Upper Arkansas River Basin: segments 14, 26
Middle Arkansas River Basin: segments 4, 13, 18
Fountain Creek Basin: segments 3a, 8
Lower Arkansas River Basin: segments 2, 6b, 13
Cimarron River Basin: segment 1

- Basin 3.3.0
  - Blue River Basin (14010002): segments 5, 20
  - Eagle River Basin (14010003): segment 11
  - North Platte River Basin (1018001, 10180002): segment 7
  - Yampa River Basin (14050001, 14050002): segment 12
- Basin 3.4.0
  - San Juan River Basin: segments 3, 10, 11
  - Piedra River Basin: segment 6
  - Los Pinos River Basin: segment 6
  - Animas and Florida River Basin: segment 13b
  - La Plata River, Mancos River, McElmo Creek and San Juan River Basin in Montezuma County and Dolores Counties: segments 3, 6, 8
  - Dolores River Basin: segment 11
- Basin 3.5.0
  - Upper Gunnison River Basin: segments 6b, 16, 28, 32
  - North Fork of the Gunnison River Basin: segment 6, 10
  - Upcomphgre River Basin: segments 10, 12.
  - Lower Gunnison River Basin: segment 4
  - San Miguel River Basin: segment 12
  - Lower Dolores River Basin: segment 4
- Basin 3.6.0
  - Rio Grande River Basin: segments 15b, 25
  - Closed Basin—San Luis Valley: segment 3
- Basin 3.7.0
  - Lower Yampa River/Green River Basin: segments 3a, 3b, 6, 14, 17, 20
  - White River Basin: segments 5, 9, 13a, 22
  - Lower Colorado River Basin: segments 11b, 11e, 13
- Basin 3.8.0
  - Republican River Basin: segments 6, 7
  - South Platte River Basin (Region 1): segment 2
  - Cache La Poudre River Basin: segments 8, 13
  - Big Thompson River Basin: segments 6, 10
  - South Platte River Basin (Region 2): segment 3
  - St. Vrain Creek Basin: segment 6
  - Boulder Creek Basin: segments 8, 11
  - Big Dry Creek Basin: segment 1
  - Clear Creek Basin: segments 8, 16, 18
  - Cherry Creek Basin: segment 4
  - South Platte River Basin (Regions 2, 3, 4): segments 7a, 11a, 16
  - South Platte River Basin (Region 3 and 4): segment 7

2. The criteria in: Column B(I)—#9; Column B(II)—#9 are assigned to the following specific segments:

- Basin 3.3.0
  - Blue River Basin (14010002): segment 12
- Basin 3.4.0
  - Animas and Florida River Basin: segment 15
  - La Plata River, Mancos River, McElmo Creek and San Juan River Basin in Montezuma County and Dolores Counties: segment 9
- Basin 3.8.0
  - Big Thompson River Basin: segment 13
  - Boulder Creek Basin: segments 4c, 6
  - Clear Creek Basin: segment 12
  - Bear Creek Basin: segments 4a, 5
  - South Platte River Basin (Region 2, 3, and 4): segment 7b

3. The criteria in: Column B(I)—#8; Column B(II)—#8 are assigned to the following specific segments:

- Basin 3.7.0—Lower Colorado River Basin: segment 4
- Basin 3.8.0—South Platte River Basin (Region 2, 3, and 4): segment 11b

4. The criteria in: Column B(I)—#14; Column B(II)—#14 are assigned to the following specific segment:

- Basin 3.2.0—Upper Arkansas River Basin: segment 8b

5. The criterion in: Column B(I)—#11 is assigned to the following specific segment:

- Basin 3.7.0—Lower Colorado River Basin: segment 4.

(15) *Arizona, Region 9*

(i) All waters assigned the use classifications in chapter 21 of the Arizona Administrative Code (AAC) which are referred to in paragraph (d)(15)(ii) of this section, are subject to the criteria in paragraph (d)(15)(ii) of this section, without exception. These criteria amend the existing State standards contained in chapter 21 of the AAC sections R9–21–101 through 304, Water Quality Standards for Waters of the State, for the toxic pollutants identified in paragraph (d)(15)(ii) of this section. For purposes of this action, the specific standards to be applied are based on the following selected use designations as defined in chapter 21, AAC §§ R9–21–101 through R9–21–304:

(A) DWS—Domestic Water Source
(B) A&W—Aquatic & Wildlife (including any aquatic life designation)

(ii) The following criteria from the matrix in paragraph (b) of this section apply to the water and use classifications defined in paragraph (d)(15)(i) of this section and identified below:

Water and use classification	Applicable criteria
Waters of the State with A&W but without DWS.	These waters are assigned the criteria in: Column B1—all pollutants. Column B2—all pollutants. Column D2—all pollutants.
Waters of the State with A&W and DWS.	These waters are assigned the criteria in: Column B1—all pollutants. Column B2—all pollutants. Column D1—all pollutants.
Waters of the State with DWS but without A&W.	These waters are assigned the criteria in: Column D1—all pollutants.

(16) *California, Region 9*

(i) All waters assigned any aquatic life or human health use classifications in the Water Quality Control Plans for the various Basins of the State ("Basin Plans"), as amended, adopted by the California State Water Resources Control Board ("SWRCB"), except for ocean waters covered by the Water Quality Control Plan for Ocean Waters of California ("Ocean Plan") adopted by the SWRCB with resolution Number 90–27 on March 22, 1990, are subject to the criteria in paragraph (d)(16)(ii) of this section, without exception. These criteria amend the portions of the existing State standards contained in the Basin Plans. More particularly these criteria amend water quality criteria contained in the Basin Plan Chapters specifying water quality objectives (the State equivalent of federal water quality criteria) for the toxic pollutants identified in paragraph (d)(16)(ii) of this section. Although the State has adopted several use designations for each of these waters, for purposes of this action, the specific standards to be applied in paragraph (d)(16)(ii) of this section are based on the presence in all waters of some aquatic life designation and the presence or absence of the MUN use designation (Municipal and domestic supply). (See Basin Plans for more detailed use definitions).

(ii) The following criteria from the matrix in paragraph (b) of this section apply to the water & use classifications defined in paragraph (d)(16)(i) of this section and identified below:

Water and use classification	Applicable criteria
Waters of the state defined as bays or estuaries except the Sacramento-San Joaquin Delta and San Francisco Bay.	These waters are assigned the criteria in: Column B1—all pollutants. Column B2—all pollutants. Column C1—all pollutants. Column C2—all pollutants. Column D2—all pollutants

Water and use classification	Applicable criteria
Waters of the Sacramento-San Joaquin Delta and waters of the state defined as inland (i.e., all surface waters of the state not bays or estuaries or ocean) that include a MUN use designation except the San Joaquin River from the mouth of the Merced River to Vernalis and the Sacramento River and its tributaries upstream from Hamilton City.	These waters are assigned the criteria in: Column B1—all pollutants. Column B2—all pollutants. Column D1—all pollutants.
Waters of the state defined as inland without an MUN use designation except waters flowing to Grasslands Water District, San Luis National Wildlife Refuge and Los Banos State Wildlife Area.	These waters are assigned the criteria in: Column B1—all pollutants. Column B2—all pollutants. Column D2—all pollutants.
Waters of the San Joaquin River from the mouth of the Merced River to Vernalis.	These waters are assigned the criteria in: Column B1—all pollutants except #10. Column B2—all pollutants. Column D1—all pollutants except #10.
Waters of the Sacramento River and its tributaries upstream from Hamilton City.	These wates are assigned the criteria in: Column B1—all pollutants except #4, 6, 13. Column B2—all pollutants except #4, 6, 13. Column D1—all pollutants except #4.
Waters flowing to Grasslands Water District, San Luis National Wildlife Refuge, and Los Banos State Wildlife Area.	These waters are assigned the criteria in: Column B1—all pollutants. Column B2—all pollutants. Column D2—all pollutants except #10.
Waters of San Francisco Bay.	These waters are assigned the criteria in: Column B1—all pollutants. Column B2—all pollutants. Column C1—all pollutants except #10. Column C2—all pollutants except #10. Column D2—all pollutants.

(17) *Nevada, Region 9*

(i) All waters assigned the use classifications in chapter 445 of the Nevada Administrative Code (NAC), Nevada Water Pollution Control Regulations, which are referred to in paragraph (d)(17)(ii), of this section, are subject to the criteria in paragraph (d)(17)(ii) of this section, without exception. These criteria amend the existing State standards contained in the Nevada Water Pollution Control Regulations. More particularly, these criteria amend or supplement the table of numeric standards in NAC 445.1339 for the toxic pollutants identified in paragraph (d)(17)(ii) of this section.

(ii) The following criteria from the matrix in paragraph (b) of this section apply to the waters defined in paragraph (d)(16)(i) of this section and identified below:

Water and use classification	Applicable criteria
Waters that the State has included in NAC 445.1339 where municipal or domestic supply is a designated use.	These waters are assigned the criteria in: Column B1—pollutant #118. Column B2—pollutant #118. Column D1—pollutants 15, 16, 18, 19, 20, 21, 23, 26, 27, 29, 30, 34, 35, 36, 37, 38, 42, 43, 55, 57-64, 66, 73, 74, 78, 82, 85, 87-89, 91, 92, 96, 98-100, 103, 104, 105, 114, 116, 117, 118.
Waters that the State has included in NAC 445.1339 where municipal or domestic supply is not a designated use.	These waters are assigned the criteria in: Column B1—pollutant #118. Column B2—pollutant #118. Column D2—all pollutants except #2.

(18) *Hawaii, Region 9*

(i) All waters assigned the use classifications in the existing State standards ("State Standards") which are referred to in paragraph (d)(18)(ii) of this section, are subject to the criteria in paragraph (d)(18)(ii) of this section, without exception. These criteria amend the existing State standards. Specifically, these criteria supplement the table of numeric standards for toxic pollutants applicable to all of Hawaii's waters in section 11-54-04(b)(3).

(ii) The following criteria from the matrix in paragraph (b) of this section apply to the waters defined in paragraph (d)(18)(i) of this section and identified below:

Water and use classification	Applicable criteria
Waters of the State assigned to Classes AA, A, 1, and 2.	These waters are assigned the criteria in: Column D2—pollutants #3, 8.
Waters of the State assigned to Classes AA and A.	These waters are assigned criteria in: Column C1—pollutant #6. Column C2—pollutants #6, 7, 8.

(19) *Commonwealth of the Northern Mariana Islands, Region 9*

(i) All waters assigned the use classifications in the existing Commonwealth of the Northern Mariana Islands Marine and Fresh Water Quality Standards ("Standards") which are referred to in paragraph (d)(19)(ii) of this section, are subject to the criteria in paragraph (d)(19)(ii) of this section, without exception. These criteria amend the existing standards. Specifically, these criteria supplement the table of numeric standards in part 7.10 of the Standards.

(ii) The following criteria from the matrix in paragraph (b) of this section apply to the waters defined in paragraph (d)(19)(i) of this section and identified below:

Water and use classification	Applicable criteria
Fresh surface waters of the Commonwealth assigned to classes 1 and 2.	These waters are assigned the criteria in: Column D1—all pollutants. Column B1—pollutants #53, 108, 118. Column B2—pollutants #53, 108, 118.
Marine waters of the Commonwealth to classes AA and A..	These waters are assigned the criteria in: Column D2—all pollutants. Column C1—pollutants #53, 108, 118. Column C2—pollutants #53, 108, 118.

(20) *Alaska, Region 10*

(i) All waters assigned to the following use classifications in the Alaska Administrative Code (AAC), chapter 18 (i.e., identified in 18 AAC 70.020) are subject to the criteria in paragraph(d)(20)(ii) of this section, without exception:

70.020.(1)(A)	Fresh water. Water supply. (i) Drinking, culinary, and food processing, (ii) Aquaculture;
70.020.(1)(B)	Water recreation. (i) Contact recreation, (ii) Secondary recreation;
70.020.(1)(C)	Growth and propagation of fish, shellfish, other aquatic life, and wildlife.

70.020.(2)(A)	Marine water. Water supply. (i) Aquaculture, (ii) Seafood processing,
70.020.(2)(B)	Water recreation. (i) Contact recreation, (ii) Secondary recreation;
70.020.(2)(C)	Growth and propagation of fish, shellfish, other aquatic life, and wildlife;
70.020.(2)(D)	Harvesting for consumption of raw mollusks or other raw aquatic life.

(ii) The following criteria from the matrix in paragraph (b) of this section apply to the use classifications identified in paragraph (d)(20)(i) of this section:

Use classification	Applicable criteria
(1)(A)i	This classification is assigned the criteria in: Column D(I)—#'s 9, 10, 53. Column D(I)—human health carcinogens: #'s 2, 3, 16, 18, 19, 20, 21, 23, 26, 27, 29, 30, 35, 36, 37, 42, 43, 44, 55, 57-64, 66, 68, 73, 74, 78, 82, 85, 87, 88, 89, 91, 92, 96, 97, 98, 99, 100, 102-111, 117-126.
(1)(A)iii	This classification is assigned the criteria in: Same as for (1)(A)i (above) plus: Column B(I)—all. Column B(II)—#'s 9, 10, 13, 53.
(1)(B)i	This classification is assigned the criteria in: Same as for (1)(A)i above.
(1)(B)ii	This classification is assigned the criteria in: Column B(I)—all. Column B(II)—#'s 9, 10, 13, 53. Column D(II)—#'s 9, 10, 53. Column D(II) human health carcinogens: #'s 2, 3, 16, 18, 19, 20, 21, 23, 26, 27, 29, 30, 35, 36, 37, 42, 43, 44, 55, 57-64, 66, 68, 73, 74, 78, 82, 85, 87, 88, 89, 91, 92, 96, 97, 98, 99, 100, 102-111, 117-126
(1)(C) This classification is assigned the criteria in:. Same as for (1)(B)(ii).	
(2)(A)i	This classification is assigned the criteria in: Column C(I)—all. Column C(II)—#'s 9, 10, 13, 53. Column D(II)—#'s 9, 10, 53. Column D(II)—human health carcinogens: #'s 2, 3, 16, 18, 19, 20, 21, 23, 26, 27, 29, 30, 35, 36, 37, 42, 43, 44, 55, 57-64, 66, 68, 73, 74, 78, 82, 85, 87, 88, 89, 91, 92, 96, 97, 98, 99, 100, 102-111, 117-126
(2)(A)i	This classification is assigned the criteria in: Column C(I)—all. Column C(II)—only for #'s 9, 10, 13, 53.
(2)(B)i & ii	These classifications are assigned the criteria in: Column D(II) for #'s 9, 10, 53. Column D(II)—human health carcinogens: #'s 2, 3, 16, 18, 19, 20, 21, 23, 26, 27, 29, 30, 35, 36, 37, 42, 43, 44, 55, 57-64, 66, 68, 73, 74, 78, 82, 85, 87, 88, 89, 91, 92, 96, 97, 98, 99, 100, 102-111, 117-126.
(2)(C) and (2)(D)	These classifications are assigned the criteria in: Same as for (2)(A)i.

(21) *Idaho, Region 10*

(i) All waters assigned to the following use classifications in the Idaho Administrative Procedures Act (IDAPA), chapter 16 (i.e., identified in IDAPA 16.01.2100,02-16.01.2100,07) are subject to the criteria in paragraph (d)(21)(ii) of this section, without exception:

16.01.2100,02.	Domestic Water Supplies.
16.01.2100,03.	Cold Water Biota.
16.01.2100,04.	Warm Water Biota.
16.01.2100,05.	Salmonid Spawning.
16.01.2100,06.	Primary Contact Recreation.
16.01.2100,07.	Secondary Contact Recreation.

(ii) The following criteria from the matrix in paragraph (b) of this section apply to the use classifications identified in paragraph (d)(21)(i) of this section:

Use classification	Applicable criteria
02	This classification is assigned the criteria in: Column D(I)—all except #'s 4, 5, 7, 10, 11, 14, 115.
03, 04 and 05	These classifications are assigned the criteria in: Column B(I)—all. Column B(II)—all. Column D(II)—all.
06	This classification is assigned the criteria in: Column B(I)—all. Column B(II)—all.
07	This classification is assigned the criteria in: Column B(I)—all. Column B(II)—all. Column D(II)—all.

(22) *Washington, Region 10*

(i) All waters assigned to the following use classifications in the Washington Administrative Code (WAC), chapter 173-201 (i.e., identified in WAC 173-201-045) are subject to the criteria in paragraph (d)(22)(ii) of this section, without exception:

173-201-045.	Class AA water supplies. Class A. Class B. Class C. Lake class.

(ii) The following criteria from the matrix in paragraph (b) of this section apply to the use classifications identified in paragraph (d)(22)(i) of this section:

Use classification	Applicable criteria
AA and A	These classifications are assigned the criteria in: Column D(I)—all. Column D(II)—all. Columns B(I), B(II), C(I), and C(II): all except #'s 4, 5a&b, 7, 8, 9, 11, 13, 53, 108, 109, 110, 115, 117, 119-126
B and C	These classifications are assigned the criteria in: Same as for AA and A except do not include Column D(I).
Lake class	This classification is assigned the criteria in: Same as for AA and A except do not include Columns C(I), C(II) or D(I).

(Note.—The following appendix will not appear in the Code of Federal Regulations.)

Appendix to Preamble of Today's Proposal

I. Introduction

The purpose of this appendix is to provide background information and further explanation of today's proposed rulemaking. Two major topics are discussed. The first topic concerns the detailed assumptions and rules followed by EPA in writing the State-specific proposed regulatory requirements (i.e., the water quality uses and criteria) contained in proposed section § 131.36(d). The second topic concerns EPA's rationale for proposing the § 131.36(d) requirements. Separate, customized rationales are provided for each jurisdiction included in the water quality standards program (i.e., as defined by 40 CFR 131.3(j)).

II. Assumptions and Rules Followed by EPA in Writing the Proposed Section 131.36(d) Requirements for all Jurisdictions

The "rules" followed by EPA in writing the proposed § 131.36(d) requirements for all jurisdictions are as follows:

1. No criteria are proposed for States which have been fully approved by EPA as complying with the section 303(c)(2)(B) requirements.

2. For States which have not been fully approved, if EPA has not previously determined which specific pollutants/criteria/waterbodies are lacking from a State's standards (i.e., as part of an approval/disapproval action only), all of the criteria in Columns B, C, and D of the proposed § 131.36(b) matrix are proposed for statewide application to all appropriate designated uses, except as provided for elsewhere in these rules. That is, EPA proposes to bring the State into compliance with section 303(c)(2)(B) via an approach which is comparable to option 1 of the December 1988 national guidance for section 303(c)(2)(B).

3. If EPA has previously determined which specific pollutants/criteria/waterbodies are needed to comply with CWA section 303(c)(2)(B) (i.e., as part of an approval/disapproval action only), the criteria in proposed § 131.36(b) are proposed for only those specific pollutants/criteria/waterbodies (i.e., EPA proposes to bring the State into compliance via an approach which is comparable to option 2 of the December 1988 national guidance for section 303(c)(2)(B)).

4. For aquatic life, except as provided for elsewhere in these rules, all waters with designated aquatic life uses providing even minimal support to aquatic life are included in the proposed rule (i.e., fish survival, marginal aquatic life, etc.).

5(a). For human health, except as provided for elsewhere in these rules, all waters with designated uses providing for public water supply protection (and therefore a potential water consumption exposure route) or minimal aquatic life protection (and therefore a potential fish consumption exposure route) are included in the proposed rule.

5(b). Where a State has determined the specific aquatic life segments which provide a fish consumption exposure route (i.e., fish or other aquatic life are being caught and consumed) and EPA approved this determination as part of a standards approval/disapproval action, the proposed rule includes the fish consumption (Column D(II)) criteria for only those aquatic life segments, except as provided for elsewhere in these rules. In making a determination that certain segments do not support a fish consumption exposure route, a State must complete and EPA must have previously approved, a use attainability analysis consistent with the provisions of 40 CFR part 131.10(j). In the absence of such an approved State determination, EPA has proposed fish consumption criteria for all aquatic life segments.

6. Uses/Classes other than those which support aquatic life or human health are not included in the proposed rulemaking (e.g., livestock watering, industrial water supply), unless they are defined in the State standards as also providing protection to aquatic life or human health (i.e., unless they are described as protecting multiple uses including aquatic life or human health). For example, if the State standards include a use such as industrial water supply, and in the narrative description of the use the State standards indicate that the use includes protection for resident aquatic life, then this use is included in the proposed rulemaking.

7. For human health, the "water + fish" criteria in Column D(I) of § 131.36(b) are proposed for all waterbodies where public water supply and aquatic life uses are designated, except as provided for elsewhere in these rules (e.g., rule 9).

8. If the State has public water supplies where aquatic life uses have not been designated, or public water supplies that have been determined not to provide a potential fish consumption exposure pathway, the "water + fish" criteria in Column D(I) of § 131.36(b) are proposed for such waterbodies, except as provided for elsewhere in these rules (e.g., rule 9).

9. EPA is generally not proposing criteria for priority toxic pollutants for which a State has adopted criteria and received EPA approval. The exceptions to this general rule are described in rules 10 and 11.

10. For priority toxic pollutants where the State has adopted human health criteria and received EPA approval, but such criteria do not fully satisfy section 303(c)(2)(B) requirements, the proposed rule includes human health criteria for such pollutants. For example, consider a case where a State has a water supply segment that poses an exposure risk to human health from both water and fish consumption. If the State has adopted, and received approval for, human health criteria based on water consumption only (e.g., Safe Drinking Water Act Maximum Contaminant Levels (MCLs)) which are less stringent than the "water + fish" criteria in Column D(I) of proposed § 131.36(b), the Column D(I) criteria are proposed for those water supply segments. The rationale for this is to ensure that both water and fish consumption exposure pathways are adequately addressed and human health is fully protected. If the State has adopted water consumption only criteria which are more stringent or equal to the Column D(I) criteria, the "water + fish" criteria in Column D(I) criteria are not proposed.

11. For priority toxic pollutants where the State has adopted aquatic life criteria and received EPA approval, but such criteria do not fully satisfy section 303(c)(2)(B) requirements, the proposed rule includes aquatic life criteria for such pollutants (e.g., because previously approved State criteria do not reflect current science contained in revised criteria documents and other guidance sufficient to protect all designated uses or human health exposure pathways). For example, if the State has adopted not-to-be-exceeded aquatic life criteria which are less stringent than the 4-day average chronic aquatic life criteria in § 131.36(b) (i.e., in Columns B(II) and C(II)), the acute and chronic aquatic life criteria in § 131.36(b) are proposed for those pollutants. The rationale for this is that the State-adopted criteria do not protect resident aquatic life from both acute and chronic effects, and that federal criteria are necessary to fully protect aquatic life designated uses. If the State has adopted not-to-be-exceeded aquatic life criteria which are more stringent or equal to the chronic aquatic life criteria in § 131.36(b), the acute and chronic aquatic life criteria in § 131.36(b) are not proposed for those pollutants.

12. Under certain conditions discussed in rules 9, 10, and 11, criteria listed in § 131.36(b) are not proposed for specific pollutants; however, EPA made such exceptions only for pollutants for which criteria have been adopted by the State and approved by EPA, where such criteria are currently effective under State law and fully satisfy section 303(c)(2)(B) requirements.

III. State-by-State Summary Information and Rationale

EPA's jurisdiction-specific rationale for the § 131.36(d) requirements is described below. In addition, all proposed § 131.36(d) requirements conform to the rules specified in the previous section of this appendix.

Region 1

Connecticut is included in today's proposal because the State has not adopted any criteria for priority toxic pollutants, either before or in response to the statutory requirement, and EPA has reason to believe that at least some criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Connecticut's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows.

—August, 1990. Draft WQS revisions were submitted to EPA by the State. In this draft revision the State proposed adopting criteria for all priority pollutants for fresh water aquatic life and human health protection. No criteria were proposed for marine waters.

—December, 1990. EPA Region I notified Connecticut that adoption of criteria for marine waters is necessary to achieve compliance with section 303(c)(2)(B).

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State Section 304(1) short list for which State criteria have not been adopted and approved.

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 34 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

—Long Island Sound study conducted as part of the National Estuaries Program which indicates presence of priority pollutants in Long Island Sound.

Maine has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—June 1990. Legislative adoption of all EPA issued section 304(a)(1) criteria by reference.

—December 20, 1990. EPA approved the adopted State criteria.

EPA fully approved the criteria for priority toxic pollutants adopted by Maine in June of 1990 as being consistent with option 1 of the December 12, 1988 section 303(c)(2)(B) guidance document.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Massachusetts has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

Massachusetts' actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—Massachusetts adopted revised standards on July 23, 1990. The State adopted the section 304(a)(1) criteria for aquatic life protection in fresh and marine waters.

—Massachusetts toxicity control policy adopted with the standards incorporates a 10^{-6} risk level.

—December 20, 1990. EPA fully approved the Massachusetts toxics criteria as fully satisfying the requirements of section 303(c)(2)(B).

EPA fully approved the criteria for priority toxic pollutants adopted by Massachusetts as being consistent with option 1 of the December 12, 1988 section 303(c)(2)(B) guidance document.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

New Hampshire is included in today's proposal because although the State adopted numeric criteria for some priority toxic pollutants before the 1987 amendments, the State has not completed a review of their numeric criteria for priority toxic pollutants in response to the statutory requirement and EPA has reason to believe that at least some additional criteria are necessary to comply with section

303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

New Hampshire's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—August 1990. The State adopted water quality standards revisions following an option 1 approach using EPA national criteria for all pollutants. New Hampshire used a 10^{-6} risk assumption for human health protection for all pollutants except 2,3,7,8–TCDD for which a risk level of 10^{-5} was assumed.

—December 19, 1990. The revised toxics criteria adopted by the State were approved with the exception of the human health criteria for dioxin, which was disapproved.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 126 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory data base and/or the Permit Compliance System data base.

Rhode Island is included in today's proposal because although the State has completed a review and adopted numeric criteria for some priority pollutants in response to the statutory requirement, EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Rhode Island's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—October 1989. The State adopted revised WQS incorporating an option 1 approach for all section 304(a)(1) criteria for aquatic life protection in fresh and marine waters. No criteria were adopted for the protection of human health.

—March 30, 1989. EPA approved the water quality standards and informed Rhode Island that to come into full compliance with Section 303(c)(2)(B) that the State would have to adopt human health criteria.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State section 304(1) short list for which State toxics criteria have not been adopted and approved.

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for an as yet undetermined number of priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

- Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.
- Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.
- Superfund monitoring data indicating presence of priority pollutants at hazardous waste sites that may enter surface water through surface drainage and ground water migration.
- The Narragansett Bay Study conducted under the National Estuaries Program which indicated presence of priority pollutants in fish and shellfish tissue.

Vermont is included in today's proposal because the State has not adopted any criteria for priority toxic pollutants, either before or in response to the statutory requirement, and EPA has reason to believe that at least some criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Vermont's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

- April 1990. Vermont proposed draft water quality standards revisions following an option 1 approach for all section 304(a)(1) pollutants for aquatic life and human health protection.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

- State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 126 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.
- Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.
- Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

Region 2

New Jersey is included in today's proposal because although the State adopted numeric criteria for some priority toxic pollutants before the 1987 amendments, the State has not completed a review/revision of their numeric criteria for priority toxic pollutants in response to the statutory requirement and EPA has reason to believe that additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

New Jersey adopted criteria for some priority toxic pollutants prior to passage of section 303(c)(2)(B) on April 29, 1985 (N.J.A.C 7:9–4.1 et seq.). EPA approved these criteria on July 8, 1985. Some of these criteria are not affected by today's proposed rulemaking.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

- June 20, 1988: the State published a public notice of proposed revisions to the State Surface Water Quality Regulation, including new numeric criteria for toxic pollutants.
- July 14, 1989: The State adopted revisions to the State Surface Water Quality Standards Regulation. Numeric criteria were not included in the adopted revisions.
- July 16, 1990: The State informed EPA that it would be proposing numeric criteria for all EPA priority pollutants.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State section 304(1) list for which appropriate State criteria have not been adopted and approved, including metals.

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 16 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

—Correspondence from the State indicating that the adoption of criteria for all EPA priority pollutants would be proposed for adoption.

Puerto Rico is included in today's proposal because although the State adopted numeric criteria for some priority toxic pollutants before the 1987 amendments, the State has not completed a review/revision of their numeric criteria for priority toxic pollutants in response to the statutory requirement and EPA has reason to believe that additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Puerto Rico adopted criteria for some priority pollutants prior to passage of section 303(c)(2)(B) on February 28, 1983 (Puerto Rico Water Quality Standards Regulation, as amended, promulgated by Environmental Quality Board Resolution Number R–83–5–2). Some of these criteria are not affected by today's proposed rulemaking.

Puerto Rico's actions to respond to the 1987 Section 303(c)(2)(B) requirement can be summarized as follows:

—March 15, 1990: The Commonwealth submitted draft water quality standards revisions to EPA for review prior to issuing proposed standards for public comment.

—May 2–3, 1990 and July 12–13, 1990: The Commonwealth held public hearings on its proposed water quality standards revisions.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the Commonwealth into full compliance with section 303(c)(2)(B). To fully protect Puerto Rico's designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate Commonwealth waters, the criteria in proposed § 231.36(b) for all priority toxic pollutants which are not the subject of approved Commonwealth criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved Commonwealth criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved Commonwealth criteria are not applicable to all appropriate Commonwealth designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect Puerto Rico's designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with Puerto Rico's designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the Commonwealth's section 304(l) short list for which appropriate state criteria have not been adopted and approved, including metals and organic compounds.

—The Commonwealth's efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The Commonwealth has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 9 priority toxic pollutants. These efforts represent evidence of the Commonwealth's recognition of the need for numeric criteria for these priority toxic pollutants.

—Presence in surface waters of the Commonwealth's priority pollutants for which sufficient Commonwealth numeric criteria have not been adopted, based on surface water monitoring data in STORET.

—Discharge to surface waters of priority pollutants for which sufficient Commonwealth numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

—Previously proposed revisions to Puerto Rico's Water Quality Standards Regulation indicating that numeric criteria for additional priority pollutants are necessary.

New York has not been included in today's proposed rulemaking because the State has water quality standards which meet the requirements of section 303(c)(2)(B). The State has met the requirements of section 303(c)(2)(B) of the Act through a combined Option 2 and Option 3 approach, as described in

EPA's December 12, 1988 guidance document.

State actions in response to the Clean Water Act requirement to adopt criteria may be summarized as follows:

—September 1985: The State adopted numeric criteria for 95 substances or classes of substances, including aquatic life and/or human health criteria. The State also adopted procedures, in regulation, for developing both aquatic life and human health based criteria. The procedures are used for developing the numeric criteria in the standards as well as for developing guidance values to be used for all purposes for which numeric criteria are used. The State has applied these procedures to develop aquatic life or human health based criteria for a total of 215 substances or classes of substances.

—September 30, 1985: EPA approved the State Water Quality Standards submittal.

—June 8, 1990: EPA approved State section 304(l) lists. No segments were included on the "short list" under Section 304(l) due to the presence of EPA priority pollutants for which the State did not have either a numeric criterion or derived guidance value.

—New York State had begun a triennial review prior to the 1987 amendments to the Clean Water Act. A notice of a public hearing and public information meetings was issued on May 25, 1990. The State has proposed the adoption of a limited number of aquatic life and human health based criteria for EPA priority pollutants. Public hearings and meetings were conducted in August 1990. A number of the proposed aquatic life and human based criteria were formerly included as guidance values. The State may be expected to convert additional guidance values during the next triennial review.

EPA approved the criteria for priority toxic pollutants adopted by New York on September 27, 1990, as being consistent with options 2 and 3 of the December 12, 1988 section 303(c)(2)(B) guidance document. In this letter, EPA directed the State to adequately address three issues: the need for greater public participation in the use of guidance values; the need for additional bioconcentration/bioaccumulation-based criteria and guidance values; and participation in the process to identify appropriate water quality criteria for use in developing TMDLs/WLAs for the waters of the New York/New Jersey Harbor Complex. EPA believes that the State has established standards which include or provide for the derivation of numeric criteria for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses".

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

The U.S. Virgin Islands has not been included in today's rulemaking. No EPA priority pollutants have been identified as impairing designated uses in the U.S. Virgin Islands through water quality monitoring and assessment activities. Further, EPA believes that there are no priority toxic pollutants present or discharged to surface waters which "may reasonably be expected to interfere with designated uses."

The following information supports EPA's conclusion:

—June 4, 1989: The U.S. Virgin Islands submitted lists of impaired waters pursuant to section 304(l). No waters were included on the section 304(l) "short list." No EPA priority pollutants were identified as impairing uses on other section 304(l) lists.

—May 9, 1990: EPA approved section 304(l) lists submitted by the U.S. Virgin Islands.

EPA has determined that the Water Quality Standards of the U.S. Virgin Islands fully meet the requirements of CWA section 303(c)(2)(B).

