewater Treatment Plant
- Hayden Area Regional Sewer Board Publicly-owned Treatment Works
- City of Post Falls Publicly-owned Treatment Works

Continuing downstream, Ecology permits discharges from:

- Liberty Lake Publicly-owned Treatment Works
- Kaiser Aluminum Industrial Wastewater Treatment Plant
- Inland Empire Paper Company Industrial Wastewater Treatment Plant
- City of Spokane Advanced Wastewater Treatment Plant

Applicable Criteria

Description of the Applicable Water Quality Standards and Numeric Water Quality Target

Within The State of Washington, water quality standards are published pursuant to Chapter 90.48 of the Revised Code of Washington (RCW). Authority to adopt rules, regulations, and standards as are necessary to protect the environment is vested with the Department of Ecology. Under the federal Clean Water Act, the EPA Regional Administrator must approve the water quality standards adopted by the State (Section 303(c)(3)). Through adoption of these water quality standards, Washington has designated certain characteristic uses to be protected and the criteria necessary to protect these uses [Washington Administrative Code (WAC), Chapter 173-201A). These standards were last adopted in November 1997.

This TMDL is designed to address impairments of characteristic uses caused by toxic effects of metals. The characteristic uses designated for protection in the Spokane River are as follows:

> *"Characteristic uses. Characteristic uses shall include, but not be limited to, the following:*
>
> *(i) Water supply (domestic, industrial, agricultural).*
>
> *(ii) Stock watering.*
>
> *(iii) Fish and shellfish:*
>
> *Salmonid migration, rearing, spawning, and harvesting.*
>
> *Other fish migration, rearing, spawning, and harvesting.*
>
> *Clam and mussel rearing, spawning, and harvesting.*
>
> *Crayfish rearing, spawning, and harvesting.*
>
> *(iv) Wildlife habitat.*
>
> *(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).*
>
> *(vi) Commerce and navigation."*

[WAC 173-201A-030(2)]

The water quality standards describe criteria for metals for the protection of characteristic uses. The Spokane River TMDL establishes allocations for cadmium, lead, and zinc. The chronic and acute criteria of these metals apply to the dissolved form and are calculated using water hardness (in mg/L as $CaCO_3$) based on the following equations:

Dissolved Cadmium

Chronic ≤ (1.101672-((ln(hardness))(0.041838)))*EXP(0.7852*(ln(hardness))-3.49)*
Acute ≤ (1.136672-((ln(hardness))(0.041838)))*EXP(1.128*(ln(hardness))-3.828)*

Dissolved Lead

Chronic ≤ (1.46203-((ln(hardness))(0.145712)))*EXP(1.273*(ln(hardness))-4.705)*
Acute ≤ (1.46203-((ln(hardness))(0.145712)))*EXP(1.273*(ln(hardness))-1.46)*

Dissolved Zinc

*Chronic ≤ 0.986*EXP(0.8473*(ln(hardness))+0.7614)*
*Acute ≤ 0.978*EXP(0.8473*(ln(hardness))+0.8604)*

[WAC 173-201A-040]

Water Quality Impairments

As a result of measurements made that show criteria are exceeded, the Spokane River (representing 18 segments) is included on Washington's 1998 Section 303(d) list (Table 1).

***Table 1*.** Spokane River 1998 Section 303(d) Listed Segments

Listed Parameter	**Segment Location (Township-Range-Section)**
Cadmium	25N-46E-06
Lead	25N-42E-14, 26N-42E-20, 25N-46E-06
Zinc	25N-42E-14, 26N-42E-20, 26N-42E-33, 25N-44E-03, 25N-46E-06
PCBs*	27N-40E-22, 26N-42E-05, 26N-42E-07, 28N-37E-33
Chromium*	25N-42E-04
Arsenic*	25N-46E-06
Sediment Bioassay*	28N-37E-33, 25N-43E-01
Dissolved Oxygen*	25N-44E-06, 25N-46E-06
pH*	28N-36E-20
Temperature*	28N-36E-20
Total Phosphorus*	26N-42E-07

- not addressed in this TMDL

Seasonal Variation

Data on total recoverable cadmium, lead, zinc, and hardness collected by Ecology at the Washington-Idaho border between 1991 and 1998 were compiled and descriptive statistics generated (Table 2). Sufficient dissolved metals data of which the TMDL is based were not available to compute similar statistics. However, similar patterns are observed with total recoverable metals and are used here only for presentation. Additional information regarding the relationship of dissolved metals with flows is presented in Pelletier and Merrill (1998). The dissolved metals vary with the seasonal flows.