If additional information is submitted during the public comment period asserting that the U.S. Virgin Islands has not fully complied with section 303(C)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Region 3

Virginia is included in today's proposal because although the State adopted numeric criteria for some priority toxic pollutants before the 1987 amendments, such criteria are not mandatory in application and, furthermore, the State has not completed a review of their numeric criteria for priority toxic pollutants in response to the statutory requirement. EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—September 29, 1987. The State Water Control Board adopted a resolution to adopt numerical criteria for toxic pollutants immediately after EPA issuance of CWA section 303(c)(2)(B) guidance.

—November 29, 1988. The State held a public meeting to receive comments on the adoption of criteria for toxic pollutants.

—December 30, 1988. EPA sent the State final "Guidance for State Implementation of Water Quality Standards for CWA section 303(c)(2)(B)."

—January 10, 1989. EPA submitted formal comments from the public meeting.

—October 23, 1989. Virginia requested EPA to submit recommendations for its triennial review.

—November 21, 1989. EPA responded to Virginia's request for triennial review recommendations.

—December 14, 1989. Virginia began public meetings to receive comments on issues to be included in the triennial review.

—February 12, 1990. Virginia began public hearings on a water quality standard for dioxin.

—February 16, 1990. EPA informed the State of EPA's intent to include the State in the national rule to promulgate numeric water quality criteria for priority toxic pollutants for those States which failed to meet the requirements of section 303(c)(2)(B).

—March 5, 1990. EPA submitted comments on Virginia's proposed dioxin standard.

—April 9, 1990. The EPA Assistant Administrator for the Office of Water informed the State that it was going to be included in a proposed national rule to establish numeric, surface water criteria for toxic pollutants designed to bring all States into full compliance with the requirements of section 303(c)(2)(B).

—July 25, 1990. Virginia began public hearings on proposed water quality standards, including criteria for toxics.

—August 7, 1990. EPA submitted comments on Virginia's proposed standards.

—August 17, 1990. Virginia reproposed changes to the water quality standards for public comment.

—September 14, 1990. EPA submitted comments on the revisions to the proposed water quality standards.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed section 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State section 304(l) short list for which mandatory State criteria have not been adopted and approved.
—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has adopted a human health criterion for dioxin and has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 67 other priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.
—Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.
—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

Delaware has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—December 30, 1988. EPA sent the State final "Guidance for State Implementation of Water Quality Standards for CWA Section 303(c)(2)(B)."
—November 18, 1988. First draft revisions to water quality standards, including toxics.
—January 25, 1989. Second draft revisions to water quality standards.
—March 1, 1989. Third draft revisions to standards.
—June 1, 1989. Workshop draft of water quality standards, including development documents.
—June 12, 1989. Delaware began public workshops on standards revisions.
—July 10, 1989. EPA provided preliminary comments on the workshop draft revisions.
—July 28, 1989. Delaware submitted revised standards for EPA review.
—September 6, 1989. Delaware held a public hearing on the triennial review revisions to the water quality standards.
—September 6, 1989. EPA provided comments at the public hearing.
—February 2, 1990. Delaware adopted revisions to the water quality standards.
—February 5, 1990. Delaware submitted revised standards to EPA.
—February 16, 1990. EPA informed the State of EPA's intent to include the State in the national rule to promulgate numeric water quality criteria for priority toxic pollutants for those States which failed to meet the requirements of section 303(c)(2)(B).
—March 13, 1990. Delaware completed a responsiveness summary for its standards review.
—March 21, 1990. Delaware's Attorney General certified the revised standards.
—April 9, 1990. The EPA Assistant Administrator for the Office of Water informed the State that it was going to be included in a proposed national rule to establish numeric, surface water criteria for toxic pollutants designed to bring all States into full compliance with the requirements of section 303(c)(2)(B).
—August 24, 1990. EPA approved Delaware's revised standards for toxics.

EPA fully approved the criteria for priority toxic pollutants adopted by Delaware on February 2, 1990 as being consistent with option 2 of the December 12, 1988 section 303(c)(2)(B) guidance document. As part of its submittal of revised standards for EPA review, the State included information which demonstrated that numeric criteria had been adopted for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses."

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Maryland has not been included in today's proposed rulemaking, because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(C)(2)(B) requirement and received Environmental Protection Agency (EPA) approval for the criteria portion of the water quality standards.

The State's response to the 1987 section 303(C)(2)(B) requirement can be summarized as follows:

—December 30, 1988. EPA sent the State final "Guidance for State Implementation of Water Quality Standards for CWA section 303(c)(2)(B)."
—February 16, 1990. EPA informed the State of EPA's intent to include the State in the national rule to promulgate numeric water quality criteria for priority toxic pollutants for those States which failed to meet the requirements of section 303(c)(2)(B).
—March 21, 1990. The State adopted revised water quality standards which

included numeric criteria for priority toxic pollutants.

—April 9, 1990. The EPA Assistant Administrator for the Office of Water informed the State that it was going to be included in a proposed national rule to establish numeric, surface water criteria for toxic pollutants designed to bring all States into full compliance with the requirements of section 303(c)(2)(B).

—April 30, 1990. The State submitted the adopted water quality standards with a State Attorney General certification to EPA for approval/disapproval.

—May 4, 1990. The State proposed in the Maryland Register to adopt maximum contaminant levels (MCLs) for selenium and silver as drinking water criteria, which corrects a printing error resulting in the criteria being placed in the wrong column in the regulations proposed on November 3, 1989.

—June 12, 1990. Maryland submitted for EPA review the public hearing record for the toxic substances regulations proposed November 3, 1989.

—September 12, 1990. EPA approved the revised State numeric criteria for priority toxic pollutants.

EPA approved the criteria for priority toxic pollutants adopted by Maryland on March 21, 1990, as being consistent with option 2 of the December 12, 1988 section 303(c)(2)(B) guidance document. As part of its submittal of final revised standards for EPA review, the State included information which demonstrated that numeric criteria had been adopted for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses".

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Pennsylvania has not been included in today's proposed rulemaking because the State has adopted a translator procedure to derive numeric criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA-approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—August 26, 1987. The State submitted to EPA a proposed list of issues to be addressed during the triennial water quality standards review.

—April 5, 1988. EPA submitted comments on the draft proposed revisions to the water quality standards.

—June 16, 1988. The State held a public hearing on its proposed water quality standards revisions, at which EPA provided verbal testimony.

—June 20, 1988. EPA submitted written comments to the State regarding the proposed water quality standards revisions.

—November 15, 1988. The State adopted revised water quality standards which included a translator procedure (option 3) for deriving numeric criteria for priority toxic pollutants.

—December 30, 1988. EPA sent the State final "Guidance for State Implementation of Water Quality Standards for CWA section 303(c)(2)(B)."

—April 17, 1989. The State submitted the adopted water quality standards with a State Attorney General certification to EPA for approval/disapproval.

—July 21, 1989. EPA requested clarification on the enforceability of the procedure adopted to derive criteria for priority toxic pollutants.

—July 28, 1989. The State responded to EPA's clarification request.

—September 29, 1989. EPA conditionally approved the State's water quality standards due to concerns regarding the enforceability and public participation of the translator procedure and the derived criteria.

—November 15, 1989. The State responded to EPA's conditional approval.

—January 18, 1990. EPA requested additional clarification regarding the State's response to the conditional approval.

—February 16, 1990. EPA informed the State of EPA's intent to develop a national rule to promulgate numeric water quality criteria for priority toxic pollutants for those States which failed to meet the requirements of section 303(c)(2)(B).

—February 20, 1990. The State provided additional clarification, in response to EPA's January 18, 1990, letter.

—April 9, 1990. The EPA Assistant Administrator for the Office of Water informed the State that it was going to be included in a proposed national rule to establish numeric, surface water criteria for toxic pollutants designed to bring all States into full compliance with the requirements of section 303(c)(2)(B).

—April 11, 1990. EPA approved the translator procedure for developing criteria for priority toxic pollutants.

EPA fully approved the procedure for developing numeric criteria for priority toxic pollutants which was adopted by Pennsylvania on November 15, 1988 as being consistent with option 3 of the December 12, 1988 section 303(c)(2)(B) guidance document.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

West Virginia has not been included in today's proposal because the State has adopted criteria for priority toxic pollutants in response to the statutory requirement and will receive full EPA approval by September 13, 1990.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—June 23, 1988. The State submitted a draft list of toxic pollutants for criteria development to EPA for review prior to issuing proposed standards for public comment.

—July 25, 1988. EPA provided written comments on the draft list of toxic pollutants for criteria development.

—September 12, 1988. The State held a public hearing on its proposed water quality standards revisions, at which EPA provided verbal testimony.

—September 21, 1988. EPA provided written comments on the proposed revisions to the water quality standards.

—October 18, 1988. The State submitted proposed revisions to EPA for review and approval.

—December 30, 1988. EPA sent the State final "Guidance for State Implementation of Water Quality Standards for CWA section 303(c)(2)(B)."

—April 27, 1989. The State adopted final revisions to the water quality standards.

—September 29, 1989. EPA disapproved criteria for seven priority pollutants. Aquatic life criteria were disapproved for arsenic, cadmium, mercury, nickel, lead, selenium, and silver. Human health criteria were disapproved for arsenic, mercury and nickel. In addition, EPA disapproved site-specific toxics criteria (cyanide, hexavalent chromium, and copper) for two waterbody segments (Little Scary Creek and Turkey Run).

—November 13, 1989. The State responded to EPA's disapproval of the final revisions to the water quality standards.

—January 30, 1990. The State sent a letter to EPA which stated that the permittee discharging to Turkey Run was relocating its outfall to another water body.

—January 31, 1990. EPA responded to the State's November 13, 1989 reply to EPA's disapproval of the water quality standards revisions.

—February 16, 1990. EPA informed the State of EPA's intent to develop a national rule to promulgate numeric water quality criteria for priority toxic pollutants for those States which failed to meet the requirements of section 303(c)(2)(B).

—March 12, 1990. EPA granted the State an extension to address EPA's disapproval.

—April 9, 1990. The EPA Assistant Administrator for the Office of Water informed the State that it was going to be included in a proposed national rule to establish numeric, surface water criteria for toxic pollutants designed to bring all States into full compliance with the requirements of section 303(c)(2)(B).

—April 1990. The State submitted rejustification for a disapproved site-specific criterion for copper.

—June 13, 1990. The State submitted emergency revisions to the water quality standards to address EPA's disapproval.

—July 16, 1990. The State held a public hearing on its emergency rulemaking, at which EPA provided verbal testimony.

—July 25, 1990. The State submitted comments received on the standards revisions by industrial representatives and requested EPA's reaction to the comments.

—July 27, 1990. EPA held a conference call with the State and discharger to Little Scary Creek to discuss the site-specific copper criteria rejustification submitted in April, 1990.

—August 2, 1990. EPA sent the State recommended revised site-specific copper criteria for Little Scary Creek.

—August 13, 1990. EPA replied to the State's July 25, 1990 request to respond to comments received by industrial representatives.

—August 20, 1990. The State adopted final emergency revisions to the water quality standards to address EPA's remaining concerns.

—August 27, 1990. The State submitted the adopted final emergency revisions to the water quality standards with a State Attorney General certification to EPA for approval/ disapproval.

—September 18, 1990. EPA fully approved the State's revised State water quality standards, including full approval of the revised numeric criteria for priority toxic pollutants.

EPA fully approved the criteria for priority toxic pollutants adopted by West Virginia on August 20, 1990 as being consistent with option 2 of the December 12, 1988 section 303(c)(2)(B) guidance document. As part of its submittal of final revised standards for EPA review, the State included information which demonstrated that numeric criteria had been adopted for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses."

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

The District of Columbia is included in today's proposal because although the District adopted numeric criteria for most priority toxic pollutants before the 1987 amendments, the District has not completed a review of their numeric criteria for priority toxic pollutants in response to the statutory requirement, and EPA has reason to believe that at least some additional criteria are necessary and some criteria need to be revised to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the District is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

On August 26, 1985, prior to the passage of section 303(c)(2)(B), the District of Columbia adopted under emergency powers some criteria for priority toxic pollutants, chapter 11 of title 21 DCMR, "Water Quality Standards of the District of Columbia." EPA approved these criteria on October 31, 1985. The District made the emergency rules final on December 27, 1985.

The District's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—August 26, 1988. EPA sent comments to the District as to what issues should be addressed for the upcoming triennial water quality standards review.

—December 30, 1988. EPA sent the State final "Guidance for State Implementation of Water Quality Standards for CWA section 303(c)(2)(B)."

—February 15, 1989. The District submitted draft water quality standards revisions to EPA for review prior to issuing proposed standards for public comment.

—May 30, 1989. EPA sent the District a letter which emphasized the need for expediting the triennial water quality standards review.

—June 26, 1989. The District submitted proposed water quality standards revisions to EPA for review.

—July 5, 1989. The District held a public hearing on the proposed water quality standards revisions.

—September 15, 1989. The District submitted revised proposed water quality standards revisions to EPA for review.

—September 25, 1989. EPA submitted comments on the proposed water quality standards revisions and indicated that the District must adopt human health criteria for the consumption of fish.

—October 3, 1989. The District responded to EPA's comments.

—November 3, 1989. EPA provided additional comments on the proposed water quality standards revisions.

—December 11, 1989. EPA telephoned the District to inquire about a response to EPA's November 3, 1989, letter and the status of the water quality standards revisions.

—February 16, 1990. EPA informed the District of EPA's intent to develop a national rule to promulgate numeric water quality criteria for priority toxic pollutants for those States which failed to meet the requirements of section 303(c)(2)(B).

—April 9, 1990. The EPA Assistant Administrator for the Office of Water informed the State that it was going to be included in a proposed national rule to establish numeric, surface water criteria for toxic pollutants designed to bring all States into full compliance with the requirements of section 303(c)(2)(B).

—September 7, 1990. The District public noticed for comment proposed water quality standards revisions.

—October 5, 1990. EPA submitted comments on the proposed water quality standards revisions.

The District has adopted aquatic life criteria for 120 priority toxic pollutants and human health criteria for 107 priority toxic pollutants. The aquatic life criteria for two of the pollutants (selenium and toxaphene) and the human health criterion for one of the pollutants (hexachlorobenzene) exceed EPA's section 304(a)(1) criteria recommendations. Therefore, EPA believes that revised criteria for these pollutants are necessary. The District did not adopt human health criteria applicable to public water supplies for nine priority toxic pollutants (lead, asbestos, 2,3,7,8-tetrachlorodibenzo-p-dioxin, vinyl chloride, bis(2-chloroisopropyl) ether, bis(2-ethylhexyl) phthalate, diethyl phthalate, dimethyl phthalate, and di-n-butyl phthalate) and has not provided justification that the discharge or presence of these pollutants cannot reasonably be expected to interfere with designated uses in the District's surface waters. Therefore, EPA believes that human health criteria for the consumption of water are necessary for these pollutants.

The District has not adopted any criteria for the protection of humans from the consumption of fish. Since the District's 1989 State Clean Water Strategy identifies that fishing does occur on District waters, EPA believes it is necessary to propose human health criteria for fish consumption for all priority toxic pollutants for which EPA has issued section 304(a)(1) criteria recommendations.

This proposed rulemaking would federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 12 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Presence in surface waters of the State of priority pollutants for which sufficient numeric criteria have not been adopted, based on surface water monitoring data in STORET.

Region 4

Alabama has not been included in today's proposed rulemaking because the State has adopted criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—January 24, 1990. The Alabama Environmental Management Commission adopted the triennial review of water quality standards.

—May 23, 1990. The State Attorney General notified EPA that the adopted water quality standards would not be certified.

—June 1, 1990. The State sent EPA a copy of the revised standards without a request for formal EPA review and approval.

—November 26, 1990. The State submitted draft water quality standards revisions for EPA review. These revisions include: (1) Criteria for protection of aquatic life based on an Option I approach as described in EPA's December 12, 1988 guidance document, (2) numeric criteria for protection of human health for 17 priority toxic pollutants based on Option II of the guidance, and (3) proposed criteria equations based on Option III of the guidance for the protection of human health for the remaining priority toxic pollutants.

—January 17, 1991. The State held public hearings on the proposed revisions to water quality standards.

—February 20, 1991. The State adopted revisions to water quality standards including the numeric criteria for priority toxic pollutant based on an Option I approach as described in EPA's December 12, 1988 guidance document.

—April 18, 1991. EPA received the State's request for formal review of the adopted water quality standards.

—May 24, 1991. The State Attorney General submitted information relating to the legal certification of the adopted water quality standards.

—July 3, 1991. The State Attorney General submitted further information relating to the legal certification of the adopted water quality standards.

—July 18, 1991. EPA approved the revised State water quality standards.

EPA fully approved the criteria for priority toxic pollutants adopted by Alabama on July 18, 1991 as being consistent with Option I of the December 12, 1988 guidance document.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Florida is included in today's proposal because although the State has adopted numeric criteria for priority toxic pollutants in response to the statutory requirement, the State has not yet requested or obtained EPA approval of the adopted criteria. In addition, EPA has reason to believe that criteria for at least one other priority toxic pollutant is necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

On September 24, 1987 EPA approved the previous triennial review of Florida Water quality standards with the exception of three areas of the water quality standards which were disapproved. Included in the water quality standards which were approved by EPA were several numeric criteria for toxic priority pollutants derived for the protection of aquatic life. These criteria were initially adopted by the State as water quality standards in adoption proceedings prior to 1985. These criteria were not revised in the State's triennial review completed in 1987.

These criteria included criteria values which are less stringent in value than several of the national ambient water quality criteria included in the proposed rulemaking. Data used to develop the national ambient water quality criteria were not available for consideration by the State at the time of the initial adoption of these criteria by the State.

In the letter approving revisions to water quality standards, EPA instructed the State "to initiate a review of existing criteria at the earliest possible date." This review was necessary to address the 1987 requirements of section 303(c)(2)(B) for adoption of numeric criteria for toxic priority pollutants.

In directing the State to complete this review, EPA stated, "Recent changes in federal law relating to water quality standards will make it necessary for the State to complete an extensive review of water quality criteria during the next triennial review of water quality standards. The Water Quality Act of 1987 mandates that each state adopt numerical criteria for all 307(a) toxics for which national criteria are available or adopt procedures which will result in numeric limitations in National Pollutant Discharge Elimination System permits for these contaminants.

Considering the above, EPA is including the national ambient aquatic life-based water quality criteria values for these toxic priority pollutants in this proposed rulemaking.

In addition, the criteria adopted by the State in 1990 for the protection of human health have not been formally submitted and certified to EPA with a request for approval. Therefore, EPA is including all national ambient water quality criteria for protection of human health (as a class of criteria).

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—December 27, 1989. The State submitted draft water quality standards revisions to EPA for review. These revisions include proposed criteria for protection of human health based on an Option II approach as described in EPA's December 12, 1988 guidance document as well as updates to adopted criteria for protection of aquatic life.

—February 7 and May 1, 1990. The State held public workshops on its proposed water quality standards revisions.

—December 7, 1990. The State adopted revisions to water quality standards which include 66 numeric criteria for priority toxic pollutants.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed section 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—priority toxic pollutants on the section 304(1) lists;

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has adopted new or revised chemical-specific, numeric criteria for 66 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Priority toxic pollutants for which there exist water quality-based limits in an NPDES permit or where NPDES permit screening shows that the Federal 304(a) criteria may be exceeded instream;

—Priority toxic pollutant ambient monitoring data or site specific data which show that the Federal 304(a) criteria in the water column or in fish tissue may be exceeded;

—Priority toxic pollutant data in the Toxics Release Inventory under section 313 of SARA title III or in the National Bioaccumulation Study which show that the Federal 304(a) criteria in the water column or in fish tissue may be exceeded;

—Priority toxic pollutant data for which there are reasonable expectations that the Federal 304(a) criteria will be exceeded in the water column or fish tissue as a result of impacts from Superfund or RCRA sites; and

—Consideration of other data such as sediment data and location of storage facilities of priority toxic pollutants where these pollutants could reasonably be expected to interfere with designated uses.

Georgia has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 Section 303(c)(2)(B) requirement can be summarized as follows:

—December 7, 1988. The State adopted revisions to water quality standards which included 12 criteria for 307(a) toxics.

—December 8, 1988. The State submitted the adopted revisions to water quality standards for review and approval.

—March 29, 1989. EPA disapproved the adopted 307(a) criteria adopted by the State.

—December 6, 1989. The State adopted water quality standards which included an Option I approach for the section 303(c)(2)(B) requirement with the exception of 2,3,7,8 TCDD (dioxin) and PCBs.

—December 14, 1989. The State submitted the adopted revisions to water quality standards for review and approval.

—March 28, 1990. The State adopted water quality criteria for dioxin and PCBs.

—April 3, 1990. EPA approved the priority toxic pollutant criteria adopted by the State on December 6, 1989.

—May 29, 1990. The State submitted the adopted criteria for dioxin and PCBs for EPA review and approval.

—October 29, 1990. The State submitted draft revisions to water quality standards including revised criteria for dioxin.

—November 27, 1990. EPA disapproved the adopted criteria for dioxin and approved the adopted criteria for PCBs.

—January 23, 1991. The State adopted revised criteria for dioxin.

—April 2, 1991. The State submitted the revised water quality standard for dioxin with a State Attorney General certification to EPA for approval.

—June 3, 1991. EPA approved the dioxin criteria, thus bringing the State into full compliance with section 303(c)(2)(B).

EPA fully approved the criteria for priority toxic pollutants on June 3, 1991 as being consistent with Option 1 of the December 12, 1988 guidance.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Kentucky has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—May 31, 1990. The State adopted revised water quality standards which included numeric criteria for priority toxic pollutants based on Option I approach for the section 303(c)(2)(B) requirement.

—June 29, 1990. The State submitted the adopted water quality standards with a State Attorney General certification to EPA for approval.

—October 5, 1990. EPA approved the revised State water quality standards, including full approval of the revised numeric criteria for priority toxic pollutants.

EPA fully approved the criteria for priority toxic pollutants adopted by Kentucky on October 5, 1990 as being consistent with Option I of the December 12, 1988 guidance document.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Mississippi has not been included in today's proposed rulemaking because the State has adopted criteria for priority toxic pollutants in response to the section 303(c)(2(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—March 22, 1990. The State adopted revisions to water quality standards in response to the section 303(C)(2)(B) requirement. The adopted revisions did not include criteria for dioxin.

—May 14, 1990. The State submitted the adopted revisions to water quality standards for review and approval.

—October 5, 1990. EPA approved the water quality criteria adopted by the State with the exception of the absence of criteria for dioxin, which was disapproved.

—January 29, 30 and 31, 1991. The State held public hearings to receive comments on the proposed dioxin criteria.

—March 28, 1991. The State adopted dioxin criteria of 1.0 ppq for protection of human health from the exposure routes of consumption of fish and shellfish and consumption of water.

—July 12, 1991. The State submitted the adopted dioxin criteria for EPA review and approval.

—July 15, 1991. The State submitted the adopted dioxin criteria for EPA review and approval.

—July 24, 1991. EPA approved the State-adopted water quality criteria for dioxin.

EPA fully approved the criteria for priority toxic pollutants adopted by Mississippi on July 24, 1991, as being consistent with Options I and III of the December 12, 1988 guidance document.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

North Carolina has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—July 13, 1989. The State adopted revisions to water quality standards in response to the section 303(C)(2)(B) requirement.

—October 27, 1989. The State submitted the adopted revisions to water quality standards for review and approval.

—April 12, 1990. EPA approved the water quality criteria adopted by the State with the exception of the criteria for arsenic (saltwater), chromium (freshwater), copper, lead, pentachlorophenol and zinc.

—October 5, 1990. EPA approved the adopted criteria for chromium (freshwater) and decided that no criteria were required for pentachlorophenol to meet the 303(c)(2)(B) requirement. In addition, EPA conditionally approved the criteria for arsenic (saltwater), copper, lead and zinc based on a commitment by the State that revisions to these criteria would be adopted by the State by December 13, 1990.

—December 13, 1990. The State adopted revised criteria for arsenic, copper, chromium, lead and zinc.

—January 18, 1991. The State submitted the adopted water quality standards with a State Attorney General certification to EPA for approval.

—February 7, 1991. EPA approved the revised North Carolina water quality standards, including full approval of the revised criteria for priority toxic pollutants.

On February 7, 1991, EPA fully approved the criteria for priority toxic pollutants adopted by North Carolina as being consistent with Options II and III of the December 12, 1988 guidance document.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

South Carolina has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—April 27, 1990. The State Legislature adopted revisions to water quality standards in response to the section 303(c)(2)(B) requirement.

—May 26, 1990. The State submitted the adopted revisions to water quality standards for review and approval.

—June 14, 1990. The State submitted for EPA review draft water quality standards revisions including numeric human health-based criteria based on Option I of the December 12, 1988 guidance document.

—August 1 and 2, 1990. The State held public hearings on proposed revisions to water quality standards which included 103 water quality criteria for protection of human health.

—October 5, 1990. EPA approved the water quality criteria adopted by the State with the exception of the criteria for protection of human health as a class of criteria. The human health criteria for arsenic and lead were approved by EPA.

—October 11, 1990. The South Carolina Board of Health and Environmental Control promulgated the proposed revisions to water quality standards which included 103 criteria for the protection of human health.

—December 7, 1990. Promulgation by the Board of the South Carolina Department of Health and Environmental Control.

—March 13, 1991. Attorney General certification made.

—April 26, 1991. Revisions to South Carolina Water Classifications and Standards, Regulation 61–68, pertaining to numeric human health criteria for Clean Water Action section 307(a) toxics became effective upon publication in the State Register.

—May 8, 1991. The State submitted the adopted human health criteria for EPA review and approval.

—July 9, 1991. EPA approved the adopted standards, thus bringing the State into full compliance with section 303(c)(2)(B).

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Tennessee has not been included in today's proposed rulemaking because the State has adopted criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—May 1, 1989. The State submitted draft water quality standards revisions to EPA for review.

—December 15, 1989. The State submitted draft water quality standards revisions to EPA for review. The proposal included revisions to the draft water quality standards based on comments made by EPA and the public.

—December 15, 1989. The State held a public hearing on proposed revisions to water quality standards.

—July 30, 1990. The State submitted draft water quality standards revisions to EPA for review. The proposal included revisions to the draft water quality standards based on comments made by EPA and the public.

—November 15, 1990. The State held a second public hearing on proposed revisions to the water quality standards.

—January 17, 1991. The State adopted revised water quality standards which included numeric criteria for priority toxic pollutants based on Option II of EPA's December 12, 1988 guidance.

—August 14, 1991. The State submitted the adopted water quality standards with a State Attorney General certification to EPA for approval.

—September 28, 1991. EPA approved the revised State water quality standard, including full approval of the criteria for toxic pollutants.

EPA fully approved the criteria for toxic pollutants adopted by Tennessee on September 28, 1991 as being consistent with Option II of the December 12, 1988 guidance.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Region 5

Wisconsin has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—February 1987. The Natural Resources Board authorized public hearings on Chapter NR 105.

—December 1987. The Natural Resources Board authorized public hearings on Chapter NR 106.

—Thirteen public hearings were held on the water quality standards revisions in 1987 and 1988.

—November 17, 1988 and December 15, 1988. The State adopted revised water quality standards (Chapter NR 106 and Chapter NR 105, respectively) which included numeric criteria for priority pollutants.

—February 3, 1989. Wisconsin Department of Natural Resources submitted the adopted water quality standards with a State Attorney General certification to EPA for approval/disapproval.

—March 1, 1989. Water quality standards became effective.

—May 15, 1989. USEPA approved the revised State water quality standards, including full approval of the revised numeric criteria for priority toxic pollutants.

USEPA fully approved the criteria for priority toxic pollutants adopted by Wisconsin on November 17 and December 15, 1988 as being consistent with option 2 of the December 12, 1988 section 303(c)(2)(B) guidance document As part of its submittal of final revised standards for USEPA review, the State included information which demonstrated that numeric criteria had been adopted for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses."

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Illinois has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—January 25, 1990. The State adopted revised water quality standards which included criteria for priority toxic pollutants.

—February 2, 1990. The State submitted the adopted water quality standards with a State Attorney General certification to USEPA for approval/disapproval.

—February 13, 1990. Water quality standards rules became effective.

—February 15, 1990. USEPA approved the revised water quality standards (Docket A), including full approval of the revised criteria for priority pollutants.

USEPA fully approved the criteria for priority toxic pollutants adopted by Illinois on January 25, 1990 as being consistent with a combination of options 2 and 3 of the December 12, 1988 section 303(c)(2)(B) guidance document. As part of its submittal of final revised standards for USEPA review, the State included information which demonstrated that numeric criteria had been adopted for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses."

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the

Agency's determination of full compliance.

Indiana has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—March 1, 2, and 7, 1989. The State conducted public hearings for the water quality standards rules revisions.

—December 13, 1989. The State adopted revised water quality standards which included criteria for priority toxic pollutants. The Governor signed the revised standards on January 31, 1990.

—March 3, 1990. Water quality standards rules became effective.

—April 5, 1990. The State submitted the adopted water quality standards with a State Attorney General certification to USEPA for approval/disapproval.

—May 7, 1990. USEPA approved the revised water quality standards including full approval of the revised numeric criteria for priority pollutants.

USEPA fully approved the criteria for priority toxic pollutants adopted by Indiana on December 15, 1989 as being consistent with a combination of options 2 and 3 of the December 12, 1988 section 303(c)(2)(B) guidance document. As part of its submittal of final revised standards for USEPA review, the State included information which demonstrated that numeric criteria had been adopted for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses."

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Ohio has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—November 28, 29 and 30, 1989. Ohio EPA conducted public hearings addressing water quality standards revisions.

—December 18, 1989 Public record closed.

—February 1, 1990. The State adopted revised water quality standards which included criteria for priority toxic pollutants.

—February 12, 1990. The State submitted the adopted water quality standards to USEPA for approval/disapproval.

—March 13, 1990. The State submitted the required Attorney General certification of the water quality standards.

—April 25, 1990. USEPA approved the revised water quality standards including full approval of the revised numeric criteria for priority pollutants.

—May 1, 1990. Water quality standards rules became effective.

USEPA fully approved the criteria for priority toxic pollutants adopted by Ohio on February 1, 1990 as being consistent with a combination of options 2 and 3 of the December 12, 1988 section 303(c)(2)(B) guidance document. As part of its submittal of final revised standards for USEPA review, the State included information which demonstrated that numeric criteria had been adopted for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses."

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Michigan is included in today's proposal because although the State adopted criteria for priority pollutants before the 1987 amendments, the State has not completed a review of their criteria for priority toxic pollutants in response to the statutory requirement and USEPA has reason to believe that modification of the water quality standards is necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Michigan adopted criteria for priority toxic pollutants consistent with option 3 of the December 12, 1988 section 303(c)(2)(B) guidance document prior to actual passage of section 303(c)(2)(B) on November 14, 1986 (General Rules of the Michigan Water Resources Commission, Part 4, Water Quality Standards, R 323 of the Michigan Administrative Code). USEPA approved these criteria on August 4, 1987. However, the translator mechanism guidelines implementing Rule 57 were not included within the water quality standards regulation itself and, therefore, the criteria calculated through the implementation of this procedure were not binding upon the Water Resources Commission but instead are considered to be recommendations to the Commission. The State's efforts in response to section 303(c)(2)(B) have consisted of bringing the existing option 3 procedure within Rule 57 itself, thereby making implementation of the procedure-generated criteria in permits mandatory.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—July 21, 1988. MDNR staff presented and the Michigan Water Resources Commission approved a proposed water quality standards review process and schedule.

—August, September and October 1988. Informal public comment on requests for changes in the water quality standards taken in Water Resources Commission meetings at Houghton, Lansing and Tawas, Michigan, respectively.

—February 28, 1989. Scoping session held by MDNR staff with interested parties prior to development of water quality standards package.

—August 20, 1989. Draft proposed water quality standards package as presented to the Commission and was approved for informal public comment through September 29, 1989.

—October 20, 1989. Staff presented a draft proposed standards package to the Commission which the Commission approved for formal public hearings.

—December 31, 1989. The proposed water quality standards were published in the November, 1989 Michigan Register along with a Notice of Public Hearing.

—February 20, 21 and 22, 1990. Public Hearings on the proposed standards were held in Lansing, Traverse City and Marquette, respectively.

—April 2, 1990. Public comment period ended.

—May 1990. Water Resources Commission approved revised water quality standards.

—September 1990. Revised water quality standards are to go before Joint Committee on Administrative Rules (JCAR) for approval/disapproval. The JCAR dropped this item from its agenda and did not address it during 1990. The Michigan

DNR has again submitted the existing revisions to JCAR for its review during February 1991.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the Michigan Section 304(l) short list (February 3, 1989) for which State criteria consistent with Section 303(c)(2)(B) have not been adopted and approved, including metals, dioxin, and polynuclear aromatic hydrocarbons.
—Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.
—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.
—1990 Michigan 305(b) Report.
—Current implementation of Michigan's Rule 57 in the State's NPDES program (e.g., Form 2c data, presence of water quality-based effluent controls in existing NPDES permits).

Minnesota has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—December 1989. Minnesota Pollution Control Agency begins rulemaking proceedings on amendments to Minnesota Rules Chapter 7050.
—February 1 to March 16, 1990. Minnesota Pollution Control Agency holds nine public hearings addressing the revised standards.
—April 10, 1990. Public record for the standards revisions closed.
—May 10, 1990. Administrative Law Judge issued his report on the standards revisions.
—June 25, 1990. Minnesota Pollution Control Agency staff met with the Minnesota Pollution Control Agency Board—Water Quality Committee to discuss standards revision issues.
—July 24, 1990. Board approved and adopted the standards revisions.
—July 16, 1991. EPA approved the revised Minnesota water quality standards, including full approval of the revised criteria for priority toxic pollutants.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Region 6

Arkansas is included in today's proposal because although the State has completed a review and adopted numeric criteria for some priority toxic pollutants in response to the statutory requirement, EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Arkansas adopted some criteria for priority pollutants on November 1984 and January 1988. EPA approved these criteria on 1/28/85 and 5/6/88 and these criteria are not affected by today's rulemaking.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—November 1984. The State adopted revised water quality standards that included numeric criteria for 16 toxic substances to protect aquatic life. These were approved by EPA on January 28, 1985.
—January 1988. The State adopted revised water quality standards that included numeric criteria for 24 priority pollutants to protect aquatic life. These were approved by EPA on May 6, 1988.
—July 27, 1990. The State proposed revised water quality standards that included numeric criteria for 36 priority pollutants to protect aquatic life and for 13 priority pollutants to protect human health at a 10–6 risk.
—August 27, 1990. The State held a public hearing to receive public comment on the proposed revisions mentioned above.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). A list of the pollutants requiring criteria was included in letters to the State dated February 15, 1990 and June 11, 1990 (copies are contained in the record). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State section 304(l) short list for which State criteria consistent with Section 303(c)(2)(B) have not been adopted and approved,

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 7 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET and the National Bioaccumulation Study.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

Louisiana is included in today's proposal because although the State has adopted criteria for some priority toxic pollutants in response to the statutory requirement, EPA disapproved the lack of criteria for dioxin and has reason to believe that some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with Section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

The State completed a triennial revision of its water quality standards since passage of the Clean Water Act (CWA) section 303(c)(2)(B) and adopted revised standards on September 20, 1989. The revised numeric criteria were approved by EPA on December 19, 1989 with the exception of dioxin (no criterion proposed). Since this revision, a review of several databases—STORET, TRI, State 305(b) reports, and NPS assessments—indicated the need for Louisiana to adopt additional numeric criteria for mercury, lead, cadmium, copper and nickel via an Option 2 approach.

On March 20, 1991 the State adopted numeric criteria for 5 metals (cadmium, copper, lead, mercury and nickel). EPA received these revisions for our review on June 20, 1991.

Today's rule would only promulgate numeric criteria for dioxin and the metals listed above. Criteria approved on December 19, 1989 by EPA are not affected by today's proposed rulemaking.

New Mexico has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—June 6, 1988. The State proposed revised water quality standards that included numeric criteria for 11 priority pollutants to protect aquatic life. Additionally, the State proposed a narrative statement about protecting against toxic substances in domestic water supplies that create more than a 10–5 cancer risk.

—June 13, 1990. The State held a public hearing to receive public comment on the proposed revisions mentioned above.

—May 22, 1991. The State adopted numeric criteria for 14 priority pollutants. EPA received these revisions for our review on June 7, 1991.

—August 19, 1991. EPA approved the revised New Mexico water quality standards, including full approval of the revised criteria for priority toxic pollutants.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Oklahoma has not been included in today's proposed rulemaking because the State has adopted criteria for priority pollutants in response to the section 303(c)(2)(B) requirement and received full approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—June 10, 1989. The State adopted revised water quality standards which included numeric criteria for priority toxic pollutants.

—November 1, 1989. The State submitted the adopted water quality standards with a State Attorney General's certification to EPA for approval/disapproval.

—January 18, 1990. EPA approved the revised State water quality standards, including full approval of the numeric criteria for priority toxic pollutants.

EPA fully approved the criteria for priority toxic pollutants adopted by Oklahoma on June 10, 1989 as being consistent with Option 1 for aquatic life criteria and Option 2 for human health criteria as described in the December 12, 1988 section 303(c)(3)(B) guidance document. EPA's review concluded that numeric criteria had been adopted for all priority toxic pollutants which "may reasonably be expected to interfere with designated uses."

If additional information is submitted during the public comment period asserting that the State is not in compliance with section 303(c)(2)(B), EPA will transmit these comments to Oklahoma and will reevaluate the Agency's determination of full compliance after Oklahoma's submittal of their 1992 revised water quality standards to EPA for our approval/disapproval.

Texas has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—April 7, 1988. The State adopted revised water quality standards that included numeric criteria for 30 toxic substances to protect aquatic life. The numeric criteria adopted for mercury protected human health in addition to aquatic life.

—June 29, 1985. EPA approved the aquatic life criteria for 30 priority toxic pollutants and the human health criterion for mercury.

—December 24, 1990. The State issued proposed water quality standards revisions for public comment. The proposed revisions included numeric criteria for 29 priority pollutants.

—February 25, 1991. The State held a public hearing on the proposed revisions to the water quality standards mentioned above.

—June 12, 1991. The State adopted numeric criteria for 29 priority pollutants. EPA received these revisions for our review on July 1, 1991.

—September 25, 1991. EPA approved the revised Texas water quality standards, including full approval of the revised criteria for priority toxic pollutants.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Region 7

Iowa has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—March 19, 1990—The Iowa Environmental Protection Commission adopted aquatic life use protection criteria for several priority toxic pollutants.

—April 9, 1990—The State submitted the adopted aquatic life criteria to EPA with a proposed effective date of May 23, 1990.

—May 3, 1990—The State submitted draft human health criteria to EPA.

—June 1, 1990—The State resubmitted draft human health criteria to EPA.

—July 11, 1990—The State published a notice of intended action concerning standards revisions for human health criteria and scheduled public hearings

—August 1, 2, and 7, 1990—The State held public hearings at three locations in the State.

—September 17, 1990—The State scheduled adoption by the Environmental Protection Commission for October 15, 1990.

—December 19, 1990. Standards become effective.

—June 11, 1991. EPA approved the revised State water quality standards as satisfying the requirement of section 303(c)(2)(B).

EPA fully approved the criteria for priority toxic pollutants adopted by Iowa on June 11, 1991, as being consistent with Option 1 of the December 12, 1988 guidance.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

EPA has withheld approval of the aquatic life criteria revisions until the State completes and submits all of the revisions and documentation necessary under section 303 (c)(2)(B).

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State section 304 (l) short list including metals for which revised state criteria have not been adopted and approved.

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for ____ priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Regional Ambient Fish Tissue Monitoring data indicating elevated fish flesh concentrations of pesticides which are not currently covered with approved state criteria.

—STORET data indicating the presence in surface waters of priority toxic pollutants which are not currently covered with approved state criteria.

Kansas is included in today's proposal because although the state adopted numeric criteria for a few priority toxic pollution before the 1987 amendments, the state has not completed a review of their numeric criteria for priority toxic pollutants in response to the statutory requirements and the Environmental Protection Agency (EPA) has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Kansas adopted some criteria for priority toxic pollutants prior to the passage of section 303(c)(2)(B) on May 1, 1986 (State Regulation K.A.R. 28-16-28e). EPA approved these criteria on June 19, 1986, and most of these criteria are not affected by today's proposed rulemaking. (Those not affected are aquatic life criteria for nickel, silver, zinc, aldrin, chlordane, DDT, dieldrin, endosulfan, endrin, heptachlor, lindane, and PCBs).

The state's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—January 1990—The state submitted a preliminary draft of numeric criteria for EPA prior to starting an internal and external review of water quality standards revisions.
—July 1990—The state stopped all action on the standards revisions citing concerns over the costs of compliance.
—January 1991—The state submitted a draft package of standards revisions to EPA including numeric criteria to satisfy section 303(c)(2)(B) and set a date of June 1991 for final adoption.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the state section 304(1) short and mini lists for which State criteria have not been adopted and approved, including metals.
—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for ____ priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.
—STORET data indicating the presence in surface water of priority toxic pollutants which are not currently covered with approved state criteria.

Missouri has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—March 17, 1989—Missouri Clean Water Commission adopted additional numeric criteria for priority toxic pollutants for aquatic life use protection.
—April 15, 1989—The adopted criteria became effective under State law.
—October 13, 1989—EPA approved criteria with a recommendation that Missouri review the need for additional human health criteria.
—August 6, 1990—The State held a public meeting to discuss human health criteria revisions.
—August 23, 1990—The State scheduled a public hearing and adoption before the Missouri Clean Water Commission for October 23, 1990.
—December 12, 1990. Clean Water Commission adopts water quality standards.
—January 30, 1991. Standards sumbitted to EPA for review.
—March 4, 1991. Standards become effective in State.
—June 11, 1991. EPA approves standards as complying with section 303(c)(2)(B).

EPA fully approved the criteria for priority toxic pollutants adopted by Missouri on June 11, 1991 as being consistent with Option 1 of the December 12, 1988 guidance.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Nebraska has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—May 20, 1988—The state adopted numeric criteria for aquatic life protection for priority toxic pollutants.
—August 29, 1988—The adopted criteria became effective under state law.
—October 18, 1988—EPA approved Nebraska's Water Quality Standards noting that the need for additional human health criteria must be evaluated.
—December 1, 1989—The state adopted some numeric priority toxic pollutant criteria for a human health use (drinking water supply).
—February 20, 1990—The adopted criteria became effective under state law.
—January 17, 1990—DEC proposed human health fish consumption criteria for priority toxic pollutants.
—February 16, 1990—The state adopted the proposed human health fish consumption numeric criteria.
—June 27, 1990—The human health fish consumption numeric criteria became effective under state law.
—August 10, 1990—The state proposed revisions to mixing zone provisions of State Water Quality Standards which affect the application of numeric criteria.
—September 21, 1990—The state adopted proposed revisions to mixing zone policies.
—August 2, 1991. EPA approved the revised Nebraska water quality standards, including full approval of the revised criteria for priority toxic pollutants.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Region 8

Colorado is included in today's proposal because, although Colorado has completed a review and adopted numeric criteria for some priority toxic pollutants in response to the statutory requirement, EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Colorado's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—June 5, 1989—Region VIII notified the State that the priority pollutant standards under consideration for adoption would not fully satisfy the requirements of section 303(c)(2)(B).

—August 17, 1989—Colorado completed its triennial review and revised the State's Basic Standards and Methodologies. The revised Standards were submitted to EPA for review on October 6, 1989. The revised Basic Standards and Methodologies included new numeric criteria for some of the priority toxic pollutants; however, not all of the priority toxic pollutants for which EPA has developed 304(a) criteria were included in the revised State rule.

—January 17, 1990—Region VIII sent a letter to the State explaining the requirements for full compliance with section 303(c)(2)(B). The letter explained that where a State selected an option 2 approach to full compliance (i.e., option 2 as described in EPA's December 12, 1988 guidance and the Region's January 17, 1990 letter to the State), the burden was on the State to demonstrate that additional criteria beyond those already adopted were not needed.

—February 5, 1990—In a letter from the Colorado Water Quality Control Division to EPA Region VIII, Colorado notified EPA that it intended to meet the full compliance requirements by way of option 2. To date, however, the documentation supporting full compliance with option 2 has not been received.

—July 9, 1990—Region VIII sent a letter to the State commenting on what the Region considered to be needed revisions to the State's Basic Standards and Methodologies. In the letter, the Region again advised the State that the current toxics provisions of the Basic Standards and Methodologies were incomplete and subject to the federal promulgation. The letter explained the Agency's approach to the upcoming promulgation, and the proposed regulatory language and criteria values to be promulgated were enclosed for State review.

—July 12, 1990—In a memorandum to the State, Region VIII provided additional information on compliance with the toxic requirements and the upcoming federal promulgation. The memorandum included a listing of EPA published and modified toxics criteria which could be used in proposing needed amendments to the existing toxics provisions in the Basic Standards and Methodologies (modified criteria were based on the most recent information in IRIS).

—August 13, 1990—Region VIII sent an improved version of the toxics criteria chart to the State staff.

—September 19, 1990. Region VIII sent to the State a "strawman" data analysis which provided stream-specific information regarding the priority toxic pollutants that may require adoption of criteria to satisfy the option 2 full compliance requirements of section 303(c)(2)(B).

—February 21, 1991. The State proposed amendments to the Basic Standards and Methodologies for its July triennial review hearing. The proposed amendments include: (1) Revisions and additions to the existing aquatic life criteria, and (2) application of EPA's human health criteria to all class 1 waters and any class 2 waters which provide an exposure pathway via consumption of contaminated aquatic organisms and/or drinking water.

—May 21, 1991. Region VIII sent a letter to the State detailing three deficiencies in the State's February 21, 1991 proposed revisions to the Basic Standards and Methodologies: (1) Failure to explain why health-based standards applicable to water supply segments were not included for more than 40 priority toxic pollutants addressed by section 304(a) guidance, (2) failure to explain why health-based standards applicable to aquatic life segments were not included for more than 20 priority toxic pollutants addressed by section 304(a) guidance, and (3) failure to finally resolve within the Basic Standards and Methodologies the applicability of: (a) The numeric aquatic life and human health standards for inorganics, and (b) certain human health numeric standards (i.e., those that address human exposure from water and fish consumption) for organics. The Region VIII letter notified the State that these deficiencies would need to be addressed to satisfy the full compliance requirements and to ensure that Colorado would not be affected by the Federal section 303(c)(2)(B) promulgation.

—July 1, 1991. The State held a public hearing on the proposed standards revisions. At the hearing, EPA submitted written testimony that identified the specific issues and options related to section 303(c)(2)(B) compliance.

—August 20, 1991. In a letter to the State, EPA Region VIII approved the August 17, 1989 toxics criteria adopted by Colorado as partially fulfilling the requirements of section 303(c)(2)(B). The letter clearly indicated that additional State action would be required to achieve full compliance.

—October 8, 1991. The State Water Quality Control Commission adopted additional numeric criteria for priority toxic pollutants, including criteria for all such toxics addressed by EPA section 304(a) criteria guidance. The adopted standards were intended to resolve all issues related to section 303(c)(2)(B) compliance. Because EPA has not yet had sufficient opportunity to review and approve these standards, today's proposal is based on the standards previously adopted by the State on August 17, 1989.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved State criteria are not applicable to all appropriate State designated uses. For example, to fully protect aquatic life uses from the impacts of inorganic priority toxic pollutants (including metals), EPA proposes to promulgate aquatic life criteria for only those particular segments and inorganic substances for which State aquatic life criteria have not been applied. EPA invites public comment regarding any specific priority pollutants or water bodies for which

Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory data base and/or the Permit Compliance System data base.

North Dakota has not been included in today's proposed rulemaking because the State has adopted revised criteria in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—May 1, 1989. North Dakota completed its triennial review and revised the State's standards. The revised standards were submitted to EPA for review on September 20, 1989. The revised standards included new numeric criteria for some of the priority toxic pollutants; however, not all of the priority toxic pollutants for which EPA has developed 304(a) criteria were included in the revised State rule.

—January 17, 1990. Region VIII sent a letter to the State explaining the requirements for full compliance with section 303(c)(2)(B). The letter explained that the burden was on the State to demonstrate that additional criteria beyond those already adopted were not needed.

—February 7, 1990. In a letter from the North Dakota Water Supply and Pollution Control Division to EPA Region VIII, North Dakota notified EPA that it intended to meet the full compliance requirements by way of option 1 (i.e., an option 1 approach as described in EPA's December 12, 1988 guidance document and the Region's January 17, 1990 letter to the State).

—July 12, 1990. In a memorandum to the State, Region VIII provided additional information on compliance with the toxics requirements and the upcoming federal promulgation. The memorandum included a listing of EPA published and modified toxics criteria which could be used in proposing needed amendments to the existing toxics provisions in the State standards (modified criteria were based on the most recent information in IRIS).

—August 13, 1990. Region VIII sent an improved version of the toxics criteria chart to the State staff.

—October 16, 1990. The Region approved the previously adopted State standards as partially fulfilling the section 303(c)(2)(B) requirements and notified the State that the standards would be considered incomplete pending completion of the full compliance requirements. The Regional WQS review letter also notified the State that the incomplete portions of the State rule would be subject to the proposed federal promulgation.

—November 15, 1990. North Dakota adopted additional standards for the priority toxic pollutants. The amended standards include criteria for all of the priority pollutants for which EPA has published 304(a) criteria plus additional criteria based on the most recent information in EPA's IRIS data base. The amended standards meet the requirements for full compliance with section 303(c)(2)(B). The amended standards became effective February 1, 1991, and the standards were submitted by the State for EPA review and approval on February 25, 1991.

—March 8, 1991. Region VIII approved the amended State water quality standards and advised the State that the amended standards met the full compliance requirements of section 303(c)(2)(B).

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

South Dakota has not been included in today's proposed rulemakingbecause the State has adopted revised criteria for priority toxic pollutants in response to the section 393(c)(2)(B) requirement and received full EPA approval.

South Dakota's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—October 8, 1987. South Dakota completed its triennial review and revised the State's Standards. The revised Standards were submitted to EPA for review on May 5, 1989. The revised Standards included a reference to EPA's Water Quality Criteria, 1986 as the numeric criteria incorporated in State Standards; however, the State did not include or identify certain information needed to distinguish which specific EPA criteria had been adopted as State Standards.

—January 17, 1990. Region VIII sent a letter to the State explaining the requirements for full compliance with section 303(c)(2)(B). The letter explained that incorporation of EPA's national criteria into State Standards by reference to EPA's Quality Criteria for Water, 1986 was acceptable; however, such a reference would have to include sufficient information to identify the specific numeric criteria which comprised State Standards. The needed information was not provided prior to today's proposal.

—February 13, 1990. Region VIII sent a letter to the State further explaining the issues that would have to be clarified before the Region would be able to grant final approval of the toxics portion of the State water quality standards.

—March 8, 1990. South Dakota further amended the State Standards to clarify the role of the Department of Natural Resources in applying the criteria in Quality Criteria for Water, 1986; however, the new amendments did not address the specific information needed to satisfy the full compliance requirements for section 303(c)(2)(B).

—July 12, 1990. Region VIII sent additional information to the State on compliance with the toxics requirements and the upcoming federal promulgation. The memorandum included a listing of EPA published and modified toxics criteria which could be used in proposing needed amendments to the existing toxics provisions in the State standards (modified criteria were based on the most recent information in IRIS).

—August 13, 1990. Region VIII sent an improved version of the toxics criteria chart to the State staff.

—November 6, 1990. Region VIII sent additional information to the State further delineating the specific application information that would be needed to achieve approval of the toxics provisions of the water quality standards.

—March 6, 1991. In a letter from the Division of Environmental Regulation, South Dakota provided a complete interpretation of the toxics control provisions in section 74:03:02:14, the section of the South Dakota water quality standards which incorporates EPA's Quality Criteria for Water, 1986 by reference. The State's letter included a listing of the specific criteria which are considered to be standards of the State. The list included all of the published 304(a) criteria and identified the uses to which the criteria applied.

—March 13, 1991. The Region approved the adopted State criteria as fulfilling the section 303(c)(2)(B) requirements.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Utah has not been included in today's proposed rulemaking because the State has adopted revised criteria in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—April 21, 1988. Utah completed its triennial review and revised the State's standards. The revised standards were submitted to EPA for review on February 10, 1989. The revised standards included new numeric criteria for some of the priority toxic pollutants for which EPA has developed 304(a) criteria were included in the revised State rule.

—January 17, 1990. Region VIII sent a letter to the State enplaning the requirements for full compliance with section 303(c)(2)(B). The letter explained that the burden was on the State to demonstrate that additional criteria beyond those already adopted were not needed.

—January 31, 1990. In a letter from the Utah Bureau of Water Pollution Control to EPA Region VIII, Utah notified EPA that it intended to meet the full compliance requirements by way of option 1 (i.e., an option 1 approach as described in EPA's December 12, 1988 guidance document and the Region's January 17, 1990 letter to the State).

—July 12, 1990. In a memorandum to the State, Region VIII provided additional information on compliance with the toxics requirements and the upcoming federal promulgation. The memorandum included a listing of EPA published and modified toxics criteria which could be used in proposing needed amendments to the existing toxics provisions in the State standards (modified criteria were based on the most recent information in IRIS).

—August 13, 1990. Region VIII sent an improved version of the toxics criteria chart to the State staff.

—November 29, 1990. The Region approved the previously adopted State standards as partially fulfilling the section 303(c)(2)(B) requirements and notified the State that the standards would be considered incomplete pending completion of the full compliance requirements. The Regional water quality standards review letter also notified the State that the incomplete portions of the State rule would be subject to the provisions of the proposed federal promulgation.

—January 18, 1991. Utah adopted additional standards for the priority toxic pollutants. The amended standards include criteria for all of the priority pollutants for which EPA has published 304(a) criteria. The amended standards meet the requirements for full compliance with section 303(c)(2)(B). The amended standards were submitted by the State for EPA review and approval on February 13, 1991.

—March 8, 1991. Region VIII approved the amended State water quality standards and advised the State that the amended standards met the full compliance requirements of section 303(c)(2)(B).

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Wyoming has not been included in today's proposed rulemaking because the State has adopted revised criteria in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—January 17, 1990. Region VIII sent a letter to the State explaining the requirements for full compliance with section 303(c)(2)(B). The letter explained that the burden was on the State to demonstrate that additional criteria beyond those already adopted were not needed.

—February 12, 1990. In a letter from the Wyoming Water Quality Division of the Department of Environmental Quality, Wyoming notified EPA that it intended to meet the full compliance requirements by way of option 1 (i.e., an option 1 approach as described in EPA's December 12, 1988 guidance document and the Region's January 17, 1990 letter to the State).

—May 29, 1990. Region VIII provided written comments for the Wyoming Environmental Quality Council triennial review hearing. The Region's comments further explained the requirements for full compliance with section 303(c)(2)(B).

—July 12, 1990. In a memorandum to the State, Region VIII provided additional information on compliance with the toxics requirements and the upcoming federal promulgation. The memorandum included a listing of EPA published and modified toxics criteria which could be used in proposing needed amendments to the existing toxics provisions in the State standards (modified criteria were based on the most recent information in IRIS).

—July 19, 1990. Region VIII provided additional written comment to the Wyoming Environmental Quality Council. The Region's comments provided further information on the toxics requirements, including specific lists of published and modified criteria for the priority pollutants which would meet the full compliance requirements.

—August 13, 1990. Region VIII sent an improved version of the toxics criteria chart to the State staff.

—October 3, 1990. Wyoming adopted additional standards for the priority toxic pollutants. The amended standards include criteria for all of the priority pollutants for which EPA has published 304(a) criteria plus additional criteria based on the most recent information in EPA's IRIS data base. The amended standards meet the requirements for full compliance with section 303(c)(2)(B). The amended standards became effective November 29, 1990, and the standards were submitted by the State for EPA review and approval on December 24, 1990. Clarification of the legal standing of the newly adopted rule was provided with a memorandum from the State dated January 12, 1991.

—March 8, 1991. Region VIII approved the amended State water quality standards and advised the State that the amended standards met the full compliance requirements of section 303(c)(2)(B).

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary to respond to those comments and reevaluate the Agency's determination of full compliance.

Montana has not been included in today's proposed rulemaking because the State has adopted revised criteria in response to the section 303(c)(2)(B) requirement and received full EPA approval. The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—September 23, 1988. The State adopted final water quality standards which included numeric criteria for the priority toxic pollutants (by reference to EPA's Quality Criteria for Water, 1986 through update #2 1987 including supporting information).

—December 9, 1988. The State submitted the adopted water quality standards with a State Attorney General certification to EPA for approval/disapproval.

—March 8, 1989. EPA approved the portion of the revised State water quality standards which responded to the requirements of section 303(c)(2)(B) (other portions of the revised standards were disapproved).

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary to respond to those comments and reevaluate the Agency's determination of full compliance.

Region 9

American Samoa has not been included in today's proposed rulemaking because it has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

American Samoa's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—January 1990. American Samoa submitted draft water quality standards revisions to EPA and the public for review.

—February 1990. American Samoa held a public hearing on its proposed water quality standards revisions.

—September 7, 1990. The American Samoa Environmental Commission adopted its proposed water quality standards revisions which include numeric criteria for priority toxic pollutants.

—September 20, 1990. American Samoa submitted the adopted water quality standards to EPA for approval/disapproval.

—September 25, 1990. American Samoa submitted the State Attorney General certification.

—September 27, 1990. EPA approved the revised American Samoa water quality standards, including full approval of the revised numeric criteria for priority pollutants.

EPA fully approved the criteria for priority toxic pollutants adopted by American Samoa on September 27, 1990 based on a determination that the criteria are consistent with option 1 of the December 12, 1988 section 303(c)(2)(B) guidance document.

If additional information is submitted during the public comment period asserting that American Samoa has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Arizona is included in today's proposal because, although the State adopted numeric criteria for some priority toxic pollutants before the 1987 amendments, the State has not completed a review of their numeric criteria for priority toxic pollutants in response to the statutory requirement and EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—Late 1988. The State submitted a series of discussion papers to EPA and the public.

—June 7, 1989. The State submitted draft water quality standards revisions to EPA for review prior to issuing proposed standards for public comment.

—December 11, 1989. The State transmitted a Surface Water Quality Standards Triennial Review Briefing Book, dated December 8, 1989, to EPA and the public.

—February 15, 1990. The State submitted, to EPA and the public, draft proposed revisions to its Surface Water Quality Standards.

—March 16, 1990. The State submitted Proposed Surface Water Quality Standards Rules to EPA and the public.

—During 1988–90, the State held several public meetings and roundtables regarding the proposed water quality standards.

—October 26, 1990. Arizona prepared revised draft water quality standards which were released for comment October 29, 1990.

—December 14, 1990. EPA provided written comments to the States.

—January 15, 1991. Arizona prepared a re-draft of the water quality standards for review and comment.

—February 13, 1991. EPA provided written comments to the States.

—May 8, 1991. Arizona approval by the Governor's Regulatory Review Council on May 7, 1991 of the Navigable Water Quality Standards proposed rules and the Economic Impact Statement.

Also announced the schedule of oral proceedings and availability of the proposed rules.

Today's proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not included in approved State criteria. EPA also proposes to promulgate the § 131.36(b) criteria where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all waters with relevant State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for section 303(c)(2)(B) criteria. For most priority toxic pollutants, however, available data on the discharge and presence of such pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that section 303(c)(2)(B) criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State Section 304(l) lists (as updated), and supporting documentation, for which State criteria have not been adopted and approved, including metals, dioxin, and some organics.
—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 126 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.
—STORET data indicating the presence in surface waters of a majority of the priority toxic pollutants which are not covered with approved State criteria.
—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

California is included in today's proposal because, although the State has completed a review and adopted numeric criteria for some priority toxic pollutants for some waters in response to the statutory requirement, EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

For ocean waters, the State adopted revised criteria on March 22, 1990, and EPA fully approved those criteria on June 23, 1990. Regarding inland waters and bays and estuaries, the State adopted numeric criteria for some priority toxic pollutants before the 1987 amendments and a few site specific criteria since 1987. Included among these criteria are numeric criteria for copper, cadmium and zinc applicable to the Sacramento River and its tributaries upstream of Hamilton City adopted by the State on August 16, 1984, and approved by EPA on August 7, 1985. Since the 1987 amendments, the State adopted numeric monthly mean and maximum criteria for selenium in the San Joaquin River from the mouth of the Merced River to Vernalis and monthly mean criteria in flows to Grasslands Water District, San Luis National Wildlife Refuge, and Los Banos State Wildlife Area on September 21, 1989; EPA approved these criteria on April 13, 1990, and, at the same time, disapproved selenium criteria for other locations. These approved numeric criteria comply with section 303(c)(2)(B) and are not amended by today's proposed rulemaking. Subsequent to these specific efforts, the State completed a review of their numeric criteria for priority toxic pollutants for State inland waters and bays and estuaries and transmitted them to EPA. EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). In addition, several parties have petitioned State Court to restrain the SWRCB from utilizing the standards for inland waters and bays and estuaries.

The State's actions, regarding inland waters and bays and estuaries, to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—October 6, 1989. The State issued a staff report proposing methodologies for development of water quality criteria for statewide plans.
—December 1, 1989. EPA submitted written comments to State on its proposed methodology.
—January 29, 1990. The State issued draft water quality standards for inland surface waters and enclosed bays and estuaries for EPA and public review.
—February 28 and March 5, 1990. The State held public hearings on proposed standards revisions.
—March 29, 1990. EPA submitted written comments to the State on proposed standards revisions.
—August 16, 1990. The State held a public workshop on development and implementation of standards for agricultural drains and ephemeral streams. (EPA testified.)
—August 22, 1990. EPA submitted written comments to the State on development and implementation of standards for agricultural drains and ephemeral streams.
—November 2, 1990. The State issued revised draft water quality standards for EPA and public review.
—December 7, 1990. EPA submitted written comments on the revised draft water quality standards.
—December 10, 1990. The State held a hearing on the revised draft standards. (EPA testified.)
—February 8, 1991. EPA provided written comments to the State re: the agricultural drains section of the Inland Surface Waters Plan.
—March 26, 1991. The State issued drafts of the Statewide Water Quality Control Plans for Inland Surface Waters and Enclosed Bays and Estuaries.
—March 27, 1991. EPA provided written comments to the San Francisco Bay Regional Water Quality Control Board re: proposed interim objectives for toxic pollutants in the South Bay.
—April 10, 1991. EPA provided written comments to the State re: The Statewide Water Quality Control Plans for Inland Surface Waters and Enclosed Bays and Estuaries.
—April 10, 1991. EPA provided written comments to the State re: EPA's position on how to proceed with dioxin related programs.
—April 11, 1991. The State adopted the Statewide Waters Quality Control Plans for Inland Surface Water and Enclosed Bays and Estuaries.
—May 10, 1991. The State transmitted to EPA the Statewide Waters Quality Control Plans for Inland Surface Water and Enclosed Bays and Estuaries.

Today's proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all State inland waters and bays and estuaries, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not included in EPA approved State criteria. EPA also proposes to promulgate section 303(c)(2)(B) criteria for priority toxic pollutants where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all waters with relevant State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some additional Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for section 303(c)(2)(B) criteria. For most priority toxic pollutants, however, available data on the discharge and presence of such pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that section 303(c)(2)(B) criteria are necessary may be summarized as follows:

—priority toxic pollutants discussed in the State Section 304(l) lists, and supporting documentation, for which State criteria have not been adopted and approved, including metals, dioxin, and some organics,

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants for inland waters and bays and estuaries, as described above. The State has completed efforts to adopt new or revised chemical-specific, numeric criteria for 68 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—STORET data indicating the presence in inland waters and bays and estuaries of priority toxic pollutants which are not covered with approved State criteria (e.g., detection of more than 40 priority toxic pollutants in the water column).

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

The Commonwealth of the Northern Mariana Islands (CNMI) is included in today's proposal because, although the State adopted numeric criteria for some priority toxic pollutants before the 1987 amendments, the State has not completed a review of their numeric criteria for priority toxic pollutants in response to the statutory requirement and EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

The Commonwealth's actions to respond to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—March 22, 1990. The Commonwealth transmitted a letter to EPA indicating that its water quality standards revision process had been delayed.

—March 28, 1991. CNMI submitted draft water quality standards revisions to EPA for review.

—May 22, 1991. EPA provided comments to CNMI re: the draft revised standards.

Today's proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not included in approved State criteria. EPA also proposes to promulgate the § 131.36(b) criteria where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all waters with relevant State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—CNMI efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. CNMI has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 108 priority toxic pollutants. These efforts represent evidence of the CNMI's recognition of the need for numeric criteria for these priority toxic pollutants.

—STORET data indicating the presence in CNMI waters of priority toxic pollutants which are not covered with approved CNMI criteria.

Guam has not been included in today's proposed rulemaking because Guam has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

Guam's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—July 2, 1987. Guam adopted revised water quality standards which include numeric criteria for priority toxic pollutants.

—August 1987. Guam submitted the adopted water quality standards with an Attorney General certification to EPA for approval/disapproval.

—September 30, 1987. EPA approved the revised Guam water quality standards, including full approval of the revised numeric criteria for priority toxic pollutants. EPA fully approved the criteria for priority toxic pollutants adopted by Guam on July 2, 1987. It has been determined since that time that the criteria are consistent with option 1 of the December 12, 1988 section 303(c)(2)(B) guidance document.

If additional information is submitted during the public comment period asserting that Guam has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Hawaii is included in today's proposal because, although the State has completed a review and adopted numeric criteria for some priority toxic pollutants in response to the statutory requirement, EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirements can be summarized as follows:

—January 8, 1990. The State adopted revised criteria.

—February 9, 1990. Hawaii submitted the adopted water quality standards with a State Attorney General certification to EPA for approval/disapproval.

—May 9, 1990. EPA approved Hawaii's water quality standards noting that omission of human health limits for five toxic metals precluded full satisfaction of the section 303(c)(2)(B) requirement.

—May 29, 1990. The State responded to the EPA approval indicating plans to adopt human health limits for the five toxic metals.