Water quality data on total recoverable metals collected in the Spokane River show seasonal variation at the Washington-Idaho border. The total recoverable metals data show increasing trends as river flows increase in the spring. Water quality data on hardness collected in the Spokane River do not show significant seasonal variation at the Washington-Idaho border. However, hardness in the river does exhibit a large summer variation in the lower reaches downstream of where significant groundwater contributions to the river are observed (Table 3).

Table 2. Seasonal Statistics of the Spokane River Total Recoverable Metals at Washington-Idaho Border

Time Period	**Cadmium** (µg/L)		**Lead** (µg/L)		**Zinc** (µg/L)	
	Median	Standard Deviation	Median	Standard Deviation	Median	Standard Deviation
Winter (December-February)	0.3	0.8	1.5	6.2	86.5	12.3
Spring (March-May)	0.4	0.0	3.1	6.4	89.6	10.3
Summer (June-August)	0.3	0.1	1.6	3.1	47.0	18.0
Fall (September-November)	0.2	0.1	1.2	0.7	49.0	23.7
Annual (January-December)	0.3	0.5	1.5	4.6	79.5	23.0

Table 3. Seasonal Statistics of the Spokane River Hardness (in mg/L as $CaCO_3$)

Time Period	**River Mile 100.7**		**River Mile 96.0**		**River Mile 85.3**		**River Mile 66.0**	
	Median	Standard Deviation	Median	Standard Deviation	Median	Standard Deviation	Median	Standard Deviation
Winter (December-February)	22.0	1.7	23.0	1.1	27.0	3.1	37.0	6.3
Spring (March-May)	23.0	2.2	23.0	0.6	26.0	1.6	36.0	2.3
Summer (June-August)	20.0	2.6	20.0	1.7	59.5	29.9	72.0	26.3
Fall (September-November)	21.0	2.0	20.5	0.7	37.0	3.4	58.0	6.3
Annual (January-December)	22.0	2.3	22.0	1.4	32.5	20.4	48.5	20.7

Modeling Approach

Linking Water Quality and Pollutant Sources

A mass-balance model of the Spokane River was developed to evaluate the effect of different effluent loading on metals and hardness (Pelletier and Merrill, 1998). The model includes a flow balance that accounts for inflow of water from the outlet of Lake Coeur d'Alene, inflow from permitted discharges, and flow exchanges from the aquifer and Hangman Creek. The model application assumed that Lake Coeur d'Alene outflow met Washington State water quality standards with a hardness of 20 mg/L as $CaCO_3$ and wastewater discharges met aquatic life toxicity criteria end-of-pipe ate effluent hardness. The model divides the river into 14 reaches from Lake Coeur d'Alene to near the headwaters of Long Lake (RM 64.6).

Calibration of the model to actual conditions in the river involved estimation of aquifer hardness and metals to match observed concentrations in the river. All other inputs in the flow and mass balance equations were directly estimated from available data. Relationships between hardness, metals, and flow are known at various locations in the river based on long-term ambient monitoring data. The model was calibrated for hardness by starting with the known upstream hardness and adjusting the groundwater hardness to equate predictions with observed values. After the hardness was calibrated, the same approach was used to estimate the dissolved cadmium, lead, and zinc of the inflows.

The calibrated mass-balance model was used to estimate concentrations of metals in the river for a variety of river flows and effluent flows. The model was used to evaluate whether water quality standards would be violated in the river assuming the river met Washington State water quality standards when it leaves Lake Coeur d'Alene and the effluent met aquatic life criteria-based limits at the point of discharge based on effluent hardness. The model results show that standards would be met for cadmium and zinc. The standards for lead would be met if the maximum concentration of total recoverable lead in the effluent does not exceed the value predicted from the extrapolated tangent line of the chronic criterion equation.

Loading Capacity

Identification of the loading capacity is an important step in developing TMDLs. The loading capacity is the amount of pollutant a water body can receive and still meet water quality standards. By definition, a TMDL is the sum of the allocations. An allocation is defined as the portion of a receiving water's loading capacity that is assigned to a particular source. EPA defines the loading capacity as "the greatest amount of loading that a water can receive without violating water quality standards."