—July 13, 1990. EPA clarified portions of the May 1990 approval letter.

Because the State has adopted criteria for priority toxic pollutants using an option 1 approach as described in EPA's December 12, 1988 guidance document EPA is taking an approach of proposing criteria for all remaining priority toxic pollutants which have been the subject of section 304(a)(1) criteria recommendations. EPA believes that the discharge or presence of these priority toxic pollutants can reasonably be expected to interfere with designated uses in the State and that Federal criteria therefore are necessary to protect Hawaii designated uses. This conclusion is based on the following information in the record:

—priority toxic pollutants on the State section 304(l) lists for which State criteria have not been adopted and approved, including these metals,

—STORET data indicating the presence in surface waters of these priority toxic pollutants.

Nevada is included in today's proposal because, although the State has completed a review and adopted numeric criteria for some priority toxic pollutants in response to the statutory requirement, EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—May 24, 1988. The State held a public hearing on it's proposed water quality standards revisions.

—September 12, 1988. The State submitted draft water quality standards revisions to EPA and the public for review.

—September 20, 1988. EPA provided comments to Nevada regarding its proposed water quality standards for toxics.

—October 21, 1988. The State submitted revisions to the Nevada toxic material definition and bioassay procedures to EPA and the public for review.

—November 10, 1988. The State held a public hearing on its proposed water quality standards revisions.

—November 29, 1988. The State held a public hearing on its proposed water quality standards revisions. (Revisions to the definition of "toxic" were adopted following this hearing.)

—May 31, 1989. The State submitted draft water quality standards revisions to EPA and the public for review.

—June 22, 1989. EPA provided comments to Nevada regarding its proposed standards for toxics.

—August 9, 1989. The State submitted draft water quality standards revisions to EPA and the public for review.

—August 22, 1989. The State submitted draft water quality standards revisions and rationale to EPA.

—September 18, 1989. EPA provided comments on Nevada's proposed water quality standards for toxics.

—September 27, 1989. The State held a public hearing on its proposed water quality standards revisions. (Revisions to the bioassay requirements as part of the narrative toxics standard were adopted following this hearing.)

—February 26, 1990. The State submitted draft water quality standards revisions to EPA and the public for review.

—March 27, 1990. EPA provided comments on Nevada's proposed February 26, 1990 toxics standards.

—March 28, 1990. The State held a public hearing on its proposed water quality standards revisions.

—May 2, 1990. EPA provided comments regarding the latest proposed standards revisions.

—May 2, 1990. The State adopted water quality standards revision which included some numeric criteria for priority toxic pollutants.

—August 23, 1990. State transmitted approved water quality standards revisions without a State Attorney General Certification to EPA for approval/disapproval.

—September 28, 1990. The State Attorney General certified the May 2, 1990 adoption.

—January 16, 1991. EPA approved in part and disapproved in part standards adopted by the State and notified them of the actions they needed to take pursuant to the disapproval and that they had not fully satisfied section 303(c)(2)(B).

—March 14, 1991. The State responded to the January 1991 approval/disapproval of standards.

Today's proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not included in approved State criteria. EPA also proposes to promulgate the § 131.36(b) criteria where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all waters with relevant State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for criteria. For most priority toxic pollutants, however, available data on the discharge and presence of such pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that section 303(c)(2)(B) criteria are necessary may be summarized as follows:

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 108 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—Presence in surface waters of the State of priority pollutants for which sufficient State numeric criteria have not been adopted, based on surface water monitoring data in STORET.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

The Trust Territories of the Pacific Islands (Palau) has not been included in today's proposed rulemaking because Palau has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

Palau's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—November 7, 1990. Palau adopted revised water quality standards which include numeric criteria for priority toxic pollutants.

—December 12, 1990. Palau submitted the adopted water quality standards with an Attorney General certification to EPA for approval/disapproval.

—January 11, 1991. EPA approved the revised Palau water quality standards, including full approval of the revised numeric criteria for priority toxic pollutants.

EPA fully approved the criteria for priority toxic pollutants adopted by Palau on January 11, 1991 based on a determination that the criteria are consistent with option 1 of the December 12, 1988 section 303(c)(2)(B) guidance document.

If additional information is submitted during the public comment period asserting that Palau has not fully complied with section 303(c)(2)(B), it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Region 10

Alaska is included in today's proposal because although the State had previously adopted all section 304(a) criteria by reference, the State Attorney General has decided that the adoption by reference is invalid. Based on information in the record (see below), EPA has reason to believe that at least some criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Alaska's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—December 20, 1989. The State submitted draft water quality standards revisions to EPA and the public for review.

—April 6, 1990. The State held public hearings and accepted written comments on its proposed water quality standards revisions through this date.

—On November 4, 1991, Region 10 sent a letter to the State partially approving the State's incorporation by reference of EPA's toxic pollutant criteria; and noting the deficiencies which will be included in EPA's proposed rulemaking (e.g. Alaska's failure to adopt a human health criteria).

This proposed rulemaking would federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above.

The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 103 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—STORET data indicating the presence in surface waters of priority toxic pollutants which are not currently covered with approved State criteria.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

Idaho is included in today's proposal because although the State adopted some numeric criteria for human health protection for some priority toxic pollutants before the 1987 amendments, the State has not completed a review of their numeric criteria for priority toxic pollutants in response to the statutory requirement. Furthermore, the State's criteria protecting human health are based only on drinking water maximum contaminant levels; fish consumption is not protected, and EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Idaho's action to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—July 23, 1990. The State submitted draft water quality standards revisions to EPA and the public for review.

This proposed rulemaking would federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously aapproved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State Section 304(l) short list for which State criteria have not been adopted and approved, including metals and some organics.

—STORET data indicating the presence in surface waters of priority toxic pollutants which are not currently covered with approved State criteria.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

Oregon has not been included in today's proposed rulemaking because the State has adopted revised criteria for priority toxic pollutants in response to the section 303(c)(2)(B) requirement and received full EPA approval.

The State's response to the 1987 section 303(c)(2)(B) requirement can be summarized as follows.

—August 28, 1987. The State adopted revised water quality standards which included numeric criteria for priority toxic pollutants.

—January 26, 1988. The State submitted the adopted water quality standards with a State Attorney General certification to EPA for approval/disapproval.

—March 9, 1988. EPA approved the revised State water quality standards, including full approval of the revised numeric criteria for priority toxic pollutants.

EPA fully approved the criteria for priority toxic pollutants adopted by Oregon on February 12, 1989 as being consistent with option 2 of the December 12, 1988 section 303(c)(2)(B) guidance document.

If additional information is submitted during the public comment period asserting that the State has not fully complied with section 303(c)(2)(B) it will be necessary at that time to respond to those comments and reevaluate the Agency's determination of full compliance.

Washington is included in today's proposal because although the State adopted numeric criteria for some priority toxic pollutants before the 1987 amendments, the State has not adopted numeric criteria for any human health based criteria for priority pollutants, and EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B). Therefore, EPA has determined for purposes of today's proposed rulemaking that the State is not currently in compliance with section 303(c)(2)(B) because it has not adopted water quality standards consistent with section 303(c)(2)(B) which have been fully approved by the appropriate EPA Regional Administrator.

Washington adopted 26 freshwater and marine criteria which EPA fully approved on March 4, 1988 (see below). The State has not completed a review of their criteria for priority toxic pollutants in response to the statutory requirement and EPA has reason to believe that at least some additional criteria are necessary to comply with section 303(c)(2)(B).

The State's actions to respond to the 1987 section 303(c)(2)(B) requirement can be summarized as follows:

—February 9, 1988. The State submitted the adopted water quality standards with a State Attorney General certification to EPA for approval/disapproval.

—March 4, 1988. EPA approved the revised State water quality standards.

—July 20, 1990. Washington released its proposed water quality standards with public comments accepted through this date.

This proposed rulemaking would Federally promulgate the criteria necessary to bring the State into full compliance with section 303(c)(2)(B). To fully protect State designated uses, and to ensure that the required criteria are adopted, EPA proposes to apply broadly the criteria in proposed § 131.36(b). At a minimum, EPA proposes to apply, to all appropriate State waters, the criteria in proposed § 131.36(b) for all priority toxic pollutants which are not the subject of approved State criteria. EPA also proposes to promulgate Federal criteria for priority toxic pollutants where any previously-approved State criteria are insufficiently stringent to fully protect all designated uses, or where such previously-approved State criteria are not applicable to all appropriate State designated uses. EPA invites public comment regarding any specific priority pollutants or water bodies for which Federal criteria may not be necessary to protect State designated uses.

For reasons which are fully discussed in the preamble, EPA has not attempted to determine the specific priority pollutants and water bodies that require criteria. However, EPA has determined that at least some Federal criteria are necessary to protect designated uses. This determination is supported by information in the record which demonstrates that priority toxic pollutants are discharged or present in surface waters at levels that can reasonably be expected to interfere with State designated uses. For some priority toxic pollutants, available data clearly demonstrate use impairment and the need for toxics criteria. For most priority toxic pollutants, however, available data on the discharge and presence of priority toxic pollutants are spatially and temporally limited. Nevertheless, EPA believes that the data for many of these pollutants are sufficient to satisfy the "reasonable expectation" test established in section 303(c)(2)(B). The information in the record which demonstrates that priority toxic pollutants are discharged or present and that Federal criteria are necessary may be summarized as follows:

—Priority toxic pollutants on the State Section 304(l) short list for which State criteria have not been adopted and approved, including metals and some organics.

—State efforts since 1987 to adopt additional numeric criteria for priority toxic pollutants, as described above. The State has initiated (but not completed) efforts to adopt new or revised chemical-specific, numeric criteria for 91 priority toxic pollutants. These efforts represent evidence of the State's recognition of the need for numeric criteria for these priority toxic pollutants.

—STORET data indicating the presence in surface waters of priority toxic pollutants which are not currently covered with approved State criteria.

—Discharge to surface waters of priority pollutants for which sufficient State numeric criteria have not been adopted, based on data in the Toxics Release Inventory database and/or the Permit Compliance System database.

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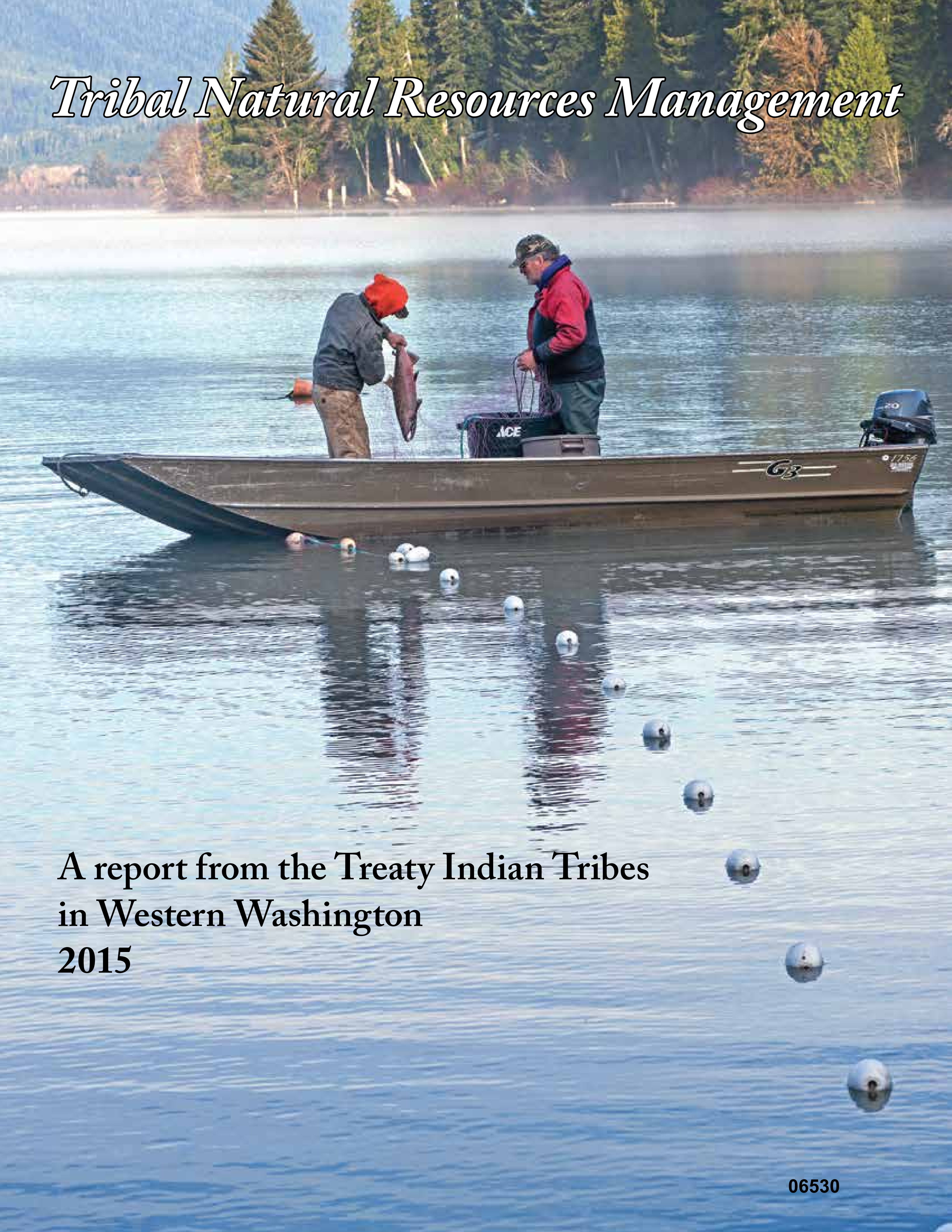
Tribal Natural Resources Management



A report from the Treaty Indian Tribes in Western Washington

2015

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We, the Indians of the Pacific Northwest, recognize that our fisheries are a basic and important natural resource and of vital concern to the Indians of this state, and that the conservation of this natural resource is dependent upon effective and progressive management. We further believe that by unity of action, we can best accomplish these things, not only for the benefit of our own people, but for all of the people of the Pacific Northwest.

– PREAMBLE TO THE NWIFC CONSTITUTION

Member Tribes of the Northwest Indian Fisheries Commission

Cover: Shawn Johnstone, left, and Skip Pickett, Quinault Indian Nation hatchery technicians, pull a coho from a net as part of the Quinault Indian Nation's hatchery operations on Lake Quinault. *Photo: Debbie Preston. Map: Ron McFarlane.*

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Year in Review

Lorraine Loomis

As we celebrated the 40th anniversary of *U.S. v. Washington* (the Boldt decision) this year we also mourned the loss of Billy Frank Jr., our longtime chairman and good friend. Billy, 83, passed away on May 5, 2014.

From his first arrest at age 14, Billy spent his entire life fighting for the recognition of tribal rights reserved in treaties with the United States. The 1974 ruling by Judge George Boldt in *U.S. v. Washington* re-affirmed the tribal treaty right to harvest salmon and established the tribes as natural resources co-managers entitled to half of the harvestable salmon returning annually to western Washington waters.

Today tribes are leaders in the management of the region's salmon fisheries and other natural resources.

Billy Frank Jr.

I am honored and humbled to follow in Billy's footsteps as chair of the Northwest Indian Fisheries Commission. The tribes remain committed to Billy's legacy and direction to "stay the course" with salmon recovery. Our goal is to return all salmon populations to sustainable levels that can support harvest. We commit ourselves to this task with the recognition that we must act in the best interests of those who will follow us seven generations from now.

Treaty Rights at Risk

Sadly, ongoing loss and damage to salmon habitat has stalled salmon recovery and threatens tribal treaty rights. For those rights to have meaning, there must be salmon available for harvest. That is why we are continuing the Treaty Rights at Risk initiative begun in July 2011 by Billy and other tribal leaders.

Through this effort we are asking the federal government, our trustee, to align its agencies and programs and take charge of a more coordinated salmon recovery effort. We want the federal government to take charge of salmon recovery because it has the obligation and the authority to ensure both salmon recovery and protection of treaty rights.

We are disappointed with the federal government's slow response and lack of progress. There has been a lot of discussion, but little action by the federal government, in spite of its responsibility to protect tribes' treaty rights and recover salmon stocks listed as threatened under the federal Endangered Species Act (ESA).

We have requested that the Treaty Rights at Risk initiative be institutionalized in the U.S. government via President Obama's Council on Native American Affairs created several years ago. Addressing tribal natural resources concerns was supposed to be one of five main areas of work when the council was founded. Subgroups of the council already have been formed to focus on economic development, education, climate change and energy. We think a similar group should be formed to address tribal natural resources concerns, especially salmon recovery and treaty rights.

Importance of Hatcheries

Even as we struggle with the continual decline of salmon populations caused by lost and damaged habitat, hatcheries are under attack. Hatcheries were designed to make up for lost natural salmon production, and are essential to fulfilling tribal treaty rights, but federal funding has not kept pace with needed repairs and replacement of aging facilities. Tribes produce about 40 million salmon and steelhead annually.

The National Marine Fisheries Service has worsened the situation by delaying review and approval of permits required under the ESA for hatchery operations. The delays led to legal action that prevented the release last fall of nearly 1 million hatchery-raised steelhead in western Washington. Indian and non-Indian fishermen will feel the loss of those fish for years to come.

Hatcheries and the salmon they produce are absolutely necessary as long as lost and damaged habitat prevents salmon recovery. They deserve more support from all corners. Today, most of the chinook and coho harvested by Indian and non-Indian fishermen come from hatcheries.

Updated Water Quality Standards

Tribes continued their efforts to encourage the state of Washington to adopt a more realistic fish consumption rate as part of updating water quality standards. The higher the fish consumption rate, the cleaner the water must be.

For more than 20 years, the state has operated under water quality rules based on a fish consumption rate of 6.5 grams per day, or one 8-ounce serving a month. This was one of the lowest rates in the nation, even though Washington residents eat more fish and shellfish than people in other states, and most tribal members consume much more than that.

In July, Gov. Jay Inslee approved an increase to 175 grams per day, a compromise rate supported by the tribes, but still lower than the actual amount of fish and shellfish eaten by Indian people in western Washington. At the same time, Inslee increased the risk of getting cancer from water pollution from one in a million to one in 100,000. The tenfold increase in cancer risk effectively cancels out most of the benefits of the higher fish consumption rate.

As a result, the treaty tribes have approached their trustee, the U.S. Environmental Protection Agency, to step in and enact new water quality rules for the state. The 1972 federal Clean Water Act requires states to implement standards that ensure waters are clean enough to support fish that are safe to eat.

Fossil Fuel Transportation

Proposals to build coal and oil export terminals in western Washington continued as major concerns in 2014. The planned increases in train and ship traffic threaten the health and safety of tribal members as well as treaty-protected rights and resources.

Coal export terminals proposed for Cherry Point near Bellingham and Longview on the Columbia River would be fed by hundreds of trains daily from coal fields in Montana and Wyoming. Coal dust from each train would be spread all along its route.

Also proposed is a plan to use mile-long crude-oil trains to feed massive new oil terminals in Grays Harbor. As with increased coal train traffic, tribes are deeply concerned about health, safety and environmental issues associated with the trains and ships transporting the oil.

Disastrous Fraser Sockeye Season

A high diversion rate of Fraser River sockeye through Johnstone Strait around the northern part of Vancouver Island led to poor catches for treaty tribal and non-tribal fishers in 2014. Nine treaty Indian tribes in western Washington harvest sockeye returning to British Columbia's Fraser River.

Typically, about half of the returning sockeye swim around Vancouver Island and through the Strait of Juan de Fuca where treaty tribal and non-Indian commercial fishermen can harvest them when they enter U.S. waters. By the end of August, Canadian fishermen had caught about five million fish; non-Indian commercial and treaty tribal fishermen harvested about 275,000.

Tribes will be requesting a declaration of natural disaster under the Stafford Disaster Relief and Emergency Assistance Act, and a fisheries economic disaster under the Magnuson-Stevens Act, which would provide services and financial assistance to fishermen.

Culvert Repairs Begin

As part of the favorable ruling for the tribes in the Culvert Case, talks began in 2014 to prioritize repair of culverts under state roads that are barriers to fish passage. The state was ordered by the federal court in 2013 to repair more than 600 state-owned culverts over the next 17 years. Fish-blocking culverts deny salmon access to hundreds of miles of good habitat in western Washington streams, affecting the fish in all stages of their life cycle. The treaty tribes and the U.S. filed the initial Culvert Case litigation in 2001 under *U.S. v. Washington*. The state has appealed the ruling.

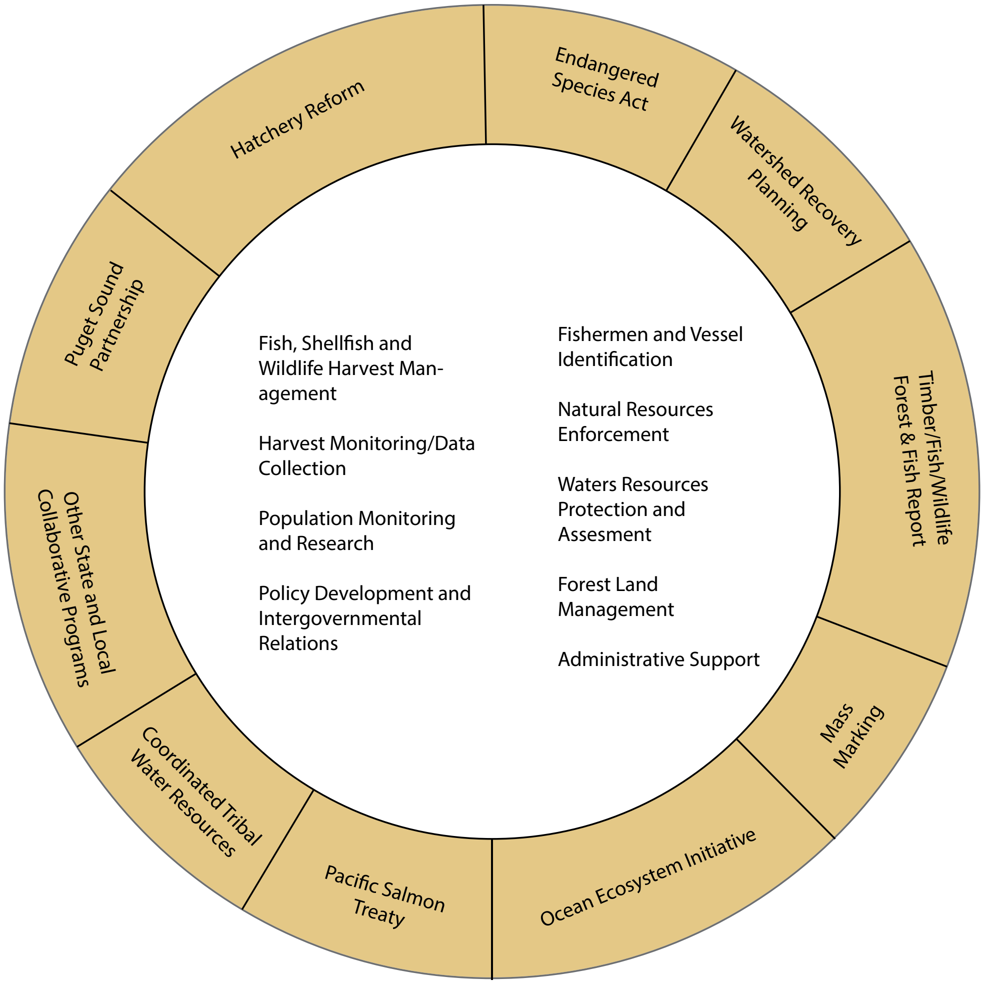
To find out more about these and other natural resources management issues important to the treaty tribes, visit the Northwest Indian Fisheries Commission website at *nwifc.org*.

Lorraine Loomis

Lorraine Loomis
NWIFC Chair

Tribal Natural Resources Management Core Program

Natural resources management functions and associated programs of the treaty tribes in western Washington:



Habitat Management

Habitat protection and restoration are essential for recovery of wild salmon in western Washington. Tribes are taking action to recover salmon in each watershed.

- The tribes continue to support the Treaty Rights at Risk initiative, calling on the federal government to align its agencies and programs to better meet salmon recovery goals, particularly those for habitat protection and restoration. The initiative calls on the federal government to lead a more coordinated salmon recovery effort because it has both the obligation and authority to recover salmon and protect tribal treaty rights.

- The NWIFC Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) provides a "living database" of local and regional habitat conditions. SSHIAP has launched an interactive map to track repairs to state-owned culverts; a tool to map potential steelhead habitat; and a data exchange for research about the nearshore environment.

- Tribes continue to address the habitat concerns identified in the 2012 State of Our Watersheds report. The report, which documents ongoing loss and damage of salmon habitat, can be viewed at *nwifc.org/sow*. It will undergo a comprehensive update in 2015.

- Tribes conduct extensive monitoring of water quality for pollution, and ensure factors such as dissolved oxygen and temperature levels are adequate for salmon and other fish. To make limited federal funding work to its fullest, tribes partner with state agencies, industries and property owners through collaborative habitat protection, restoration and enhancement efforts.

- In western Washington, the National Oceanic and Atmospheric Administration's Pacific Coastal Salmon Recovery Fund has supported projects that have restored thousands of acres of forest, protected hundreds of acres of habitat and removed hundreds of fish passage barriers.

Lower Elwha Klallam Tribe Monitors Restored River

Tiffany Royal

With the Glines Canyon and Elwha dams completely removed, the Elwha River now flows freely.

While two massive fish-blocking dams on the Elwha River were being torn down between 2011 and 2014, the Lower Elwha Klallam Tribe was studying how the river, salmon and wildlife were responding to dam removal.

After the 108-foot-tall Elwha and 210-foot-tall Glines Canyon dams were built in the early 1900s, millions of cubic yards of sediment built up behind the structures, creating lakes Aldwell and Mills.

As the dams were deconstructed, sediment flowed downriver, changing the dynamics of the river and restoring the river mouth from cobblestone to sandy beach. Scientists have found forage fish and shellfish, such as Dungeness crab, using the new habitat.

In the estuaries, tribal staff are seining the ponds to examine fish populations and study the stomach contents of juvenile salmon.

After the Elwha Dam was completely removed by spring 2013, salmon were found spawning above the former dam site. The second dam, Glines Canyon, was completely removed by end of September 2014 and soon after, bull trout and chinook were detected beyond that dam site.

Biologists have been counting adult fish through scuba surveys and a sonar camera in the lower river. Since 2013, biologists have counted nearly 9,000 chinook and steelhead returning to the river.

The tribe's new hatchery was finished in 2010 and regularly spawns and rears coho and chum salmon. It also operates steelhead and pink broodstock programs.

Since lakes Aldwell and Mills were drained, crews from the tribe, Washington Conservation Corps and Olympic National Park have been eradicating invasive plants and replacing them with native trees, shrubs and grasses within the new open riverbeds. More than 50 engineered logjams have been installed to help slow the river's velocity and create pools and other salmon habitat.

The tribe's wildlife staff studied river otters and American dippers, looking at how the animals used the river for food and habitat and how those needs were impacted by dam removal. Post-dam removal, the wildlife staff is monitoring how elk, deer and small mammals are using the newly exposed lakebeds as habitat.

Hatchery Management

Hatcheries must remain a central part of salmon management in western Washington as long as lost and degraded habitat prevents watersheds from naturally producing abundant, self-sustaining runs of sufficient size to meet tribal treaty fishing harvest rights.

- Treaty Indian tribes released more than 39 million salmon in 2013, including 10 million chinook, 16.5 million chum and 7.7 million coho.

- Most tribal hatcheries produce salmon for harvest by both Indian and non-Indian fishermen. Some serve as wild salmon nurseries that improve the survival of juvenile fish and increase returns of salmon that spawn naturally in our watersheds.

- Tribes conduct an extensive mass marking and coded-wire tag program. Young fish are marked by having their adipose fin clipped before release. Tiny coded-wire tags are inserted into the noses of young salmon. The tags from marked fish are recovered in fisheries, providing important information about marine survival, migration and hatchery effectiveness.

Tribal Programs Support Threatened Steelhead

Tribal hatcheries not only produce fish for harvest, but also provide a vital role in helping imperiled stocks. Some tribal facilities are the linchpin in restoring weak runs of steelhead. Puget Sound steelhead are listed as threatened under the federal Endangered Species Act.

Hatchery programs started by the Skokomish, Puyallup and Muckleshoot tribes in 2006 to rescue weak runs of steelhead have seen tremendous results.

The steelhead population in the Skokomish River has doubled since the Skokomish Tribe began its supplementation project as part of a 16-year-long project to boost the steelhead stocks in Hood Canal.

"The increase in the number of egg nests has given us an early indication that the project is working, but the long-term monitoring will be the true test of its success," said Matt Kowalski, the tribe's steelhead biologist.

The tribe spent the past eight years collecting 30,000 steelhead eggs annually from the Skokomish River. The eggs, collected between May and June, have been raised to smolts in a state hatchery. Most are released as juveniles, but 400 of the fish are transported to a federal hatchery where they are raised to 4-year-old adults before release to improve their chances of spawning in the river.

The Puyallup Tribe of Indians is continuing its successful steelhead broodstock program by releasing young steelhead from an acclimation pond in the upper White River.

"Acclimation ponds help ensure there are juvenile steelhead in the river each year to take advantage of the available habitat," said Blake Smith, the tribe's hatchery manager. The fish will be released at a pond on Huckleberry Creek, a tributary to the White River in the Puyallup watershed.

To help recover the declining run, the Muckleshoot and Puyallup tribes started the steelhead broodstock program eight years ago. Each year, the partners spawn up to 25 wild steelhead taken from an adult trap on the White River.

Up to 50,000 juvenile steelhead are produced annually at the Muckleshoot Tribe's White River hatchery. This year will mark the first release of hatchery steelhead from the acclimation ponds.


Tiffany Royal

Tribal and federal staff and volunteers collect steelhead eggs from the Skokomish River valley.

Harvest Management

Salmon

Treaty Indian tribes and the Washington Department of Fish and Wildlife co-manage salmon fisheries in Puget Sound, the Strait of Juan de Fuca and nearshore coastal waters.

- For decades, state and tribal salmon co-managers have reduced harvest in response to declining salmon runs. Tribes have cut harvest by 80-90 percent since 1985.
- Under *U.S. v. Washington* (the Boldt decision), harvest occurs only after sufficient fish are available to sustain the resource.
- The tribes monitor their harvest using the Treaty Indian Catch Monitoring Program to provide accurate, same-day catch statistics for treaty Indian fisheries. The program enables close monitoring of tribal harvest levels and allows in-season adjustments.
- Tribal and state managers work cooperatively through the Pacific Fishery Management Council and the North of Falcon process to develop fishing seasons. The co-managers also cooperate with Canadian and Alaskan fisheries managers through the U.S./Canada Pacific Salmon Treaty.

Fraser Sockeye Run Avoids U.S. Waters

Kari Neumeyer

Swinomish fisherman Landy James helps bring in Fraser sockeye during the tribes' ceremonial and subsistence fishery.

Tribal fishermen had high hopes for the 2014 Fraser River sockeye fishery, forecast to be more than 20 million fish.

The returning fish were the offspring of the record 2010 Fraser run of about 30 million fish.

Unfortunately, 96 percent of the sockeye were diverted into Canadian waters, out of reach for the nine tribes with treaty-reserved rights to harvest Fraser sockeye. The tribes are Jamestown S'Klallam, Lower Elwha Klallam, Lummi, Nooksack, Makah, Port Gamble S'Klallam, Suquamish, Swinomish and Tulalip.

This year's diversion rate was one of the highest on record. Usually, about half of the sockeye swim around Vancouver Island through the Strait of Juan de Fuca, where tribal fishermen can harvest them when they enter U.S. waters. But by the end of August, Canadian fishermen had caught about five million Fraser sockeye, while in the States, tribal and non-tribal fishermen had caught about 275,000 fish.

Tribes will be requesting a declaration of natural disaster under the Stafford Disaster Relief and Emergency Assistance Act, and a fisheries economic disaster under the Magnuson-Stevens Act, which would provide services and financial assistance to fishermen.

Before the commercial fishery opened in August, the Swinomish Tribe held a one-day ceremonial and subsistence fishery intended to harvest sockeye for both Swinomish and Tulalip tribal members to put away for the winter.

"The tribes take some of their quota to save for ceremonies, and to give to tribal members to cook or can," said Lorraine Loomis, fisheries manager of the Swinomish Tribe. "We don't have enough fish to get through the winter."

The tribes were targeting 35,000 sockeye to be caught for the nine sockeye tribes' ceremonial and subsistence use, but only 3,100 were caught.

Lummi Nation tribal members fished for Fraser sockeye with a traditional reef net in addition to their commercial purse seine and gillnet fleet.

"It's an imitation of the seafloor, like a reef," said Lummi fisherman Richard Solomon. "*Sxwole* is what our people called it."

The net is suspended from two canoes while tribal fishermen watch for salmon to swim into the simulated reef and then lift the net.

"We have to relive the path," said Lummi fisherman Troy Olsen. "Our journey back to the *sxwole*, our reef net, is in its infancy and we're just now starting."

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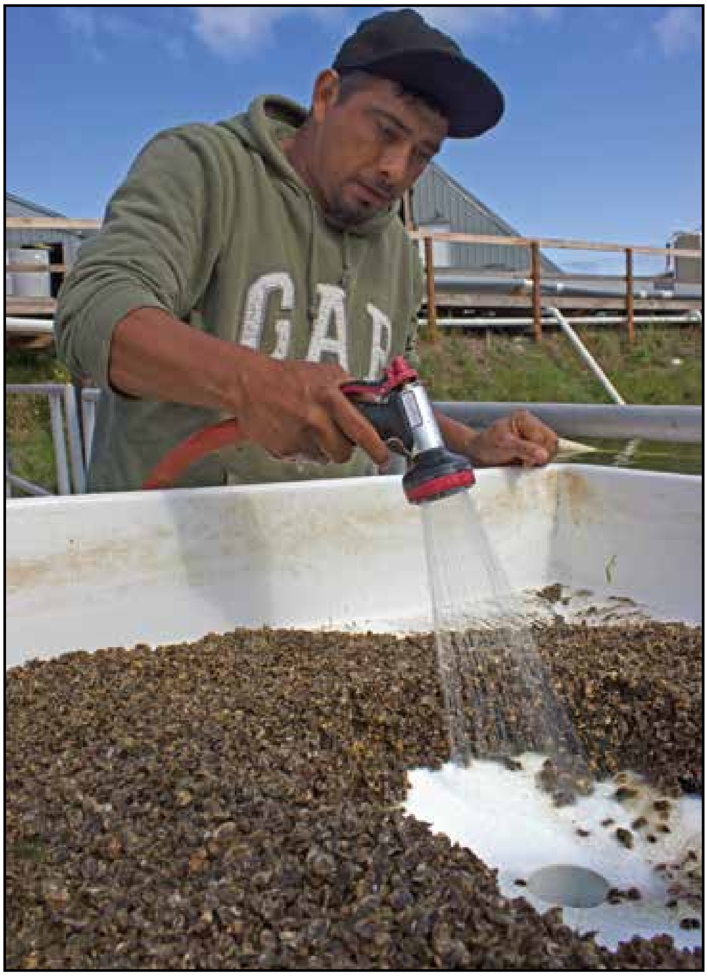
Shellfish

Treaty tribes harvest native littleneck, manila and geoduck clams, Pacific oysters, Dungeness crab, shrimp and other shellfish throughout the coast and Puget Sound.

- Shellfish from ceremonial and subsistence fisheries are for tribal use only, and are a necessary part of their culture and traditional diet.
- Tribal shellfish programs manage harvests with other tribes and the state through resource-sharing agreements. The tribes are exploring ways to improve management of other species, including sea cucumbers, Olympia oysters and sea urchins.
- Tribes continue to work with property owners to manage harvest on non-tribal tidelands.
- Tribal shellfish enhancement results in bigger and more consistent harvests that benefit both tribal and non-tribal diggers.
- Shellfish harvested in commercial fisheries are sold to licensed shellfish buyers. For the protection of public health, shellfish are harvested and processed according to strict state and national standards.
- In 2013, treaty tribes in western Washington commercially harvested nearly 900,000 pounds of manila and littleneck clams; more than 2.6 million pounds of geoduck clams; more than 4 million oysters; 8.5 million pounds of crab; nearly 271,000 pounds of sea cucumbers and more than 247,000 pounds of shrimp.

Jamestown S'Klallam, Partners Start Hatchery


Tiffany Royal

Hatchery technician Nicolas Rosales rinses oysters before placing them in a floating upwelling system.

The Jamestown S'Klallam Tribe is developing its own shellfish hatchery to benefit both tribal and non-tribal shellfish operations in Puget Sound.

The tribe plans to raise shellfish and grow seed to sell, said Kurt Grinnell, Jamestown S'Klallam Tribe vice-chair.

The tribe leased the former Washington Department of Fish and Wildlife shellfish hatchery in Quilcene in late 2013 and started rearing 800 Pacific oysters in March.

The tribe is working in partnership with Troutlodge, a private salmon and shellfish aquaculture company, and Jones Farm, a shellfish farm on Lopez Island. The tribe and its partners are working together because water chemistry has been an issue when sourcing seed from one location.

"We lower risk by partnering up with others," Grinnell said.

The primary focus will be growing manila clams, geoduck and oysters from seed to adult, plus the algae needed to feed everything, as well as selling seed to others.

"We want to create our own larvae and broodstock here and provide seed to others," Grinnell said. "We've had a need for something like this for a long time and to have it accessible to all the tribes. We're going to make this work, we just have a long ways to go. There is such a demand for seed and everything we grow will be sold."

Marine Fish

Treaty tribes are co-managers of the marine fish resource. They work closely with the state of Washington, federal agencies and in international forums to develop and implement species conservation plans for all groundfish stocks in Puget Sound and along the Pacific coast.

- The Pacific Fishery Management Council, which includes the tribal and state co-managers, regulates the catch of black cod, rockfish and other marine fish. Halibut are managed through the International Pacific Halibut Commission, established by the United States and Canada governments. Tribes are active participants in season-setting processes and the technical groups that serve those bodies.
- The state of Washington, Hoh Indian Tribe, Makah Tribe, Quileute Tribe and the Quinault Indian Nation are working with the National Oceanic and Atmospheric Administration to develop research goals that look at changing ocean conditions and managing ocean resources.
- The tribes and state support ocean monitoring and research leading to ecosystem-based management of fishery resources. In 2013, the Quinault Indian Nation developed a nearshore ocean-monitoring system that uses sensors in crab pots to gather water quality information.

Halibut Hook Links Generations


Debbie Preston

Makah elder Jesse Ides examines a modern day halibut hook designed to test traditional fishing methods.

A fish hook has tied history, culture and the Makah community together in unexpected ways.

The *čibu·d* (pronounced "cha bood"), or halibut hook, became the subject of a student project during an internship with Makah Fisheries Management.

"I had a student, Larry Buzzell, come to me wanting to do a project that related to historical fishing methods," said Jonathan Scordino, marine mammal biologist for the Makah Tribe.

Historically the hooks were made of both wood and bone. As the tribe gained access to new materials, they also made hooks from metal.

"The goal of the project was to test if the *čibu·d* was more selective for catching halibut than contemporary circle hooks when fished on a longline," Scordino said.

Setting up the experiment was challenging because the study required 200 *čibu·d* to be made by hand. The Makah Cultural and Research Center opened its exhibit preparation space for several weeks to allow community members to come in and help make the hooks.

Through trial and error, a group of volunteers learned it was better to bend the metal hooks cold rather than heat the metal.

Elder Jesse Ides (*Hushta*) watched as young people learned to make the hook he used in his youth.

"It's terrific seeing them show the determination to make it and use it," Ides said.

He recalled his father hauling canoes out to the halibut grounds to fish.

"You'd catch just halibut with that gear, nothing else," he said.

"The *čibu·d* was known to not only fish selectively for halibut, but not catch too small or too big a halibut," Scordino said. "From a management perspective, that's exactly the size you want to catch so the older spawners remain and the young grow to be a harvestable size."

Wildlife Management

The treaty Indian tribes are co-managers of wildlife resources in western Washington, which include species such as deer, elk, bear and mountain goats.

- Western Washington treaty tribal hunters account for a small portion of the total combined deer and elk harvest in the state. In the 2013-14 season, treaty tribal hunters harvested a reported 432 elk and 567 deer, while non-Indian hunters harvested a reported 7,246 elk and 27,448 deer.
- Tribal hunters do not hunt for sport, but for sustenance. Most do not hunt only for themselves. Tribal culture in western Washington is based on extended family relationships with hunters sharing game with several families. Some tribes have designated hunters who harvest wildlife for tribal elders and others unable to hunt for themselves, as well as for ceremonial purposes.
- All tribes prohibit hunting for commercial purposes.
- As a sovereign government, each treaty tribe develops its own hunting regulations and ordinances for tribal members. Tribal hunters are licensed by their tribes and must obtain tags for animals they wish to hunt.
- Many tribes conduct hunter education programs aimed at teaching tribal youth safe hunting practices and the cultural importance of wildlife to the tribe.

Tracking Deer and Elk Predators: Bobcats, Cougars

Olympic Peninsula tribes are tracking bobcats and cougars to find out whether they are the primary predators of deer and elk on the peninsula. Until now, there hasn't been much scientific evidence supporting or disproving that theory.

Several tribes are putting radio-signal transmitting collars on cougars to better understand their home ranges, diet and other behavior. The Makah Tribe is the only entity collecting similar data on bobcats.

"There really has been no research done on bobcats in Washington," said Rob McCoy, Makah wildlife division manager. The tribe has been conducting research on cougars since December 2010 and started radio-collaring bobcats in January 2012.

"We have really good data on cougars and male bobcats," McCoy said. "We're working to get more females into the study to better understand reproduction and size of litters and survival."

The tribe now has four male and four female bobcats with collars.

When a collared cat makes a kill, the radio signals show that it has stopped moving while it feeds. Biologists walk in and note the kill species.

"We're still gathering data, but right now, we just aren't seeing elk in the bobcat diet at all," McCoy said. "It's early in the study, but we aren't seeing a significant number of deer being killed by bobcats either. There is evidence they scavenge on deer opportunistically after a cougar kill or natural cause of death."

McCoy said that bobcats may actually survive on smaller prey such as mountain beavers, birds, rabbits, moles and mice.

Adult male bobcats have little overlap of home ranges as they are quite territorial.

"One of the things we want to know about female cats is whether their home ranges are larger or smaller and how territorial they are, comparatively," McCoy said.

Coupled with extensive research of elk and deer within their traditional hunting area, the tribe will use the research on cats to manage them in the future.


Debbie Preston

Rob McCoy, wildlife division manager for the Makah Tribe, applies eyedrops to a bobcat prior to fitting it with a radio collar.

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Regional Collaborative Management

Puget Sound Partnership

The Puget Sound Partnership (PSP) was created in 2007 to recover Puget Sound's health by 2020. Tribes are actively involved in leadership and participation in a wide range of projects to improve the health of Puget Sound.

- U.S. Reps. Derek Kilmer and Denny Heck formed the Puget Sound Recovery Caucus in 2013. The congressional caucus coordinates action at the federal level and collaborates with stakeholders on efforts to improve the health of Puget Sound.

- The 2014-15 Action Agenda update focused on revisions to recovery activities that should begin or be completed within two years. New initiatives, priorities and strategies are not included in this update, but will be considered when substantial review and updating takes place in 2016.

- Tribal representatives are active in partnership efforts to protect salmon habitat. One approach seeks improved habitat protection through review and improvements to current regulatory processes.

Tribes Collaborate on Salish Sea Survival


Emmett O'Connell

Jed Moore, salmon biologist for the Nisqually Indian Tribe, takes zooplankton samples to better understand the food available to migrating juvenile salmon.

Fisheries managers studying poor ocean survival of salmon are concentrating their research on juvenile fish and their preferred prey. Several tribes collaborated on studies in 2014.

The Tulalip, Nisqually, Port Gamble S'Klallam, Lummi, Swinomish and Sauk-Suiattle tribes are among the collaborators sampling zooplankton throughout the region.

Zooplankton and ichthyoplankton are the preferred prey for juvenile salmon. Researchers want to find out whether prey availability has changed in the Salish Sea during the critical period of juvenile salmon development, leading to poor growth and survival.

"This effort will fill critical knowledge gaps in understanding the lower levels of the marine food web that affect juvenile salmon," said Paul McCollum, director of natural resources for the Port Gamble S'Klallam Tribe. "The data will contribute to the development of ecosystem indicators that have already been demonstrated to greatly improve adult salmon return forecasting."

In Hood Canal and Admiralty Inlet, the Port Gamble S'Klallam Tribe has been conducting nearshore research and monitoring of juvenile salmon and forage fish, using acoustics, trawl and beach seine methods, as well as zooplankton sampling.

"The increasing inability in recent years to accurately estimate annual salmon returns is impacting tribal treaty rights and implementation of the U.S./Canada Pacific Salmon Treaty," said Terry Williams, commissioner of fisheries and natural resources for the Tulalip Tribes. "It also impairs the critical decision-making necessary to achieve salmon recovery goals and sustainable fisheries."

The Tulalip and Nisqually tribes are partnering on a study of juvenile salmon in the Snohomish and Nisqually river watersheds and adjacent nearshore and offshore marine areas.

The study will examine the entire community structure of competitors and predators, including plankton and other fish species. Smolt traps operate continuously on both rivers from winter through summer to collect timing, size and abundance data for out-migrating salmon. Both tribes also sample juvenile fish use of nearshore marine areas and pocket estuaries using fyke nets and beach seines.

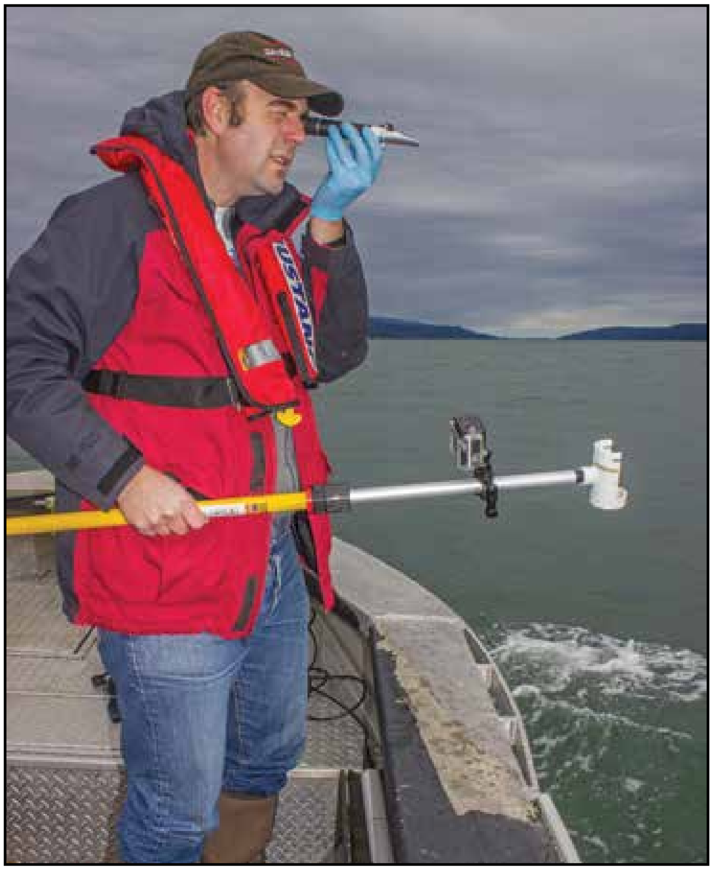
This sampling data should allow researchers to identify the life stage, timing and locations where growth of juvenile salmon is limited.

Ocean Ecosystem Management

The state of Washington, the Hoh, Makah and Quileute tribes and the Quinault Indian Nation work with the National Oceanic and Atmospheric Administration (NOAA) to integrate common research goals to understand changing ocean conditions and create the building blocks for managing these resources.

- In recognition of the challenges facing the Olympic Coast ecosystem, the tribes and state of Washington established the Intergovernmental Policy Council to guide management of Olympic Coast National Marine Sanctuary. Many of the research and planning goals established by tribes and the state mirror the recommendations of the U.S. Ocean Policy.
- Climate change and ocean acidification have been top priorities the past two years. Because of their unique vulnerability, coastal indigenous cultures are leaders in societal adaptation and mitigation in response to events driven by climate change.
- The tribes continue to work with the state of Washington and federal partners to respond to the findings of the state's blue ribbon panel on ocean acidification including prioritizing research to understand its effects on marine ecology and shared natural resources.

Tribal Environmental Protection and Water Resources Program


Tiffany Royal

Skokomish Tribe water quality biologist Seth Book measures the salinity of a water sample from Hood Canal near Hoodsport.

The Coordinated Tribal Water Quality Program was created by the Pacific Northwest tribes and the federal Environmental Protection Agency (EPA) to address water quality issues under the Clean Water Act.

- EPA's General Assistance Program (GAP) was established in 1992 to improve capacity for environmental protection programs for all tribes in the country. Many tribes are now participating in the pilot "Beyond GAP" project to build on the investments of the last 20 years by creating environmental implementation programs locally while supporting national environmental protection objectives.
- These programs are essential to combat the threats to tribal treaty resources such as declining water quality and quantity. In western Washington, climate change and urban development negatively affect water resources and aquatic ecosystems, and will get worse with a state population expected to rise by 1 million in the next 20 years.
- Tribal water quality resource program goals include establishing instream flows to sustain harvestable populations of salmon, identifying limiting factors for salmon recovery, protecting existing groundwater and surface water supplies, and participating in multi-agency planning processes for water quantity and quality management.

Regional Collaborative Management (continued)

Forest Management

Two processes, the Timber/Fish/Wildlife (TFW) Agreement and the Forests and Fish Report (FFR), provide the framework for an adaptive management process that brings together tribes, state and federal agencies, environmental groups and private forest landowners to protect salmon, wildlife and other species while providing for the economic health of the timber industry.

- Treaty tribes in western Washington manage their forestlands to benefit people, fish, wildlife and water.
- Reforestation for future needs is part of maintaining the healthy forests that are key to vibrant streams for salmon, and that enable wildlife to thrive.
- Forestlands are a source of treaty-protected foods, medicine and cultural items.
- A tribal representative serves on the state's Forest Practices Board, which sets standards for activities such as timber harvests, road construction and forest chemical applications. Tribes also are active participants in the FFR Cooperative Monitoring, Evaluation and Research Committee (CMER).

Upper Skagit Tribe Improves Elk Forage

Debbie Preston

Elk populations in the North Cascades have suffered as a result of degraded habitat. The Upper Skagit Tribe recently helped thin a forest and added mulch to the soil to improve forage quality.

The Upper Skagit Indian Tribe's natural resources department thinned and mulched forestland on Puget Sound Energy (PSE) property last fall to improve elk forage in the North Cascades mountains.

Degraded and disconnected habitat is one of the main causes of the decline in numbers of the Nooksack elk herd, which went from a population of more than 1,700 20 years ago to about 300 by 2003. Since then, tribal and state co-managers have improved elk habitat in the region. Annual population surveys indicate that the herd is showing signs of recovery.

"Elk need a corridor of habitat that is rich in forage to keep them from becoming nuisances in populated areas," said Scott Schuyler, natural resources director for the Upper Skagit Tribe.

PSE acquired the land from the Department of Natural Resources as part of the mitigation requirements of the 2008 relicensing agreement with the Federal Energy Regulatory Commission for the utility's Baker River Hydroelectric Project.

A crew used chainsaws to remove hundreds of trees on about 3 acres of land and 1,500 feet of road. The trees, mostly small Douglas fir, were then put through a wood chipper to mulch the dry, rocky soil.

"We needed to remove enough of the canopy to let light in so grasses can grow," said Upper Skagit timberland services manager Robert Schuyler. "The trees we left can be harvested later for a commercial crop."

The mulched ground was seeded with grasses, clover and small burnet.

"There's no forage out here, it's all knee-deep salal, Oregon grape and sword fern, which elk don't eat," said Tony Fuchs, PSE wildlife biologist. "Once we get grasses and clover established, elk will find a better place to forage."

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NWIFC Functions, Programs and Activities

Tiffany Royal

NWIFC fish pathologist Marcia House, left, and Lower Elwha Klallam Tribe hatchery manager Larry Ward discuss coho that returned to the hatchery in November 2014.

The Northwest Indian Fisheries Commission (NWIFC) was created in 1974 by the 20 treaty Indian tribes in western Washington that were parties to the *U.S. v. Washington* litigation that affirmed their treaty-reserved salmon harvest rights and established the tribes as natural resources co-managers with the state.

The NWIFC is an inter-tribal organization that assists member tribes with their natural resources co-management responsibilities. Member tribes select commissioners who develop policy and provide direction for the organization. The commission employs about 70 full-time employees and is headquartered in Olympia, Wash., with satellite offices in Forks, Kingston and Burlington.

The NWIFC provides broad policy coordination as well as high-quality technical and support services for its member tribes in their efforts to co-manage the natural resources of western Washington. The NWIFC serves as a clearinghouse for information on natural resources management issues important to member tribes. The commission also acts as a forum for tribes to address issues of shared concern, and enables the tribes to speak with a unified voice.

The NWIFC has coordinated the tribal Treaty Rights at Risk initiative that seeks to encourage the federal government to align its agencies and programs with salmon recovery goals and to lead a more coordinated salmon recovery effort. Tribes are calling on the federal government for assistance because it has both the obligation and authority to recover salmon and protect tribal treaty rights.

Habitat Services

- Coordinate policy and technical discussion between tribes and federal, state and local governments, and other interested parties.
- Coordinate, represent and monitor tribal interests in the Timber/Fish/Wildlife Forests and Fish Report process, Coordinated Tribal Water Resources and Ambient Monitoring programs. Analyze and distribute technical information on habitat-related forums, programs and processes.
- Implement the Salmon and Steelhead Habitat Inventory and Assessment Project.

U.S./Canada Pacific Salmon Treaty

- Facilitate inter-tribal and inter-agency meetings, develop issue papers and negotiation options.
- Inform tribes and policy representatives about issues affected by the treaty implementation process.
- Serve on the pink, chum, coho, chinook, Fraser sockeye and data-sharing technical committees, and other work groups and panels.
- Coordinate tribal research and data-gathering activities associated with implementation of the Pacific Salmon Committee.

Quantitative Services

- Administer and coordinate the Treaty Indian Catch Monitoring Program.
- Provide statistical consulting services.
- Conduct data analysis of fisheries studies and developing study designs.
- Update and evaluate fishery management statistical models and databases.

Fisheries Management

- Long-range planning, wild salmon recovery efforts and federal Endangered Species Act implementation.
- Annual fisheries planning: developing pre-season agreements; pre-season and in-season run size forecasts; monitoring; and post-season fishery analysis and reporting.
- Marine fish management planning.
- Shellfish management planning.

Enhancement Services

- Coordinate coded-wire tagging of more than 4 million fish at tribal hatcheries to provide information critical to fisheries management.
- Analyze coded-wire data.
- Provide genetic, ecological and statistical consulting for tribal hatchery programs.
- Provide fish health services to tribal hatcheries in the areas of juvenile fish health monitoring, disease diagnosis, adult health inspection and vaccine production.

Information and Education Services

- Provide internal and external communication services to member tribes and NWIFC.
- Develop and distribute communication products such as news releases, newsletters, videos, photos and web-based content.
- Respond to public requests for information about the tribes and their tribal natural resources management activities.
- Work with state agencies, environmental organizations and others in cooperative communication efforts.

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Northwest Indian
Fisheries Commission
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Olympia, WA 98516
(360) 438-1180
nwifc.org

PCB/PBDE Loading Estimates for the Greater Lake Washington Watershed

September 2013

King County

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PCB/PBDE Loading Estimates for the Greater Lake Washington Watershed

Prepared for:

U.S. Environmental Protection Agency Region 10

Submitted by:

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Disclaimer:

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Department of
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Water and Land Resources Division

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Citation

King County. 2013. PCB/PBDE Loading Estimates for the Greater Lake Washington Watershed. Prepared by Curtis DeGasperi, Water and Land Resources Division. Seattle, Washington.

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EXECUTIVE SUMMARY

King County was awarded a Puget Sound Action Agenda: Technical Investigations and Implementation Assistance Grant by the U.S. Environmental Protection Agency (USEPA) to estimate loading of polychlorinated biphenyls (PCBs) and polybrominated diphenylethers (PBDEs) to Lake Washington, Lake Union and Puget Sound; and model potential reduction in Lake Washington fish tissue concentrations associated with selected PCB loading reduction scenarios. A field study was designed and implemented to measure concentrations in key contaminant loading pathways to Lakes Washington and Union (i.e., rivers, streams, stormwater, combined sewer overflows, highway bridges and atmospheric deposition) and measure the PCB/PBDE concentrations in the export pathway leaving the lake system through the Ship Canal locks to Puget Sound. By combining contaminant concentration data with long term flow estimates for these pathways, mass loading estimates to Lakes Washington and Union and export to Puget Sound for total PCB (tPCB) and total PBDE (tPBDE) were developed. Details of the tPCB and tPBDE loading calculation approach and resulting estimates are presented in this report. Sampling details and results are the subject of a separate report.

This project is considered a first step toward understanding the relative importance of major contaminant loading pathways that contribute PCBs and PBDEs to these lakes as well as understanding their long term fate and the potential for recovery. The end result will be a more complete understanding of major pathways transporting PCBs and PBDEs to these lakes, processes controlling their ultimate fate and potential for management actions to reduce health risks from consuming contaminated fish from Lake Washington. The study will also provide a better understanding on which future monitoring and modeling efforts can be planned.

Some overall findings from the PCB and PBDE loading report are highlighted below:

PCB Loading Estimate Findings

- As much as 70 percent of the tPCB load to Lake Washington comes from local tributary watersheds around the lake.
- Three creeks (Thornton, Juanita and May) representing a range in the type and intensity of development were monitored.
- o Thornton Creek had the highest amount of commercial/industrial development that occurred prior to the ban on PCB manufacture and use limitations and the highest estimated tPCB loading.
- o May Creek had the lowest amount of older commercial/industrial development and the lowest estimated tPCB loading.
- o Juanita Creek had intermediate amount of older commercial/industrial development and an estimated tPCB loading that fell between the estimate for Thornton and May creeks.
- Loading estimates and additional analyses suggest that the predominant source of tPCBs is stormwater runoff from developed areas – possibly linked to older

commercial/industrial development. This is consistent with the conceptual model of tPCB sources and pathways emerging from other studies that suggest that PCB sources are concentrated in urban centers containing older commercial and industrial buildings in which paints, caulks, and sealants containing PCBs were used.

- Estimated total tPCB loading to Lake Washington is less than the estimated loading exported from the lake outlet. This is because the lake acts as a sink for PCBs, primarily as the result of sediment accumulation and burial, but also through volatilization through the lake surface. The relative importance of these fate processes will be evaluated in the next phase of this study.
- tPCB concentrations (and hence loading), increase from the outlet of Lake Washington to the outlet of Lake Union to Puget Sound. tPCB loading estimates for Lake Union suggest that this may be the result of loading from CSOs and runoff from local drainage basins.

PBDE Loading Estimate Findings

- In general, there was more uncertainty associated with tPBDE loading estimates and source pathways appeared to be more diffuse. This is consistent with an emerging conceptual model for PBDE sources and pathways based on the fact that PBDEs were introduced more recently into the environment and sources are more dispersed throughout the urban and suburban landscape (e.g., upholstery containing PBDE-based fire retardants).
- Loading estimates for the two major rivers to Lake Washington (Cedar and Sammamish) suggest a tPBDE load somewhat smaller than the tributary stream load, although there is a high degree of uncertainty in these estimates. Loadings from rivers include all pathways from upstream waterbodies.
- The contribution of atmospheric deposition to the surface of Lake Washington was also estimated to be relatively significant; close to 30 percent of the total loading estimate for PBDEs.
- tPBDE loading to Lake Union was dominated by input from Lake Washington. This input was estimated to contribute about 80 percent of the total tPBDE load.

The tPCB loading estimates documented in this report will be used in models that will be developed in the next phase of this study to simulate the response of Lake Washington to reductions in tPCB loading that might result from various management approaches and resulting changes in concentrations in resident fish.

1.0. INTRODUCTION

In 2010 King County was awarded a Puget Sound Action Agenda: Technical Investigations and Implementation Assistance Grant by the U.S. Environmental Protection Agency (USEPA) to estimate loading of polychlorinated biphenyls (PCBs) and polybrominated diphenylethers (PBDEs) to Lake Washington, Lake Union and Puget Sound; and model potential reduction in Lake Washington fish tissue concentrations associated with selected PCB loading reduction scenarios. A field study was designed and implemented to measure PCB and PBDE concentrations in key contaminant loading pathways to Lakes Washington and Union (i.e., rivers, streams, stormwater, combined sewer overflows, highway bridges and atmospheric deposition) and measure the concentrations in the export pathway leaving the lake system through the Ship Canal locks to Puget Sound (King County 2013). By combining contaminant concentration data with long term flow estimates for these pathways, mass loading estimates to Lakes Washington and Union and subsequent export to Puget Sound for total PCB (tPCB) and total PBDE (tPBDE) were developed. Details of the tPCB and tPBDE loading calculation approach and resulting estimates are presented in this report. Sampling details and results are the subject of a separate report (King County 2013).

This project is considered a first step toward understanding the relative importance of major contaminant loading pathways that contribute PCBs and PBDEs to these lakes as well as understanding their long term fate and the potential for recovery. The end result is expected to be a more complete understanding of pathways transporting PCBs and PBDEs to these lakes, processes controlling their ultimate fate and the potential for management actions to reduce health risks from consuming contaminated fish from Lake Washington. Knowing the relative importance of the loadings pathways will provide a better understanding on which future monitoring and modeling efforts can be planned.

1.1 Background

1.1.1 PCBs

PCBs are chlorinated organic compounds that were manufactured for uses that required chemical stability and low flammability. PCBs include 209 individual compounds known as congeners that vary to some degree in physical, chemical and toxicological properties based primarily on the degree of chlorination. Due to their chemical stability and low water solubility, PCBs are persistent in the environment, bind strongly to sediment and soil particles; and bioaccumulate in aquatic organisms, wildlife and humans.

Bioaccumulation of PCBs presents a potential health risk to aquatic life, terrestrial wildlife, and humans. The Washington Department of Health (WADOH) issued a fish consumption advisory for PCBs in Lake Washington which covers yellow perch, cutthroat trout, carp, and northern pikeminnow (WADOH 2004).[1] PCB concentrations in Lake Washington fish exceed both the National Toxics Rule[2] levels for protection of human health and the 95th-percentile of concentrations measured in fish collected statewide (Seiders and Deligeannis 2009).

Commercial production of PCBs began in the 1920s, initially for use as a dielectric fluid in electrical transformers, capacitors and electric motors. After World War II, production increased substantially and PCB use diversified to include heat transfer fluids, hydraulic fluids, plasticizers, carbonless copy paper, lubricants, inks, laminating agents, paints, adhesives, waxes, additives in cements and plasters, casting agents, sealing liquids, fire retardants, immersion oils and pesticides (De Voogt and Brinkman 1989). PCBs were voluntarily phased-out of production in the 1970s and manufacture and most uses were banned in 1979 in the United States (44 FR 31514).[3] While the sale and production of PCBs has been banned for over three decades, considerable amounts of PCBs remain in use – primarily as dielectric fluid in so-called closed sources like transformers and capacitors and in open sources such as building paints, caulks and sealants (Diamond et al. 2010b; Robson et al. 2010).

In general, halting the production of PCBs, elimination of many uses, and a declining inventory of PCBs in use has resulted in declining concentrations in environmental media, including fish tissue and aquatic sediments (Peterman et al. 1990; Van Metre and Mahler 2005). However, studies of fish tissue and sediment concentrations in many areas of the world indicate that the initial rate of decline appears to have slowed or halted completely (Van Metre et al. 1998; Hickey et al. 2006; Bhavsar et al. 2007).

Historical data on PCB levels in non-anadromous fish collected from Lakes Washington and Union are insufficient to evaluate long-term trends in PCB concentrations (McIntyre 2004). Studies have been conducted on anadromous fish; however, these fish generally spend only a portion of their life cycle in these lakes and the measured contaminant concentrations are generally lower than those observed in resident (non-anadromous) fish species (McIntyre 2004; Fletcher 2009).

Substantial declines in Lake Washington sediment PCB concentrations have been documented. Surface sediment PCB levels are now about a third of the peak concentrations measured at depth in sediment core horizons dated to the early 1970s (Yake 2001; Van Metre et al. 2004; Van Metre and Mahler 2005; Furl et al. 2009). The increase and subsequent decrease in sediment PCB concentrations coincide with national trends in production, use and subsequent use limitations and elimination of production. In the case of Lake Washington, the increase and decline also coincides generally with the development and growth of cities around the lake and subsequent diversion of inputs of

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[1] Washington State Department of Health Fish Consumption Advisories (see: http://www.doh.wa.gov/CommunityandEnvironment/Food/Fish/Advisories.aspx

[2] U.S. Environmental Protection Agency (USEPA) National Toxics Rule (see: http://water.epa.gov/scitech/swguidance/standards/wqsregs.cfm)

[3] U.S. Environmental Protection Agency (see: http://www.epa.gov/history/topics/pcbs/01.html)

treated wastewater from Lake Washington to Puget Sound that was completed in 1968 (Edmondson and Lehman 1981).

1.1.2 PBDEs

PBDEs are brominated organic compounds that have been in use, primarily as flame retardants in plastics and textiles, since 1965. Specific uses of PBDEs include incorporation into flexible polyurethane foams used in upholstery stuffing for furniture and car seats, electronic components, electrical components, and plastics used in the casings of televisions, personal computers, and other electronic equipment (USEPA 2010). PBDEs are manufactured as three primary formulations: "Penta," "Octa," and "Deca," which differ in the relative combination of specific PBDE congeners.