The hardness of the wastewater effluent from the various discharges is significantly higher than the hardness of the Spokane River. The metals criteria for protection of aquatic life are based on hardness, because the toxicity of metals decreases as hardness increases. Thus, as the Spokane River flows downstream, its loading capacity for metals increases due to inflow of harder water.

The Spokane River Metals TMDL utilizes a different measure than *"daily loads"* to fulfill requirements of Section 303(d). Instead, the TMDL is expressed in terms of concentration as allowed under EPA regulations [defined as *"other appropriate measures"* in 40 CFR §130.2(i)]. In this case, a concentration measure is appropriate because the relationship between the effluent hardness-based criterion and the receiving water quality holds for all river and effluent flow rates. The use of effluent flow to establish a loading limit would not only be unnecessary, but also could be misconstrued to represent a restriction on effluent flow. Also, a loading limit could require unnecessary TMDL and permit modifications to change loading limits as communities grow and flows increase.

Load and Waste Load Allocations

Cadmium, lead, and zinc concentrations in the Spokane River at the state line often exceed water quality standards. EPA and Idaho Department of Environmental Quality are developing a TMDL to control pollution sources in Idaho. One of the necessary objectives of the work is to meet Washington's water quality standards in the Spokane River. The load allocation is the concentration required to meet the chronic criterion at the outlet of Lake Coeur d'Alene. The wasteload allocations in Washington assure compliance with Washington State water quality standards if the criteria are met only at the Washington-Idaho border

The waste load allocation is based on the most restrictive permit limits based on the comparison of:

- Potential limits based on meeting aquatic life criteria at effluent hardness, or
- Potential limits, plus 10%, based on maintaining existing concentrations of metals in effluent, where adequate data exist.

Whichever method results in the lower limit is established as the waste load allocation.

Margin of Safety

The statute requires that a margin of safety be identified to account for uncertainty when establishing a TMDL. The margin of safety can be explicit in the form of an allocation, or implicit in the use of conservative assumptions in the analysis. Several assumptions and critical conditions used in the modeling analysis of the Spokane River TMDL provide an inherent margin of safety as required by the statute. These conservative assumptions and critical conditions are listed below:

- Effluent hardness was assumed to be the 10^{th} percentile hardness as measured at the Spokane Advanced Wastewater Treatment Plant

- Effluent hardness was assumed to be a lower value based on a mixture of river and groundwater used for production proposes at the Kaiser Industrial Wastewater Treatment Plant.

- Effluent total recoverable metal concentrations were assumed to be approximate maximum values reported.

- The hardness for the outflow for Lake Coeur d'Alene was assumed to be the seasonal 10^{th} percentile for the low flow and high flow periods, and the 5^{th} percentile from all seasons.

- The hardness in the river was assumed to equal the 10% prediction limits from the regression equations with flow.

- The dissolved metals were assumed to equal the 90% prediction limits from the regressions with flow.

Summary Implementation Strategy

The success of the TMDL largely relies on controlling the upstream sources in Idaho so that the toxicity criteria of Washington's Water Quality Standards for Surface Water (WAC 173-201 A) are met at the Washington/Idaho border. Effluent limits will be placed in all NPDES permits for direct discharge to the Spokane River where adequate low-level effluent data exist.

Monitoring Plan for TMDLs Developed Under the Phased Approach

EPA (1991) guidance calls for a monitoring plan for TMDLs where implementation will be phased in over time. The monitoring is conducted to provide assurance that the control measures achieve the expected load reductions. All Spokane River NPDES discharge permits in Washington, which do not currently have adequate metals monitoring, will be opened and monthly monitoring will be added by the end of 1999, which will follow appropriate clean sampling protocols and EPA 1600-series analytical methods for total recoverable. Quarterly dissolved metals monitoring should also be included if source-specific effluent dissolved/total recoverable metals ratios are to be determined.

Reasonable Assurances

All Spokane River dischargers will have the TMDL-based limits placed in their permits within 2½ years from the initiation of monthly low level monitoring. Monitoring requirements have already been placed in the Liberty Lake Sewer District permit and effluent metals limits will be put into City of Spokane's permit which is now targeted to be issued in June 1999.

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Figures

Appendix A

Public Participation Materials

Appendix B

<u>Responses to Comments Received</u>

Appendix C

Quality Assurance Project Plan

Appendix D

Technical Report

Bound Separately as Ecology Publication No. 98-329