PBDEs have chemical, physical and toxicological properties similar to those of PCBs. However, only recently have PBDEs come under scrutiny for their potential for environmental harm due to their toxicity, persistence, and potential to bioaccumulate (Oram et al. 2008). These concerns led to the voluntary withdrawal of the Penta and Octa forms by U.S. manufacturers in 2004, leaving only the Deca formulation currently in commercial use in the United States (USEPA 2010). In 2007, Washington banned most PBDE uses (RCW 70.76) and the ban became effective for Penta and Octa containing products, and for mattresses containing Deca, in 2008. As a result of follow-up studies required in the new law, Washington banned the manufacture, sale and distribution of televisions, computers and residential upholstered furniture containing Deca by January 2011.[4] At the national level, USEPA announced a national phase-out of the Deca formulation in 2009, with production, importation, and sales for most uses in the United States to end by the end of 2012 and all uses to end in 2013 (USEPA 2010).

Data are insufficient to evaluate trends in PBDE concentrations measured in water, sediment, fish or other aquatic life in Lakes Washington or Union. A study of water and tissue concentrations of PBDEs in resident Lake Washington fish was conducted by WADOH and Ecology in 2005 (Johnson et al. 2006). Johnson et al. (2006) also compiled and compared fish tissue data collected from 44 sites representing 36 rivers/impoundments and lakes in the state. Lake Washington had the fifth highest level of tPBDE fish tissue concentrations.

1.2 Project Goals and Objectives

This project will fill data gaps and develop modeling tools to help answer three management questions:

1. Which types of loading pathways are the highest priorities for PCB/PBDE load reduction?
2. Will potential loading reductions from these pathways reduce fish bioaccumulation and contribute substantially towards lifting the fish consumption advisory on Lake Washington?

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[4] Washington Department of Ecology (see: http://www.ecy.wa.gov/news/2009news/2009-017.html)

3. How long might it take the system to respond to these hypothetical loading reductions?

This report presents the loading calculation approach and resulting estimates that will be used to address the first question above and provide key inputs for the development of models that will be used to address all three project management questions. The development and application of these models will be the subject of a future report.

1.3 Study Area

1.3.1 Greater Lake Washington Watershed

The study area encompasses the 1,590 km^2 (614 mi^2) Greater Lake Washington watershed (Figure 1) from its mouth at the Hiram M. Chittenden Locks (Locks).[5] The area experiences a generally mild maritime climate with heaviest precipitation occurring in winter months, primarily as rain at lower elevations and as snow at higher elevations. Elevations are generally less than 1,000 m (3,281 ft), but the total amount of annual rainfall is very dependent on elevation which ranges from about 6 m above mean sea level (msl) to 1,700 m (4,464 ft), and this results in a range of annual precipitation from almost 1,000 mm (39 in) at lake level to over 2,500 mm (100 in) at the highest elevations. Winds are highly variable, but during the winter, major storms and associated winds typically originate from the southwest.

Two major rivers drain to Lake Washington. The Sammamish River drains Lake Sammamish and tributaries in the Sammamish River valley and enters Lake Washington from the north, providing about 30 percent of the total inflow to lake. The Cedar River enters the south end of the lake and contributes about 50 percent of the total inflow (Edmondson 1977; King County 2003a; Cerco et al. 2004). Lake Washington then drains through the Montlake Cut to Lake Union, which drains through the Lake Washington Ship Canal (Ship Canal) and Locks to Puget Sound.

Historically, Lakes Washington and Union were not connected. By 1916 a canal was completed between the two lakes, the outlet of Lake Union was widened and deepened and a lock and dam system was in operation (Chrzastowski 1983). Prior to canal and lock construction, the main inflow to Lake Washington was from the Sammamish River and outflow was through the Black River at the southern end of the lake. To provide sufficient water for lock operation and to reduce flooding, the Cedar River, which had previously joined the Black River near the southern end of the lake, was diverted to Lake Washington (Chrzastowski 1983). These engineering changes resulted in the summer intrusion of saltwater from Puget Sound that enters through the Locks and Ship Canal into Lake Union, resulting in a layer of denser saline water in the lake, which is then entrained and flushed from the lake during winter high flows. The extent of intrusion of saline water is limited to Lake Union through various mitigation measures, including a salt water barrier at the upstream side of the larger of the two locks and a saltwater drain located in a depression at

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[5] This watershed area estimate includes the surfaces of all lakes, streams and wetlands in the watershed.

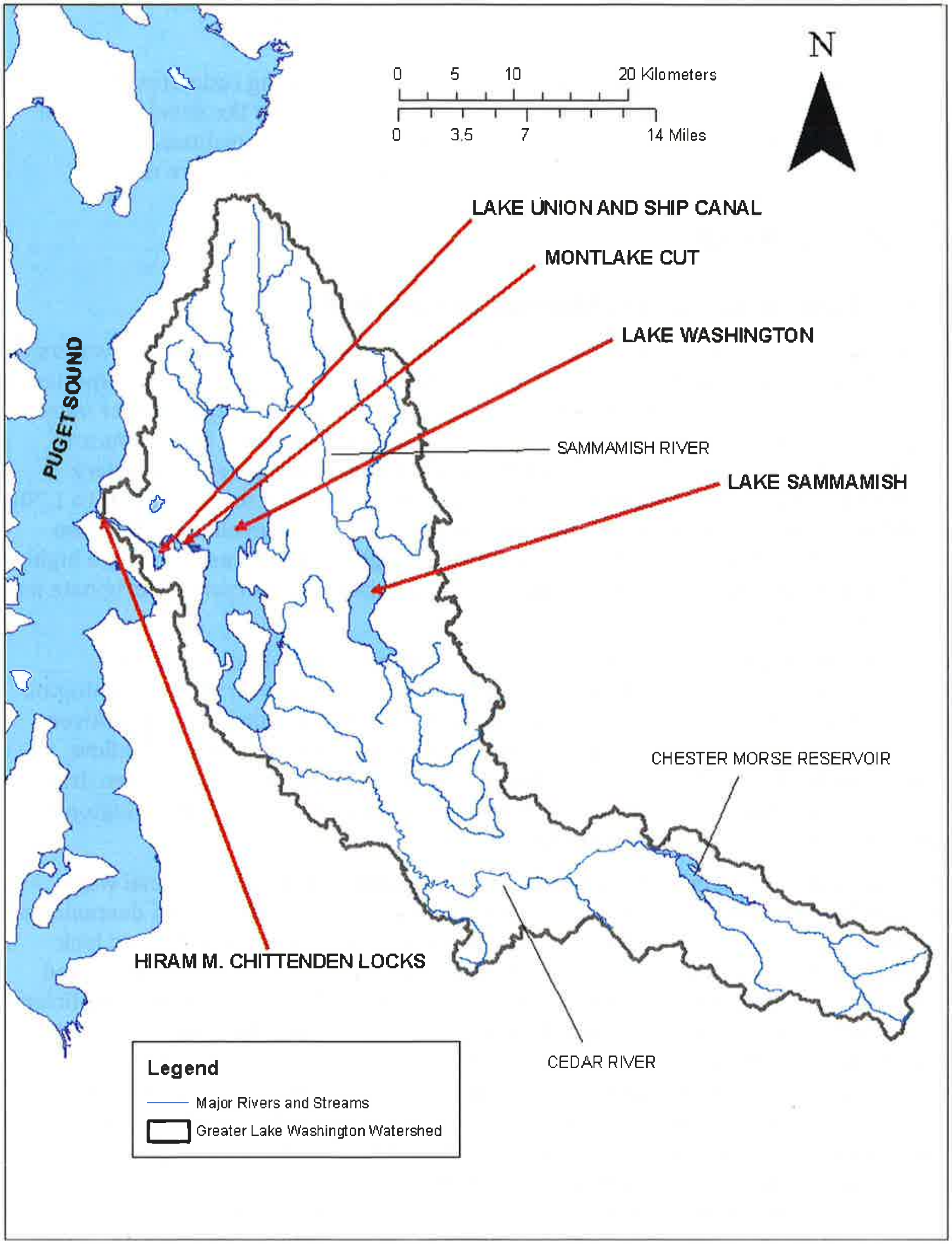

Figure 1. Greater Lake Washington Watershed.

the head of both locks. Salinity is monitored continuously in summer at the University Bridge and is not to exceed 1 ppt (173-201A WAC).

The immediate area around Lake Washington and Lake Union/Ship Canal (simply Lake Union hereafter) is highly developed and includes the major cities (i.e., >50,000 residents) of Seattle, Bellevue, and Renton. While Lake Washington received wastewater from a number of municipal treatment plants until 1968, there are still approximately 70 combined sewer overflows (CSOs) that intermittently discharge to locations along the Seattle shoreline of Lakes Washington and Union. In general, industrial activity around Lake Washington has been limited, while the Lake Union shoreline has historically experienced more intensive industrial uses that are transitioning to mixed use commercial/residential developments.

Approximately 40 sites in the study basin are listed for PCB contamination in Ecology's Confirmed and Suspected Contaminated Sites database (Figure 2).[6] Of these, the sites most often highlighted with respect to Lakes Washington and Union are the Boeing Renton and Quendall Terminals sites on Lake Washington (Era-Miller et al. 2010) and the Seattle Steam Plant site on Lake Union (Cubbage 1992).[7]

The lakes are each crossed by one state and one interstate highway. Lake Washington is crossed by two floating bridges – State Route 520 (SR 520) to the north and Interstate 90 (I-90) to the south. Lake Union is spanned by Interstate 5 (I-5) and State Route 99 (SR 99).

The study area also includes relatively undeveloped, primarily forested, areas in the headwaters of the two major river basins. The headwaters of tributaries along the southeast shoreline of Lake Washington are also relatively undeveloped. The headwaters of the Cedar River are in a protected watershed for the Chester Morse water supply reservoir that provides Seattle Public Utilities (SPU) with a portion of its potable water supply.

1.3.2 Lake Washington and Lake Union

Lake Washington is the second largest natural lake in the state. The lake is an elongated north-south trending glacial trough approximately 35 km (21.7 mi) long with an average depth of 32.9 m (108 ft), a maximum depth of 65.2 m (214 ft), a surface area of 87.6 km^2 (33.8 mi^2) and a volume of 2.884 x 10^9 m^3 (2,338,000 acre-ft) (Anderson 1954).[8] Edmondson and Lehman (1981) provide estimates of annual lake hydraulic renewal times, which indicate that on average the fraction of lake volume renewed each year with

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[6] Ecology Confirmed and Suspected Contaminated Sites list downloaded October 31, 2012: https://fortress.wa.gov/ecy/tcpwebreporting/

[7] The former site of the Shuffleton Power Plant in Renton that discharged cooling water to Lake Washington until 1989 has also been discussed (see Era-Miller et al. 2010), but this site was designated No Further Action by Ecology in 2000.

[8] King County geographic information system (GIS) data indicate a lake surface area (including Union Bay) closer to 89 km^2 (34.4 mi^2), but this may be due to the exclusion of Union Bay from the earlier estimate. Also, Edmondson and Lehman (1981) report a total lake volume of 2.885 x 10^9 m^3 (2,339,000 acre-ft).

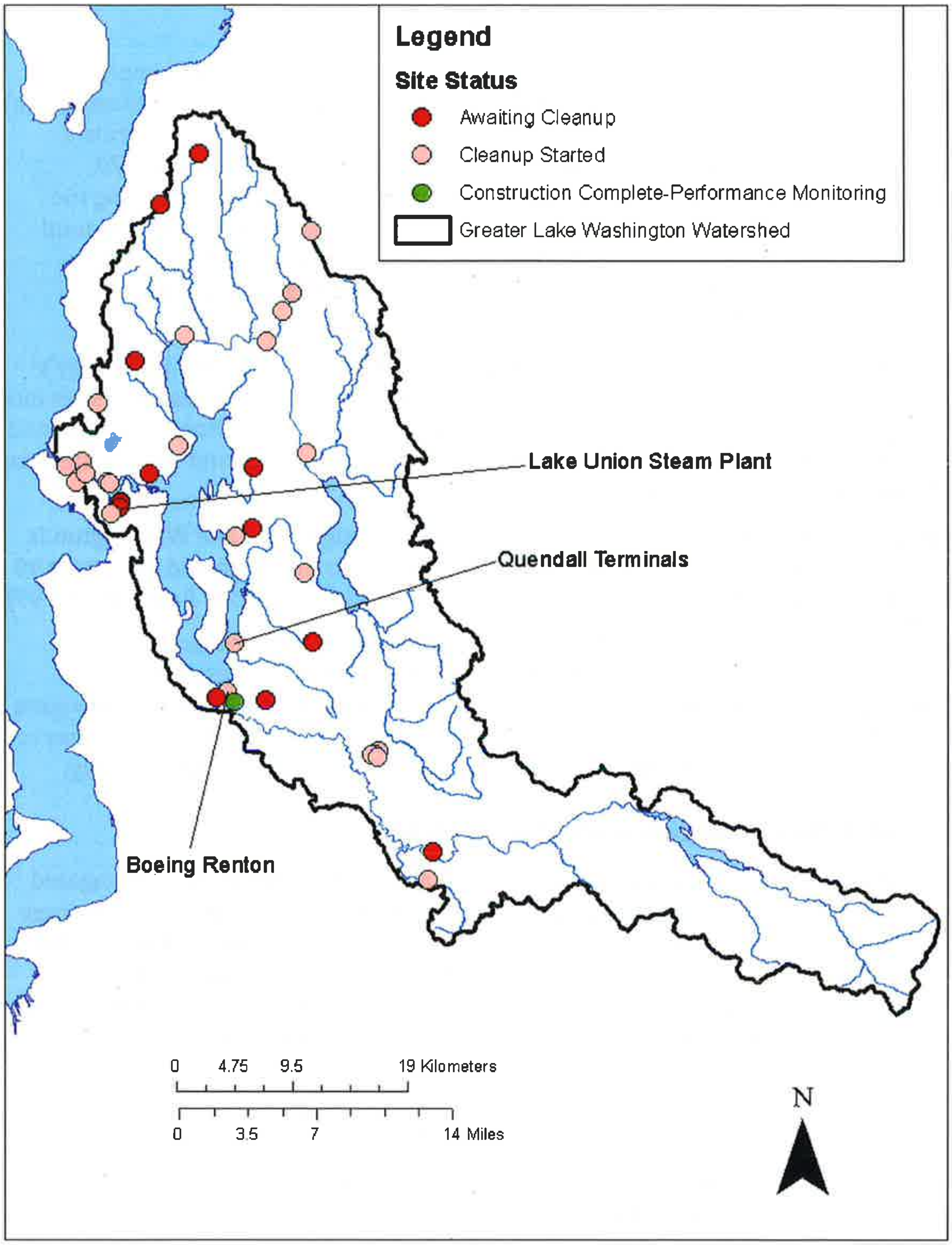

Figure 2. Sites within the Greater Lake Washington watershed with confirmed or suspected PCB contamination and their cleanup status, within the Greater Lake Washington watershed.

Source: Ecology's Confirmed and Suspected Contaminated Sites database.

incoming water (corrected for evaporation) is 0.43 per year. The reciprocal of this is 2.3 years – the average hydraulic residence time of water in the lake.

Lake Union is much smaller than Lake Washington with a total surface area of about 3.8 km^2 (1.5 mi^2) and a volume of approximately 2.5 x 10^7 m^3 (20,000 acre-ft).[9] A navigation channel is maintained to a depth of 9 m (30 ft) in the canals and bays between Union Bay in Lake Washington and the locks, while the lake itself is deeper and does not require dredging. The lake is separated by a sill into north and south basins with depths of 14 and 15 m (46 and 49 ft), respectively (Rattray et al. 1954). The contribution of water from the local watershed is small relative to the inflow from Lake Washington; it generally enters as surface runoff, through storm drains, or via CSOs. Due to the small volume of Lake Union relative to the watershed area, it is estimated that the entire volume of the lake is completely exchanged about once a week on average (Tomlinson et al. 1977).

1.4 Report Organization

The report is organized into an introduction (Section 1.0) to the issues of concern, the overall study goals and specific objective of the analyses presented in this report. General and study area specific background information on PCBs and PBDEs is also provided in Section 1.0. Section 2.0 presents a conceptual model for the hypothesized relationships among PCB sources, pathways, lake fate processes, and links to environmental impairments. PBDEs receive some limited treatment in this section. However, the main focus of the overall project is the collection of PCB data (and calculate loading) to support the development of a PCB fate and bioaccumulation model of Lake Washington. Section 3.0 describes the methods and data used to develop the PCB and PBDE loading estimates and Section 4.0 presents the results of those calculations. A discussion of the results is presented in Section 5.0 and Section 6.0 provides some general conclusions drawn from the results and discussion of the loading estimates.

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[9] This is likely the volume of Lake Union only and does not include the volume of the Ship Canal.

2.0. CONCEPTUAL MODEL

The conceptual model presented in this report is adapted from the one developed for San Francisco Bay (Davis et al. 2006). The conceptual relationships of PCB sources, major pathways, lake fate processes and bioaccumulation linkages to fish tissue contamination are shown in Figure 3. The sections below describe the PCB sources and pathways, fate processes and bioaccumulation linkages. Emphasis in these sections is on the conceptual model of PCB sources and pathways – the fate and bioaccumulation modeling components that are part of the next phase of this project will provide more details on the these components of the overall conceptual model. PBDE receives limited treatment in this section as the main focus of the overall study is on the sources, pathways, fate and bioaccumulation modeling of PCBs in Lake Washington.

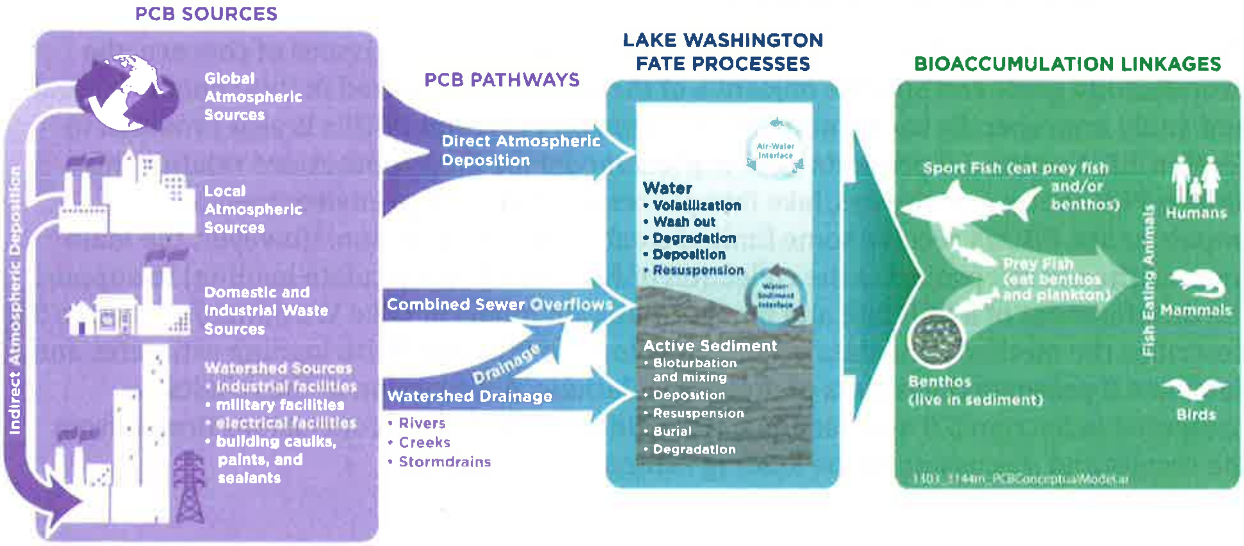

Figure 3. Conceptual relationships of important PCB sources, pathways, in-lake fate processes and bioaccumulation linkages.

Note: Adapted from Figure 18 in Davis et al. (2006)

2.1 Sources and Pathways

Current sources of PCBs in the Greater Lake Washington watershed include long-range transport of airborne contamination and local air emissions sources that are deposited directly on the lake surface (direct deposition) or are deposited on lake watersheds (indirect deposition) (EPA 2001, Totten et al. 2004, Wethington and Hornbuckle 2005, Totten et al. 2006, Persoon et al. 2010, Melymuk et al. 2012). The indirect deposition may be stored on the land surface (e.g., on buildings, rooftops, paved areas, in soils, on vegetation, or in ponds and wetlands) but some percentage of the deposited PCB can be mobilized and transported to the lake via volatilization or resuspension as dust and subsequent direct deposition or by rainfall washoff and transport via lake tributary streams, stormwater outfalls or through CSOs. Long-range atmospheric sources could include distant industrial and commercial centers, particularly those associated with activities such as coal combustion, steel smelting and waste incineration. Landfills with PCB-containing materials and former industrial sites contaminated with PCBs can also be an atmospheric source of PCBs. Commercial/Industrial areas can also be an atmospheric source of PCBs through volatilization of PCBs from open sources such as PCB-containing paints, caulks and sealants or leaking transformer oils.

Many of these potential local atmospheric sources can also be local runoff sources within the watershed via indirect deposition and subsequent mobilization (Rossi et al. 2004, Ecology 2007, Zgheib et al. 2010, Morace 2012). These sources include abrasion of exterior PCB-containing paint, caulks and sealants as well as capacitors and transformers.

Major pathways that PCBs take to reach the lake include direct atmospheric deposition to the lake surface, rivers, streams draining the urban and suburban watersheds around the lake, and runoff from urban areas along the Seattle shoreline that result from a highly developed stormwater and wastewater conveyance network. This network routes some of the runoff into a combined stormwater/wastewater conveyance system that delivers this combination to treatment plants that discharge the treated water to Puget Sound. A relatively small, portion of this combined stormwater/wastewater results in the CSO pathway to the lake when the conveyance capacity of this system is exceeded.

Based on a number of relatively recent studies, the emerging paradigm is that urban runoff is a major source of PCBs to receiving waters (Rossi et al. 2004, Davis et al. 2007, Ecology 2007, Diamond et al. 2010a, Morace 2012). For example, Davis et al. (2007) indicated that urban runoff from local watersheds is a particularly significant pathway for PCBs entering San Francisco Bay. Diamond et al. (2010a) found high concentrations of PCBs in air, soil and tributaries at urban vs. rural sites in and around Toronto, which pointed to urban areas as the main source of PCBs to nearshore Lake Ontario. This assessment was consistent with an inventory conducted of open and closed PCB sources in Toronto building stock (Diamond et al. 2007b, Robson et al. 2010). Another relevant finding is that organic films (soot) sampled from window surfaces in downtown Baltimore had higher concentrations of PCBs in downtown compared to more suburban sites (Liu et al. 2003). It appears that PCBs have an enhanced affinity for soot (Bucheli and Gustafsson 2003). Work has already begun to estimate stocks of PCB containing caulk in buildings in the San Francisco Bay area (Klosterhaus et al. 2011).

Urban runoff also appears to be a significant source of PBDEs to receiving waters (Oram et al. 2008, Diamond et al. 2010a), although sources appear to be more geographically dispersed than PCBs. PBDEs appear to follow a similar pathway of release to air, primarily from indoor air contaminated by volatilization from PBDE containing plastics and polyurethane foam used in furniture, and then deposited on land surfaces, which can be mobilized by stormwater runoff (Melymuk et al. 2012).

2.2 Fate Processes

Once PCBs (and PBDEs) are introduced the lake, a number of loss and recycling processes determine their mass (and concentration) in the water and sediments of the lake (Gobas et al. 1995, Davis 2004, Oram et al. 2008). These processes include gas exchange across the air-water interface, diffusion across the sediment-water interface, settling and resuspension, burial in deep sediments and washout through the lake outlet. Partitioning between dissolved and sorbed forms determines the amount of particulate-bound contaminant that settles to the bottom and the amount in dissolved form determines exchanges at the air-water and water-sediment interfaces.

2.3 Bioaccumulation Linkages

PCBs (and PBDEs) enter the lake foodweb through accumulation by phytoplankton at the base of the food web, uptake directly from the water and through accumulation by sediment dwelling organisms (benthos) (Gobas et al. 1995, Arnot and Gobas 2004, Kuo et al. 2010). Contaminant concentrations can then increase with each increase in trophic level (i.e., biomagnify) posing the greatest risk to fish eating animals, including humans, river otters and fish-eating birds.

3.0. METHODS

The method used to calculate surface runoff loading of tPCB and tPBDE from watersheds (drainage basins) to Lakes Washington and Union follows the approaches used in similar contaminant mass budget studies (Davis et al. 2007; Oram et al. 2008; Herrera 2011; Gries and Osterberg 2011) where specific basin inputs and pathways are monitored relatively intensively, including the largest fluvial sources, and loads from unmonitored sources are derived based on areal loading rates of the monitored basins. This approach is based on the assumption that monitored drainage basins are representative of the average loads from unmonitored basins, which is not absolutely correct but serves as a basis for a first order estimate of total contaminant loading (Oram et al. 2008).

In general, this approach is suitable for:

- identifying major land uses which are significant sources of these contaminants
- use as a planning tool to evaluate load reductions associated with managing inputs from major pathways
- identifying portions of a watershed where pollutant accumulation and delivery to receiving waters may be greatest
- use in a simple box mass budget model of lake water and sediment to understand how these lakes might respond to reductions in contaminant loading

Loading estimates were based on average hydrological conditions over the last decade (2002 to 2011 Oct-Sep Water Years) to provide a representative starting point for comparisons among pathways and as an appropriate time scale for use as input to the mass budget box model of Lake Washington that will be developed in the next phase of this study.

3.1 tPCB and tPBDE Data

The field study portion of this project was designed to provide adequate representation of the spatial and temporal variation in contaminant concentrations in various surface water loading pathways. These pathways included the two major rivers (Cedar and Sammamish), tributary inputs from three local watersheds (Thornton, Juanita and May creeks) representing a range of development intensity, highway runoff, stormwater, and CSOs (Figure 4). In addition to collection of samples from surface water pathways, the field study also measured bulk contaminant deposition[10] (atmospheric loading) at two locations within the study area (see Figure 4). Atmospheric deposition data are used directly from the associated project data report (King County 2013) to compare relative loadings from various surface water pathways to loading directly to the surface of the lakes. The reader is

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[10] This is also sometimes referred to as atmospheric flux, which can to refer to the downward flux, but also can refer to the net exchange across the air-water interface. Net exchange will be estimated in the modeling component of this study. The term *atmospheric deposition* is used in this report to avoid any confusion that might arise through the use of the term *flux*.

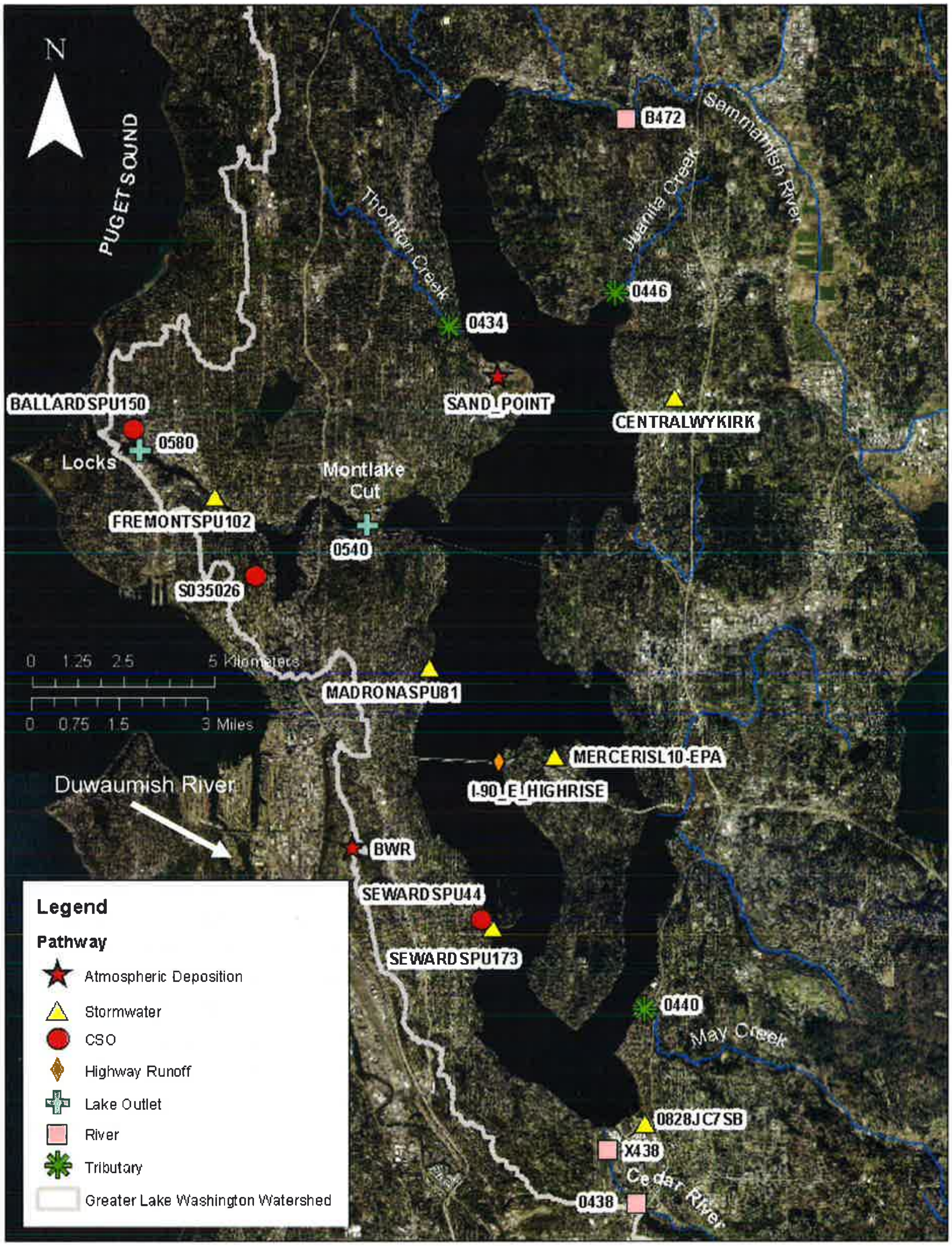

Figure 4. Locations sampled in this study categorized by loading pathway.

Table 1referred to the associated project data report for sampling details, results, and data handling rules (King County 2013).

Table 1 provides summary statistics for tPCB and tPBDE concentrations in surface water pathways measured at each sampling location. Note that all concentrations are reported here in ng/L (10^{-3} µg/L) to two significant figures. Summary statistics include the minimum, maximum, mean, median (i.e., 50th-percentile) and 25th- and 75th-percentile concentrations. In general, tPCB and tPBDE concentrations were highest in CSOs and lowest in the two major rivers and lake outlets. tPCB concentrations in stormwater runoff were much lower than concentrations in CSOs and somewhat higher than concentrations measured in tributary streams. tPBDE concentrations in stormwater were somewhat lower than those measured in CSOs and generally higher than concentrations measured in tributary streams.

An initial evaluation of the data indicated that the greatest amount of skew, and hence uncertainty in loading calculations, was observed in the CSO tPCB sampling data (King County 2013). This was partly due to the relatively small number of samples collected (8 CSO events from 3 CSOs were sampled), but was also likely due to other sources of as yet unexplained variation (e.g., PCB contamination hot spots in a particular CSO basin or dominance of older commercial/industrial buildings containing PCB contaminated materials).

Fortunately, additional tPCB data have been collected from CSOs discharging to the Duwamish River using similar sampling methods and laboratory analytical techniques (King County 2011). The Duwamish River empties into marine waters of Elliott Bay in Seattle just south of the outlet of the Greater Lake Washington watershed to Puget Sound (see Figure 1). A total of 45 samples were collected from seven individual CSO locations during the Duwamish River Basin CSO study (King County 2011). tPCB concentrations reported in the Duwamish study were similar to those measured in this study, although not nearly as positively skewed. Also, the mean concentration in the Duwamish study was somewhat lower (65.2 vs. 100 ng/L) and the median concentration was somewhat higher (47.7 vs. 23 ng/L) than in this study (Table 2).

The data from the Duwamish CSO study were combined with the data from this study to develop a more accurate estimate of the mean CSO tPCB concentration and more accurate statistical characterization to use in estimating tPCB loading uncertainty to Lakes Washington and Union from this pathway. The statistical summary of the combined CSO tPCB data are provided in Table 2.

Mean concentrations determined for each pathway were used to calculate tPCB and tPBDE loading, while the 25th- and 75th-percentile concentrations were used to establish the range of uncertainty in the estimates. Median concentrations were also used to estimate loading for comparison to loading estimates based on the mean concentration and to illustrate the amount of skew in observed pathway concentrations.

Table 1. tPCB and tPBDE results summary for surface water samples. Note that concentrations are all shown in ng/L and rounded to two significant figures.

		tPCB (ng/L)						tPBDE (ng/L)					
						Percentiles						Percentiles	
Pathway/Location [a]	n	mean	min	max	25th	50th [b]	75th	mean	min	max	25th	50th [b]	75th
Major Rivers/Lake Outlets													
Sammamish River	6	0.12	0.042	0.27	0.073	0.110	0.13	0.61	0.02	1.6	0.03	0.47	1.1
Cedar River[c]	6	0.091	0.022	0.23	0.043	0.066	0.11	0.60	0.003	3.2	0.02	0.058	0.25
Montlake Cut	6	0.11	0.051	0.26	0.059	0.085	0.11	0.65	0.18	1.6	0.27	0.53	0.76
Ship Canal Locks [d]	6	0.29	0.14	0.58	0.15	0.20	0.43	0.80	0.029	2.1	0.23	0.60	1.1
Tributaries [e]													
Thornton	4	4.2	1.1	11.0	1.5	2.7	5.4	7.5	1.9	21	2.3	3.6	8.8
Juanita	4	1.7	0.081	5.9	0.23	0.47	2.0	3.8	0.059	14	0.37	0.53	4.0
May	4	1.1	0.10	2.6	0.12	0.77	1.7	0.9	0.059	2.8	0.10	0.42	1.2
All combined	12	2.4	0.081	11	0.24	1.3	2.9	4.1	0.059	21	0.39	1.3	3.2
Highway Bridge (I-90)	4	9.3	3.3	16	5.6	8.9	13	60	2.0	220	4.2	6.2	62
Stormwater													
Renton	3	2.3	1.5	3.4	1.7	2.0	2.7	0.8	0.0091	2.4	0.026	0.043	1.2
Kirkland	4	1.2	0.0078	2.5	0.21	1.2	2.2	0.97	0.012	3.0	0.23	0.43	1.2
Fremont	3	18	3.9	39	7.3	11	25	57	1.8	170	3.1	4.5	85
Madrona	4	7.1	4.1	12	4.7	6.3	8.7	4.1	1.6	9.4	1.6	2.8	5.3
Mercer Island	4	1.9	0.55	3.6	0.87	1.8	2.9	0.79	0.0078	2.2	0.020	0.47	1.2
Seward Park	3	1.9	0.77	2.5	1.6	2.4	2.5	0.070	0.013	0.18	0.017	0.022	0.10
All Combined	21	5.1	0.0078	39	1.5	2.5	4.1	9.4	0.0078	170	0.024	0.93	2.4
CSOs													
Ballard	2	23	19	28	-	23	-	91	16	170	-	91	-
Dexter	3	250	28	570	93	160	360	140	74	210	110	150	180
Seward Park	3	4.3	2.3	6.2	3.4	4.5	5.3	16	6.7	21	14	20	21
All Combined	8	100	2.3	570	5.8	23	61	83	7	210	19	48	150

[a] ***Sample station locator IDs**: **Rivers/Lake Outlets** - Sammamish River (B472), Cedar River (0438), Montlake Cut (0540), Ship Canal Locks (0580;, Tributaries - Thornton Creek (0434), Juanita Creek (0446), May Creek (0440); **Highway Bridge I-90** – I-90_E_HIGHRISE; **Stormwater** – Renton (0828JC7SB), Kirkland (CENTRALWYKIRK), Fremont (FREMONTSPU102), Madrona (MADRONASPU81), Mercer Island (MERCERISL10-EPA), Seward Park (SEWARDSPU173), **CSOs** – Ballard (BALLARDSPU150), Dexter (S035026), Seward Park (SEWARDSPU44).*

[b] *The 50th percentile is synonymous with the median.*

[c] *Upper Cedar River station only.*

[d] *All PBDE congeners were qualified as non-detect in one sample at the Ship Canal Locks. The highest detection limit of all congeners in this sample was used to represent the tPBDE result.*

[e] *The tributary sample statistics represent one base flow and three storm event samples for each tributary (total of four samples per tributary).*

Table 2. Comparison of CSO tPCB concentrations (ng/L) measured in this study and a previous study of Duwamish River CSOs.

	Minimum	25th-percentile	Median	Mean	75th-percentile	Maximum
			tPCB (ng/L)			
This study (n = 8)	2.3	5.8	23.	100	61.	570
Duwamish River [a] (n = 45)	8.01	30.0	47.7	65.2	71.7	455
Combined data (n = 53)	2.3	28.	44.	71.	72.	570

[a] Source: King County (2011)

3.2 Hydrologic Data

In addition to the PCB/PBDE data collected as part of this study, available river and stream flow data provided by the U.S. Geological Survey (USGS), King County and Snohomish County were used to estimate contaminant loading from the monitored rivers and tributary streams (Figure 5).[11] Note that river and stream monitoring locations were intentionally selected to be co-located with continuous gauging locations.

Because discharge from the locks to Puget Sound is not directly measured, precipitation data were used in conjunction with daily flow, lake elevation and evaporation estimates to develop a lake water budget. The water budget provided an estimate of discharge to Puget Sound that was combined with contaminant concentrations measured just upstream of the locks to estimate contaminant loading to Puget Sound. Precipitation data were also used to estimate highway bridge runoff and contaminant loading to the lakes from this pathway.

Daily precipitation data for two stations near the Lake Washington shoreline were obtained from the National Climatic Data Center (Figure 5). Evaporation data were provided by the Washington State University (WSU) Puyallup Research and Extension Center in Puyallup, WA approximately 37 km (23 mi) to the south of Lake Washington.[12] This is the closest station reporting this type of continuous data over the period of interest.

Daily changes in the elevation of Lakes Washington and Union were based on a stage record at the locks obtained from the Seattle District U.S. Army Corps of Engineers (USACOE) (Figure 5).[13] Details of methods used to develop the lake water budget are described in Section 3.4.6 below.

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[11] Respectively, USGS: http://waterdata.usgs.gov/wa/nwis/dv/?referred_module=sw; King County: http://green.kingcounty.gov/wlr/waterres/hydrology/; Snohomish County: http://www1.co.snohomish.wa.us/Departments/Public_Works/Divisions/SWM/Library/Data/

[12] WSU Extension Puyallup AgWeatherNet station: http://weather.wsu.edu/awn.php

[13] U.S. Army Corps of Engineers, Northwestern Division dataquery: http://www.nwd-wc.usace.army.mil/perl/dataquery.pl?k=%22lake+washington%22

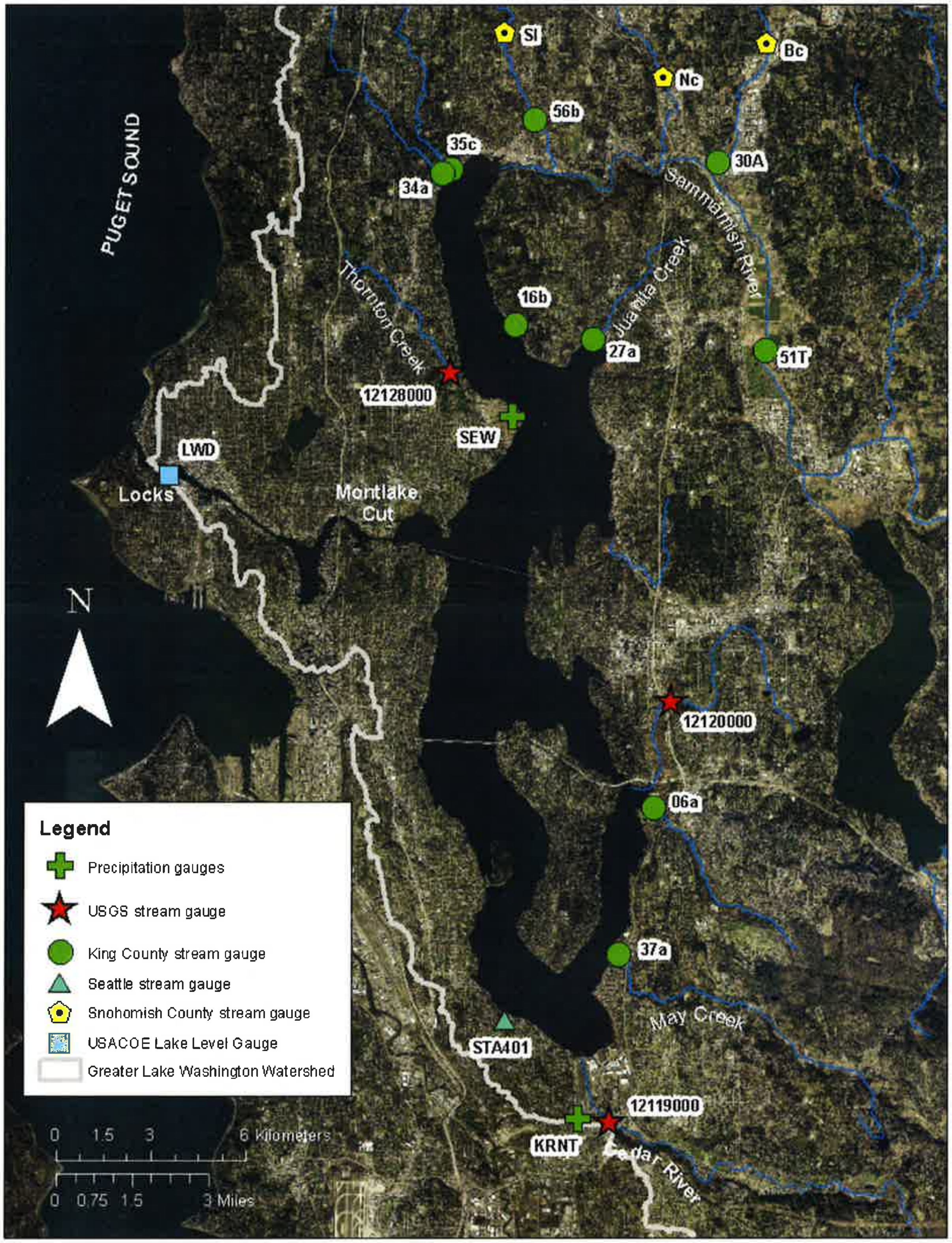

Figure 5. Locations where flow and precipitation were recorded and obtained for use in this study.

3.3 Extrapolation of Flow to Unmonitored Drainage Basins

It was not feasible to measure all inputs from every tributary stream and stormwater drainage basin to a lake system of this size. Therefore, extrapolation was necessary to estimate total contaminant loading from this pathway. Although hydrologic and water quality models (Hydrologic Simulation Program-FORTRAN [HSPF]) have been developed for tributary stream basins to Lake Washington (King County 2003b)[14], these models have not been updated to represent more recent land cover or meteorological data. In addition, these models have not been calibrated to flow data that are available for many of these tributary basins. One exception is Juanita Creek, which King County recently updated and calibrated for use in a stormwater retrofit study (King County 2012).

After updating the land cover represented in these models and calibration to available flow gauging data, extrapolation to ungauged basins would still be necessary, albeit via the sophistication of a continuous hydrologic model. It is uncertain that such an extrapolation approach would be more accurate considering the findings of Dinicola (2001) that calibrated HSPF models of Puget Lowland tributaries are not readily transferable to ungauged basins without additional calibration. Regardless, updating and calibrating these models was beyond the scope of this study.

Methods used to extrapolate flow to unmonitored drainage basins for use in the lake water budget are described below. The method used to extrapolate contaminant loading to unmonitored drainage basins is described in Section 3.4.2.

3.3.1 Definition of Terms

Before describing the methods used to extrapolate flow to unmonitored drainage basins, it may be helpful to define some terminology. For example, hydrologists use a variety of terms that are more or less synonymous, but may have more specific meaning for some readers.

For example, a *drainage basin* is an area of the land surface where rain (or melting snow) drains or runs to a single point defined at the discretion of a researcher or by geographic features, such as where a river, creek or stream enters a lake. Other terms that are synonymous with drainage basin are *catchment, tributary basin* or *watershed.* A *drainage basin* as defined here is a river, creek, stream or stormwater conveyance system that is flowing into another or larger water system (e.g., a stormwater conveyance system to a stream, a stream to a lake). Drainage basins within the Greater Lake Washington watershed defined for the purposes of this report are placed into four categories:

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[14] The Lake Union watersheds were not modeled as part of that project, nor were the combined and partially separated drainages to Lake Washington to the north and south of Union Bay.

- River basins: The Cedar and Sammamish basins are the largest and best defined drainage basins to Lake Washington with reliable flow measurements for the study period of interest.
- Tributary basins: Smaller drainages to Lake Washington with some remaining historical stream network that discharges to the lake. Several of these basins have reliable flow measurements for the study period of interest (e.g., Juanita Creek), but some do not (e.g., Forbes Creek).
- Partially separated basins: For lack of a better term, this is used to describe basins that no longer have much of an existing historical stream network and consist of partially separated stormwater and wastewater conveyance networks. These basins are found within the Central Seattle area and drain to the central western shore of Lake Washington and to Lake Union and the Ship Canal. For the most part, these basins do not have reliable flow data and the area of the basin that contributes to surface runoff that is ultimately delivered to the lakes is not well defined.
- Stormwater basins: These are relatively small, well defined drainage areas with little or no historical stream network that route precipitation runoff through a stormwater conveyance network that discharges directly to Lakes Washington or Union. These basins do not have reliable flow data for the study period of interest, although instantaneous flow measurements were made when study samples were collected for analysis.

Hopefully, these definitions will assist in more clearly describing the methods used to extrapolate flow and contaminant data from monitored to unmonitored drainage basins.

Definitions of various components of drainage basin flow or discharge hydrographs will hopefully provide necessary context for the description of methods used to separately calculate drainage basin loads from *base flow*, *storm flow* and *stormwater runoff* (see Figure 6). In typical Lake Washington tributary basins, there is a base level of flow (*base flow*) that is maintained through the release of shallow groundwater to the stream – more in winter and progressively less through the driest late summer and early fall period. During precipitation events, particularly in urbanized basins with stormwater drainage basins (i.e., stormwater conveyance systems) connected to the stream, *stormwater runoff* is delivered to the stream, which increases flow so that the stream carries a mixture of stormwater runoff and base flow that is defined here as *storm flow*. Base flow can also increase initially, in part due to the relatively rapid delivery of water passed laterally through the soil to the stream. Figure 6 provides a visual representation of the flow hydrograph definitions developed above.

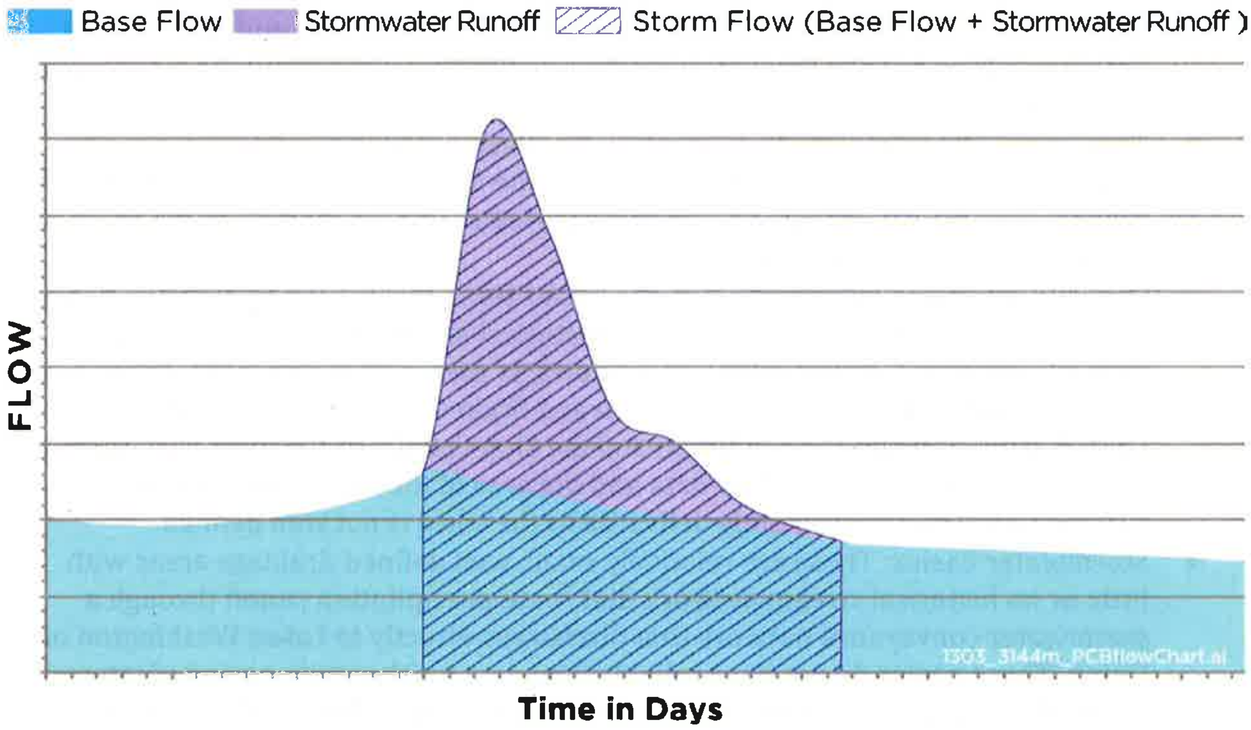

Figure 6. Conceptual storm and base flow hydrograph, including visual definitions of base flow, stormwater runoff and storm flow (Base Flow + Stormwater Runoff).

3.3.2 Estimating Ungauged Drainage Basin Flow

To estimate long-term average flow from ungauged drainage basins, the long-term mean annual flow (2002-2011) of gauged tributary basins around the lake was calculated and compared to the contributing basin area for each gauge.[15] A linear regression ($r^2 = 0.84$; $p < 0.0001$, SE = 30%) of basin area vs. mean annual flow indicated that basin area could be used as a reasonable first approximation of mean annual flow in other tributary basins around the lake (Figure 7). The slope of the linear regression line indicated an average water yield of 0.103 cms per km^2 (1.4 cfs per mi^2).

There appeared to be two outliers (Mercer/Kelsey Creek and Thornton Creek) in the relationship between mean annual flow and basin area. Mercer/Kelsey Creek yields more water and Thornton Creek yields less water per unit area than is typical of other gauged Lake Washington tributaries. The explanation for the lower yield of Thornton Creek is in part the result of the significant amount of flow that is diverted past the gauge via a direct discharge from Meadowbrook Pond to Lake Washington (City of Seattle 2007). The higher yield of Mercer/Kelsey is more difficult to explain, although it is believed that water is occasionally diverted to Mercer/Kelsey Creek from Phantom Lake in the Lake Sammamish drainage just east of the headwaters of the Mercer/Kelsey basin (City of Bellevue 2009). Regardless, removal of these two data points did not change the slope of the regression, but did increase the regression coefficient ($r^2 = 0.98$; $p < 0.0001$, SE = 13%). Therefore, 0.103

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[15] King County GIS Center. topo_basin: http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=topo_basin

cms per km^2 (1.4 cfs per mi^2), the average water yield, is used to extrapolate gauged drainage basin flows to ungauged Lake Washington drainage basins.

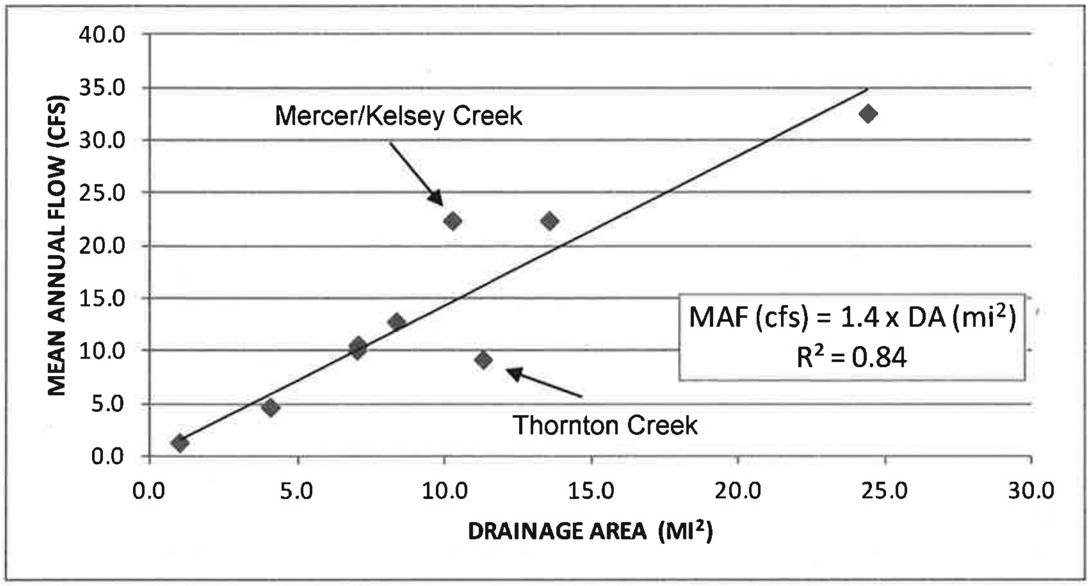

Figure 7. Scatter plot and linear regression best-fit line of mean annual flow vs. drainage area for gauged Lake Washington tributaries.

Note: MAF = Mean annual flow; DA = Drainage area; 1.4 cfs mi^{-2} = annual areal water yield

Because of a significant backwater effect of Lake Washington on the Sammamish River (King County 2009), the existing flow gauge is located upstream of three major tributaries (Little Bear, North and Swamp creeks) that enter the river below the gauge but before it discharges to Lake Washington. Swamp and Little Bear creeks have been gauged near their mouths in the past decade, but these gauges have been discontinued and, in the case of Swamp Creek, the gauge was operated for just a few years. Fortunately, Snohomish County has maintained gauges on all three creeks over the past decade.

Total flow from the three Sammamish River tributaries below the gauge was estimated by scaling the observed flow rate at the upstream tributary gauge by the ungauged lower tributary watershed area (Total Flow = Gauged Flow x Total Area/Gauged Area). Flow from the ungauged valley area to the river was based on the unit area flow rate of 0.025 cms per km^2 (0.9 cfs per mi^2) derived from previous hydrologic modeling of the Sammamish River (King County 2009). This value is less than the unit area runoff rate used for the unmonitored Lake Washington basins because of low impervious cover and relatively flat terrain of the Sammamish River valley floor.

3.3.3 Estimating Flow from Central Seattle Basins

Extrapolation of flow to the most urbanized drainage basins in central Seattle, which do not have long-term gauging data, is made more challenging because a portion of these drainages are part of a combined sewer system that transfers stormwater runoff and domestic wastewater to treatment plants that discharge directly to Puget Sound. Some of these combined systems are responsible for episodic CSOs that discharge to the lake and canal system. The remainder of this area is served by a partially separated system, often with rooftop drains connected to the wastewater conveyance system, and street and parking lot runoff directed to a stormwater conveyance system. The stormwater conveyance system may eventually discharge to the lake or canal, but sometimes an initially separated stormwater conveyance ultimately empties into the wastewater conveyance system.

Although hydraulic models of the combined wastewater system exist, they are generally not integrated with stormwater conveyance system details that would readily provide an estimate of flow to the lake and ship canal system. It may be possible to develop partially separated basin flow estimates from the wastewater conveyance models; however, this approach is beyond the scope and resources for this project.

To provide a first approximation of the flow from the partially separated areas, a GIS coverage of the partially separated basin areas provided by the City of Seattle[16] was intersected with central Seattle tributary watershed boundaries (Figure 8) to estimate the drainage areas contributing flow to Lakes Washington and Union. This area was then used along with the approach described above for extrapolating flows to ungauged partially separated basins to estimate the average flow contribution from these areas. This provides a reasonable first approximation until better estimates of flow from these areas can be developed.

3.3.4 Estimating the Thornton Creek Flow Bypass

As mentioned above, a flow bypass on Thornton Creek diverts flow during high flow events via a diversion to Meadowbrook Pond located just below the confluence of the north and south branches of the creek. When storage in the pond is exceeded, flows are diverted to an outfall that discharges directly to Lake Washington (City of Seattle 2007). The amount of flow bypassed can be substantial relative to the total flow of Thornton Creek. The Thornton Creek Watershed Management Committee (2000) indicated that the bypass flow rate can be as high as 9.91 cms (350 cfs) with an annual average of approximately 0.147 cms (5.2 cfs). The average flow rate of 0.147 cms (5.2 cfs) was used to approximate the additional stormwater flow from Thornton Creek.

3.4 Loading Estimates

Loading is determined by multiplying a contaminant concentration in units of mass per volume by a flow rate in volume per time, resulting in an estimate of the mass delivered per some unit of time. For tPCBs and tPBDEs, contaminant loading is typically reported in grams per year (g yr^{-1}). Loading is also reported on a per unit area basis by dividing the

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[16] King County GIS Center. cse_dbasin: http://gisdw/intranet/sdc/nonkcgis/content/hydro_ext/cse_dbasin.htm (KC intranet access only)

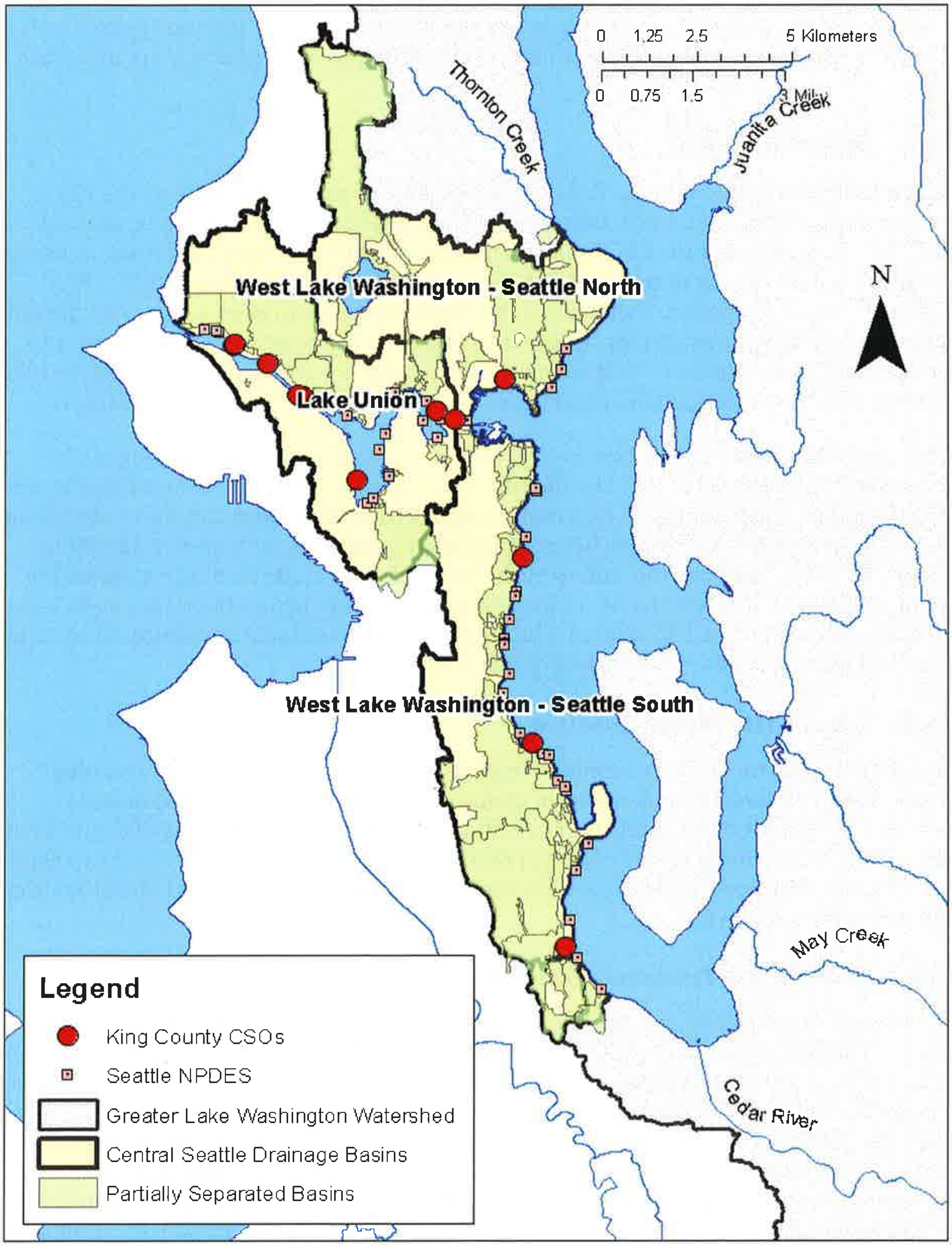

Figure 8. Location and extent of Central Seattle and Lake Union tributary basins and the contributing area of partially separated basins.

estimated load by the total watershed area above that point. Areal loads for these contaminants are typically reported in grams per square kilometer per year (g km^{-2} yr^{-1}). Details of methods used to estimate contaminant loading for each pathway are described below.

3.4.1 Major Rivers

tPCB and tPBDE loading from the Cedar River were calculated by multiplying the mean concentration of tPCB and tPBDE measured at Station 0438 by the annual average flow (2002-2011) observed at the USGS gauge (Station 12119000) on the Cedar River at Renton. Contaminant data were also collected at a station located closer to the mouth (Station X438) to evaluate the potential increase in contaminant concentration as the river passed through part of downtown Renton. Concentrations of tPCB and tPBDE did not appear to increase based on comparison of the four synoptic sampling events (see King County 2012 for more details regarding comparison of upstream and downstream concentrations).

Contaminant loading from the Sammamish River was calculated by multiplying mean concentrations measured at B472 by the sum of the annual average flow measured at the upstream gauge (King County 51T), tributary inputs from Little Bear and North creeks, and the flow from the river valley area between the river gauge and contaminant sampling location. Total loading from the Sammamish River did not include loading estimated for Swamp Creek, which enters the river below Station B472 but before the river enters Lake Washington (see Section 3.3.2 above). The method used to estimate unmonitored tributary watershed loading is described in the next section.

3.4.2 Local Drainage Basins

The approach to estimating contaminant loading from local drainage basins, including loading from tributary streams and from Central Seattle basins, is described below. Methods are described separately for estimating loading from local drainage basins (1) that were monitored during this study, and (2) that were unmonitored, for which extrapolation was used, including loading from partially separated drainages within the Central Seattle watersheds (see Figure 8).

3.4.2.1 Monitored Tributary Basins

Total loads from local tributary basins were estimated by assuming that unmonitored basins contribute comparable PCB loads as monitored tributary basins with similar overall land uses (i.e., Thornton, Juanita and May creeks). This approach is similar to that used to estimate PCB and PBDE loadings to the San Francisco Estuary (Davis et al. 2007; Oram et al. 2008). The method used to develop loading estimates for monitored tributary basins follows the approach used by Herrera (2011) to estimate areal contaminant loading rates from specific land use types monitored in several small watersheds located in two Puget Sound river basins (Puyallup and Snohomish). Details of calculating loads from monitored tributary basins and extrapolation to the remaining unmonitored drainage basins are described below.

Loading from monitored tributaries was calculated using gauged flow data and measured contaminant concentrations at the same location. One base flow and three storm flow samples were collected from each tributary basin. A stream flow hydrograph separation program based on the local-minimum method implemented in HYSEP (Sloto and Crouse 1996) was used to quantify mean base flow and storm event flow rate using decade-long (2002-2011) daily flow records available for each tributary contaminant sampling location. Base and storm flow loadings were calculated by multiplying base flow and mean storm flow contaminant concentrations by the respective mean flow rates. In the case of Thornton Creek, estimated average storm bypass flow of 0.147 cms (5.2 cfs) was added to mean storm flow from the base flow separation analysis before calculating the storm load. Base and storm flow loads were then summed to obtain the total loading rate in g yr^{-1} for each tributary. Total basin area of each tributary was then used to calculate the areal loading rate for tPCB and tPBDE.

Although hydrograph separation is a somewhat subjective process, computer algorithms allow for the consistent application of a certain set of rules to remove some of the subjectivity inherent in this type of analysis as noted by Soto and Crouse (1996). In addition to the stream flow time series, basin area above the gauge is used in the program to determine the appropriate time interval to use in flow separation analysis.

3.4.2.2 Extrapolation to Unmonitored Drainage Basins

Extrapolation of contaminant loading to ungauged watersheds in the San Francisco Estuary studies (Davis et al. 2007; Oram et al. 2008) used the average areal loading rate derived for monitored basins representing approximately 10 percent of the local drainage.[17] However, they note that their estimate may have been too low because inputs from small, historically industrial watersheds could contribute relatively large loads that might not have been well represented in their studies.

In this study, the three monitored tributary basins represent over 20 percent of the local drainage to Lake Washington (excluding estimated drainage to the combined system) and also have a range of land uses reflective of the local tributary drainages to the lake. These tributaries were selected for monitoring because they had operating continuous flow gauges. The three tributaries also represented historical and current development ranging from older high density residential and commercial development in Thornton Creek to somewhat lower intensity and younger development in Juanita Creek and more recent medium to low density and mixed commercial development in May Creek.

Rather than use average areal contaminant loading rates of the three basins to extrapolate loading to the remainder of the local drainages, hypotheses were developed based on the conceptual model presented above (see Section 2.1) and additional information presented below to estimate contaminant loading rates. Based on evaluation of these hypotheses, we identified unmonitored Thornton Creek-like, Juanita Creek-like and May Creek-like tributary basins as a first approximation for extrapolation. Our intent was to lay the

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[17] Local drainage refers to creeks and river drainages surrounding the estuary, excluding the Sacramento-San Joaquin Basin ("Delta" flow in their publications) which drains about a third of California.

foundation of a conceptual model to frame interpretation of the loading information generated in this study and generate hypotheses to guide future studies and management activities.

Previous studies have identified urban areas as significant sources of PCBs and PBDEs from atmospheric emission (Persoon et al. 2010; Wethington and Hornbuckle 2005; Melymuk et al. 2012) and urban runoff (Davis et al. 2007; Oram et al. 2008). For PCBs, this is consistent with Robson et al. (2010) who found that significant stocks of PCBs remain in urban areas in closed sources like transformers, capacitors and light ballasts and in open sources like caulks and sealants used in commercial and industrial buildings.

Melymuk et al. (2012) noted that atmospheric concentrations of PCBs and PBDEs were highest in the vicinity of the central business core of Toronto, Canada. This pattern is consistent with results of a recent Puget Sound contaminant deposition study that found highest deposition rates of PCBs and PBDEs at a highly urban and industrial site in Tacoma, WA (Brandenberger et al. 2010). One study has even suggested a link between linear distance from percent commercial land use and PCB contamination of perch sampled from sub-estuaries around Chesapeake Bay (King et al. 2004).

A recent Puget Sound contaminant loading study focused on small drainage basins with relatively consistent land use within each basin characterized as either commercial/industrial, residential, agricultural or forest/field/other (Herrera 2011). They found that highest areal loads of PCBs and PBDEs were delivered in storm flow from basins with predominantly commercial/industrial land use. Areal loading from base flow was similar among the four land use categories.

Based on the conceptual model and additional synthesis of previous studies, estimated areal loading rates from Thornton, Juanita and May creeks were compared to basin-scale population density, percent impervious cover, percent of basin built in or before 1979, and percent of basin area built as commercial or industrial property in or before 1979. This information was used to evaluate hypotheses to classify unmonitored drainage basins as similar to one of the monitored basins. Population density was based on the most recent census block data, percent impervious cover was based on the 2006 National Land Cover Database (Fry et al. 2011), and percent of land built in or before 1979 was based on analysis of the most recent King County parcel layer and assessor tables.

3.4.3 Highway Runoff

Contaminant loadings from highway bridges that cross Lakes Washington (SR 520 and I-90) and Union (I-5 and SR 99) were calculated by multiplying surface areas of these highways[18] by the average of long-term (2002-2011) mean annual precipitation reported at the Renton Airport located at the southern end of Lake Washington and Sand Point on the western shore of the lake (see Section 3.2 above). Annual surface runoff was then multiplied by mean tPCB and tPBDE concentrations measured in bridge runoff during the

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[18] Data based on bridge inspection reports provided by Archie Allen, Maintenance and Operations Bridge Superintendant, Washington State Department of Transportation, Bellevue, WA.

study to estimate total annual contaminant loads to each lake system from this pathway. It was assumed that there were no evaporative losses during runoff events.

3.4.4 Combined Sewer Overflows

Loading from combined sewer overflows was estimated by compiling the most recent and most reliable CSO flow estimates for King County and Seattle CSOs available from annual reports (e.g., King County 2012c; Seattle Public Utilities 2012). To represent flow conditions, the most recent reliable flow data were selected. For King County CSOs, flow data were available for 2007 through 2011; a five year period. Reliable flow data were available for Seattle CSOs only for three years (2009 through 2011). Total annual CSO flow was summed separately for CSO discharges to Lake Washington and to Lake Union. The mean annual flow rates to Lake Washington and to Lake Union were then multiplied by the average CSO concentrations based on the combination of data from this study and the data from the Duwamish River study (see Section 3.1 above) to estimate long-term annual contaminant loading from CSOs.

3.4.5 Atmospheric Deposition

Atmospheric loading was based on deposition data collected during this study. Field methods and details of deriving deposition rates are documented in a separate report (King County 2013). Reported contaminant deposition rates from the two stations were averaged and the mean areal deposition rate was multiplied by the surface area of each lake system to derive an estimate of annual loading from this pathway.

3.4.6 Loading to Puget Sound

Discharge from Lake Union and the locks to Puget Sound is not directly measured because of the complexity of the lock and dam system at the outlet of the Greater Lake Washington watershed. To estimate loading to Puget Sound, estimates of total outflow were derived using two slightly different approaches. One approach was based on a daily water balance approach that has been used in previous water quality modeling studies of the lake (Cerco et al. 2004).

The water balance equation solved for the system outflow is:

$$Q_{out} = \left(Q_{in} + Q_{prec}\right) - \left(Q_{\Delta S} + Q_{evap}\right)$$

Where:

$Q_{out} \equiv$ Total outflow to Puget Sound

$Q_{in} \equiv$ Watershed inflows

$Q_{prec} \equiv$ Precipitation

$Q_{\Delta S} \equiv$ Storage

$Q_{evap} \equiv$ Evaporation

Watershed inflows were based on the sum of gauged river and tributary inflows and estimated ungauged tributary inflows between October 2002 and September 2011. Because daily flow from ungauged tributaries was needed for this approach, the annual average unit area flow estimate described above was unsuitable for this purpose. For the daily lake water balance, ungauged tributary flows were based on scaling daily flow from a representative gauged tributary. The daily flow record for May Creek was selected as the basis for extrapolation. May Creek was used because it has complete daily flow records for the period of interest (i.e., no missing daily values) and does not appear to be affected by significant flow diversions (see Section 3.3.2 above).

The remainder of inputs to the daily water balance included the average of daily precipitation measured at the Renton Airport and at Sand Point. Daily evaporation data was obtained from the WSU Experimental Station in Puyallup, WA. Storage changes in the lake were based on daily changes in lake level reported by the Seattle District USACOE and the surface area of Lakes Washington and Union. All inputs were converted to daily flow by multiplying the depth of rainfall, evaporation or lake level change by the total combined area of Lakes Washington and Union of 92.8 km^2 (35.8 mi^2).

The second approach was based on the knowledge that over a decade long period, lake storage changes become a relatively unimportant component of the water budget and can be omitted from the water balance equation. This is especially true for this system, considering that the level of the lake generally ranges no more than 0.61 m (2 ft) and is closely controlled to the same maximum level in summer and the same minimum level in winter.

Therefore, the water balance on a long-term basis becomes:

$$Q_{out} = (Q_{in} + Q_{prec}) - (Q_{evap})$$

Where:

$Q_{out} \equiv$ Total outflow to Puget Sound

$Q_{in} \equiv$ Watershed inflows

$Q_{prec} \equiv$ Precipitation

$Q_{evap} \equiv$ Evaporation

Furthermore, daily flow inputs can be replaced with long-term average flows, which means that the unit area flow scaling approach (described in Section 3.3.2 above) can be used to estimate long-term mean flow from ungauged tributaries. Both approaches were applied using data for the Water Year (Oct-Sep) period 2002-2011.

3.5 Uncertainty Assessment

Understanding uncertainty in measured hydrologic and contaminant data is critical to appropriate water quality assessment, management and modeling (Harmel et al. 2009). Harmel et al. (2006) identified four procedural sources of uncertainty including streamflow measurement, sample collection, sample preservation/storage and laboratory analysis.

Herrera (2011) identified a slightly more expansive list of sources of uncertainty that included streamflow measurement and laboratory error, but also included extrapolation of sampling results as another source of uncertainty. Uncertainty from extrapolation includes extrapolation from instantaneous loads based on measured flow and concentration to longer periods (months to years) and extrapolation of loads estimated for a measurement location to unmonitored locations (Webb et al. 1997).

A quantitative uncertainty analysis based on propagation of all quantifiable sources of error is beyond the scope of this study.[19] In general, surface runoff estimates developed for this study are assumed to be relatively certain. An earlier water budget of Lake Washington that included first-order error analysis, determined that because much of the river and stream flow to the lake is measured relatively accurately, the total estimated discharge to the lake is associated with relatively little error (Edmondson and Lehman 1981). The greatest uncertainty is likely associated with estimated mean contaminant concentration in each loading pathway and associated extrapolation errors. To provide a first approximation of uncertainty in these loading estimates, the 25th- and 75th-percentile contaminant concentrations were used to calculate a likely upper and lower bound on the loading estimate based on the mean concentration measured in a particular loading pathway.

Contaminant loading estimated using the median concentration is also calculated and compared to the load estimated using the mean concentration to highlight the degree of skew in observed tPCB and tPBDE concentrations in each loading pathway. The skew in environmental contaminant data is typically positive; the tail on the right side of the data distribution is longer and the majority of concentration values lie to the left of the mean (i.e., the mean is higher than the median value).

Although relatively large differences between mean and median values suggest significant skew in the population of contaminant concentrations in a particular loading pathway, this does not imply that the loading estimate based on the median (or geometric mean) would be a more accurate estimate of loading. However, the relatively large skew in the small data sets generated for particular loading pathways in this study indicates that the current estimate of the mean concentration and subsequent loading estimate is highly uncertain. In the cases where skew appears to be relatively smaller, loading estimates have relatively less uncertainty.

To demonstrate that the mean concentration is the correct value to use in loading calculations, a simple example is presented here using an existing data set consisting of one year of daily flow and total phosphorus (TP) measurements made in Issaquah Creek (Birch 1976). Issaquah Creek is the main inflow to Lake Sammamish (see Figure 1). TP data are right-skewed with a mean and median concentration of 57.4 and 37.0 µg/L, respectively. The mean flow during the sampling period was 3.99 cms (141 cfs). Assuming that daily TP

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[19] Note that the terms "error" and "uncertainty" as used here are synonymous and refer to the uncertainty in (or error of) our measurements and estimations of total average flow and contaminant concentrations, which if known with absolute certainty for each pathway would provide the true contaminant load to the system.

values are an accurate representation of the concentration in the river each day[20], the actual load can be calculated by multiplying the daily concentration by the daily flow which yields an estimated loading of 7,200 kg TP yr^{-1}. One can arrive at very nearly the same result by multiplying the mean annual flow by the mean concentration. However, if one uses the median concentration, the estimated load is 4,700 kg TP yr^{-1} – about 35 percent less than the best estimate of total load based on the daily flow and concentration data.

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[20] Single daily grab samples collected in the study were probably not the best representation of daily average TP concentration, but this is mostly a separate sampling and statistical issue not being addressed explicitly here, but acknowledged as an issue in our study (i.e., procedural uncertainty).

4.0. RESULTS

Results for each loading pathway are summarized below and compared to data from other studies with a focus on studies conducted within the Puget Sound basin.

4.1 Major Rivers

Estimated tPCB and tPBDE loading from the two major rivers is summarized in Table 3. Estimated loads are based on the average (2002-2011) flow rate of 19.6 cms (692 cfs) for the Cedar River and 10.9 cms (384 cfs) for the Sammamish River. Even though the total flow from the Sammamish River is lower than that of the Cedar River, estimated loading from these rivers is similar in magnitude, although the contribution from the Sammamish River based on mean concentrations is somewhat lower than that from the Cedar for both tPCB and tPBDE. Note that the range of river loading estimates indicate positive skew in the concentration data, particularly for tPBDE concentrations measured in both rivers where the loading estimates using the mean are greater than those estimated using the 75th-percentile concentration.

Estimated areal loadings of tPCB and tPBDE from the Cedar and Sammamish rivers are summarized in Table 4. As with total loading, estimated loadings on an areal basis are similar for the two rivers. Because the drainage area represented by the Sammamish River estimate is somewhat larger than that represented by the Cedar River, areal loading rates based on mean concentrations are somewhat lower for the Sammamish River.

In general, areal tPCB loading estimates for the Cedar and Sammamish rivers are near the lower range reported by Gries and Sloan (2009) for the Green River just to the south of the Cedar River basin. Their estimate was based on analysis of contaminants sorbed to suspended particulate matter and ranged from 0.14 to 1.99 g km^{-2} yr^{-1}. Estimates of areal loading for the Cedar and Sammamish rivers reported here are also within the range of estimated areal loads of tPCB from the study of five major Puget Sound rivers, which ranged from 0.058 to 0.364 g km^{-2} yr^{-1} reported as the 25th and 75th percentile (Ecology and King County 2011; Greis and Osterberg 2011). Areal tPBDE loading from the same five rivers ranged from 0.118 to 0.230 g km^{-2} yr^{-1} again reported as the 25th and 75th percentile (Ecology and King County 2011; Greis and Osterberg 2011). Estimated areal loadings of tPBDE for the Cedar and Sammamish rivers are generally closer to the higher range of loading estimates for large Puget Sound rivers.

Table 3. Loading estimates of tPCB and tPBDE to Lake Washington from the Sammamish and Cedar rivers.

	25th-percentile	Median	Mean	75th-percentile
		tPCB (g yr^{-1})		
Cedar River	27	41	56	68
Sammamish River[a]	25	38	41	45
		tPBDE (g yr^{-1})		
Cedar River	9.9	36	370	150
Sammamish River[a]	11	160	210	380

[a] *Note that the estimated load from the Sammamish River is based on measured concentrations and estimated flow at B472, which is above the point where Swamp Creek enters the Sammamish River. Estimated loading from Swamp Creek is included in the unmonitored tributary loading estimate below.*

Table 4. Areal loading estimates of tPCB and tPBDE for the Sammamish and Cedar rivers.

	25th-percentile	Median	Mean	75th-percentile
		tPCB (g km^{-2} yr^{-1})		
Cedar River	0.054	0.082	0.11	0.14
Sammamish River[a]	0.045	0.068	0.074	0.081
		tPBDE (g km^{-2} yr^{-1})		
Cedar River	0.020	0.072	0.74	0.30
Sammamish River[a]	0.020	0.29	0.38	0.68

[a] *Note that the estimated load from the Sammamish River is based on measured concentrations and estimated flow at B472, which is above the point where Swamp Creek enters the Sammamish River. Estimated loading from Swamp Creek is included in the unmonitored tributary loading estimate below.*

4.2 Local Drainage Basins

4.2.1 Monitored Tributary Basins

The first step in the approach used to estimate loading from the three monitored tributaries was to conduct a base flow separation analysis in order to assign a concentration for days of base flow and another concentration representing days with storm flow. Example results for the analysis of the flow records from the three gauged basins are provided in Figure 9.

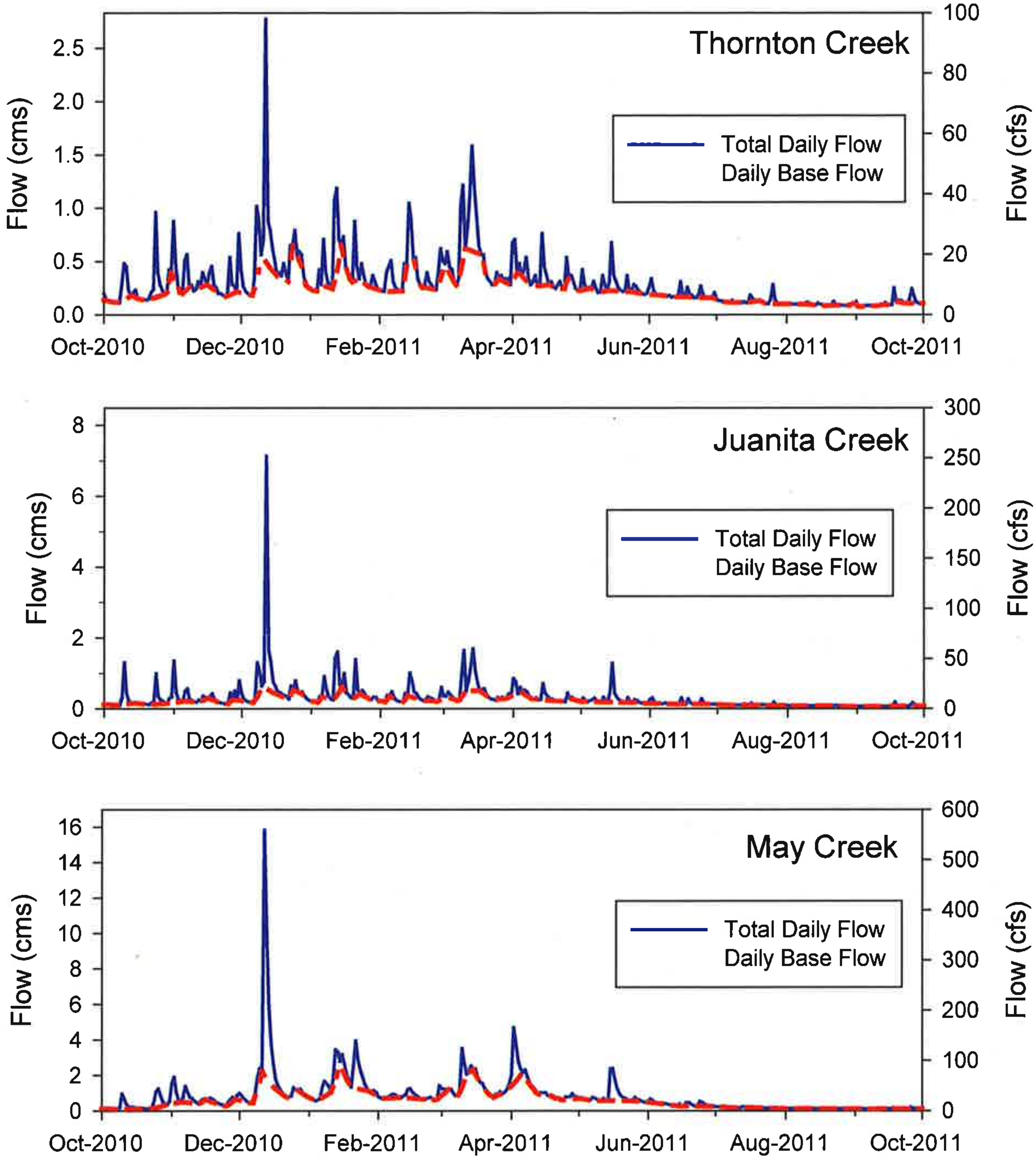

Figure 9. Time series graphs of daily average flow and estimated base flow for Water Year (Oct-Sep) 2011 discharge observed in Thornton (top graph), Juanita (middle graph) and May (bottom graph) creeks.

Note: The y-axis scale is different in each graph.

The mean base and storm flow (2002-2011) estimates derived from the base flow separation analysis are provided in Table 5. Flow (base, storm and mean) was highest in May Creek, which is consistent with its much larger basin area and higher elevation headwaters. The Juanita Creek drainage is about 40 percent smaller than Thornton Creek, but had similar base flow. Accounting for the flow that bypasses the Thornton Creek gauge at the mouth results in storm and mean flows that are higher than those in Juanita Creek, but not quite as much as would be expected based on basin area. It is possible that some of the runoff in the Thornton Creek basin remains unaccounted for, either as a result of error in the bypass flow estimate or as the result of diversion of storm drainage to another basin or to a combined sewer system.

Table 5. Base and storm flow estimates based on base flow separation analysis of Thornton, Juanita and May creeks.

	Base Flow	Storm Flow cms (cfs)	Mean Flow
Thornton Creek	0.068 (2.4)	0.317 (11.9) [a]	0.408 (14.4) [a]
Juanita Creek	0.068 (2.4)	0.232 (8.2)	0.300 (10.6)
May Creek	0.116 (4.1)	0.518 (18.3)	0.634 (22.4)

[a] *The storm flow and mean flow estimates for Thornton Creek include the estimate for the flow bypass from Meadowbrook Pond to Lake Washington. The observed mean flow (2002-2011) was 0.261 cms (9.2 cfs).*

Estimated tPCB and tPBDE loadings from the three monitored tributaries based on measured contaminant concentrations and the base and storm flow estimates provided above are summarized in Table 6. The range in observed storm flow concentrations was carried through to the estimate of total tPCB and tPBDE loadings from these tributary basins in Table 7. Note that the range of loading estimates generally indicate positive skew in the storm flow concentration data such that estimated mean loadings are greater than estimates based on the median storm flow concentrations, with the possible exception of May Creek. Estimated loadings from May Creek based on mean and median storm flow concentrations were the same for tPCB.

Areal loading estimates for these tributary basins are summarized in Table 8. On an areal basis, loading from these basins was higher than that observed for the Cedar and Sammamish rivers. Also, mean areal loading rates were consistently lowest for May Creek and highest for Thornton Creek.

Tributary basin areal loading rates shown in Table 8 are comparable to the median estimates for Puget Sound commercial/industrial land uses reported by Herrera (2011). Based on Puget Sound drainage areas for each land use type characterized in their study, the median loads provided in Table 15 of their report were converted to areal loading, which resulted in an estimated tPCB loading rate of 1.2 g km^{-2} yr^{-1} and a tPBDE loading rate of 1.9 g km^{-2} yr^{-1}. Areal loading rates for other land uses targeted in their study (residential,

Table 6. Base and storm flow loading estimates of tPCB and tPBDE to Lake Washington from Thornton, Juanita and May creeks.

	Base Flow ($g\ yr^{-1}$)	Storm Flow			
		25th-percentile	Median	Mean	75th-percentile
			tPCB ($g\ yr^{-1}$)		
Thornton Creek	2.5	28.	39.	56.	76.
Juanita Creek	0.17	3.5	4.9	17.	24.
May Creek	0.46	12.	23.	23.	33.
			tPBDE ($g\ yr^{-1}$)		
Thornton Creek	4.0	38.	50.	99.	140.
Juanita Creek	1.3	2.0	3.5	36.	53.
May Creek	2.6	1.4	1.9	16.	23.

Table 7. Total loading estimates of tPCB and tPBDE to Lake Washington from Thornton, Juanita and May creeks.

	25th-percentile	Median	Mean	75th-percentile
		tPCB ($g\ yr^{-1}$)		
Thornton Creek	31.	41.	59.	78.
Juanita Creek	3.7	5.1	17.	24.
May Creek	13.	23.	23.	34.
		tPBDE ($g\ yr^{-1}$)		
Thornton Creek	42.	54.	100.	140.
Juanita Creek	3.3	4.8	37.	55.
May Creek	4.1	4.5	19.	26.

Table 8. Total areal loading estimates of tPCB and tPBDE for Thornton, Juanita and May creeks.

	25th-percentile	Median	Mean	75th-percentile
		tPCB ($g\ km^{-2}\ yr^{-1}$)		
Thornton Creek	1.1	1.4	2.0	2.7
Juanita Creek	0.20	0.28	0.93	1.3
May Creek	0.37	0.67	0.66	0.95
		tPBDE ($g\ km^{-2}\ yr^{-1}$)		
Thornton Creek	1.4	1.9	3.5	4.8
Juanita Creek	0.18	0.26	2.0	3.0
May Creek	0.12	0.13	0.53	0.74

agricultural, forest/field/other) were lower that estimates for Thornton, Juanita and May creeks by one or more orders of magnitude; 0.084 to 0.148 g km^{-2} yr^{-1} for tPCB and 0.064 to 0.163 g km^{-2} yr^{-1} for tPBDE based on median loads reported in Herrera (2011).

4.2.2 Extrapolation to Unmonitored Local Drainage Basins

Estimated areal loading from the three monitored tributary basins was consistent with the expectation that the range in character and degree of development among the monitored basins would result in a range of areal loading estimates – highest in Thornton Creek and lowest in May Creek. The areal loading estimates were compared to four basin characteristics to identify a plausible and somewhat objective means of extrapolating loading rates to unmonitored drainage basins around the lake. These characteristics were percent total impervious cover, population density, percent of basin developed in or before 1979 and percent of basin developed as commercial/industrial parcels in or before 1979.

Comparisons of tPCB and tPBDE areal loading rates (based on mean storm flow concentrations) to the four basin characteristics are shown in Figure 10. All comparisons suggest a positive relationship between the selected basin characteristics and areal tPCB and tPBDE loading rates. With only three points of comparison, the relationships cannot be evaluated statistically. The relationship between percent developed as commercial/industrial in or before 1979 was chosen as the basis for extrapolation because it seemed to best fit the emerging conceptual model, at least for PCBs, that commercial/industrial land use may be a significant source of these types of contaminants. The relationship also indicated a convenient separation of areal loading rates among the basins. The rule selected for assigning areal loading rates to unmonitored basins was as follows:

- Less than or equal to 4 percent – use May Creek areal loading rates
- Greater than 4 percent but less than or equal to 8 percent – use Juanita Creek areal loading rates
- Greater than 8 percent – use Thornton Creek areal loading rates

The classification of each drainage basin with respect to percent developed as commercial/industrial in or before 1979 is shown in Figure 11. The range of estimated tPCB and tPBDE loading from local drainages to Lake Washington and Lake Union is provided in Table 9. The range of estimated tPCB and tPBDE areal loading from local drainage basins to Lake Washington and Lake Union is provided in Table 10. Estimated mean areal loading rates ranged from 1.2 to 2.0 and 2.2 to 3.5 g km^{-2} yr^{-1} for tPCB and tPBDE, respectively. These areal loading rates are comparable to the median estimates for Puget Sound commercial/industrial land uses reported by Herrera (2011), which is consistent with the moderate to high percentages of this type of land use in the watersheds surrounding these lakes.

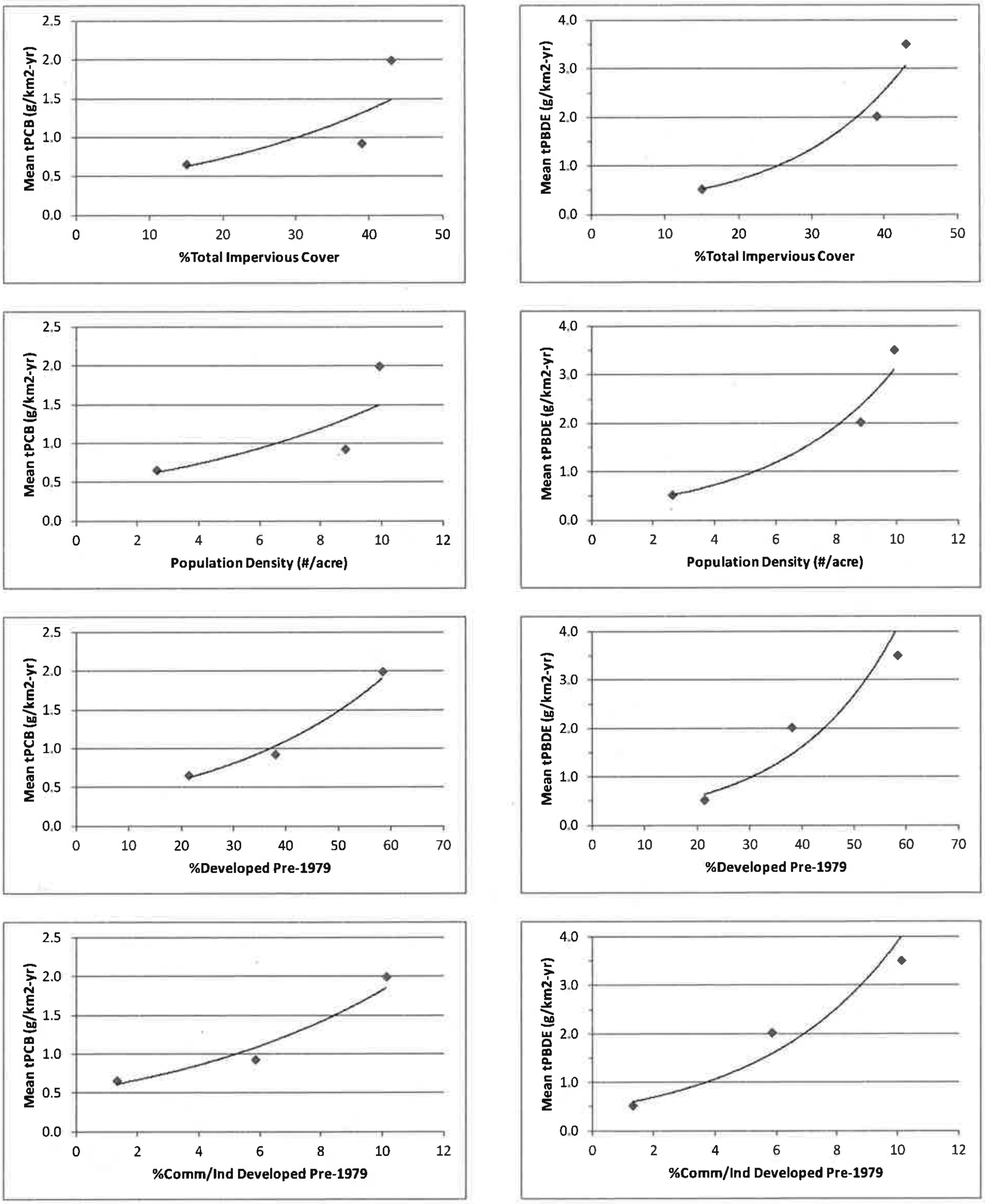

Figure 10. Scatterplots of areal loading of tPCB (left panel) and tPBDE (right panel) for percent total impervious cover, population density, percent developed in or before 1979, and percent developed as commercial/industrial land use in or before 1979.

Note: An exponential regression fit is shown only to illustrate the suggestive positive relationships between the four basin characteristics and areal contaminant loading.

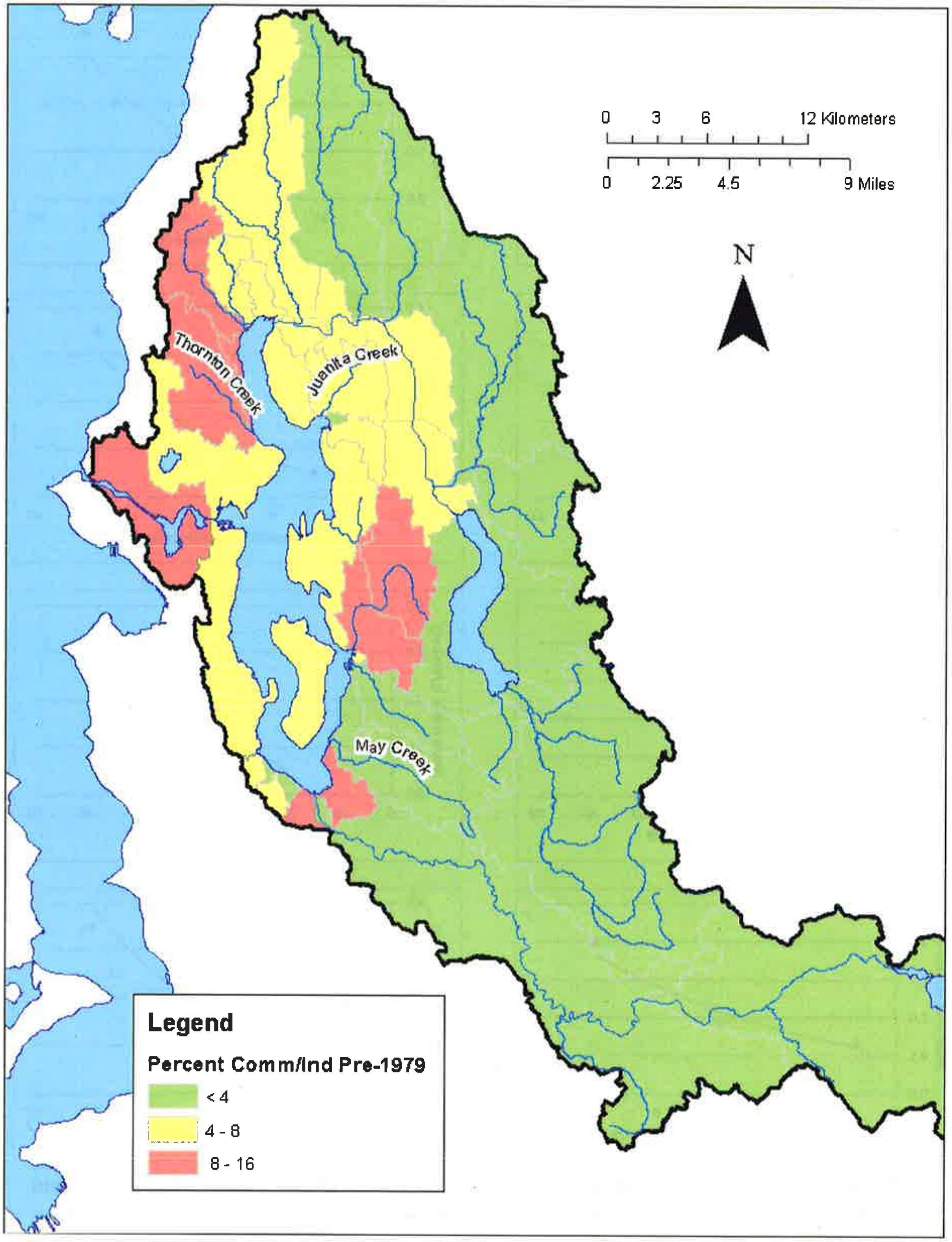

Figure 11. Lake Washington and Lake Union local drainage basins categorized by percent developed as commercial/industrial land use in or before 1979.

Table 9. Loading estimates of tPCB and tPBDE to Lakes Washington and Union from local drainage basins.

	25th-percentile	Median	Mean	75th-percentile
		tPCB ($g\ yr^{-1}$)		
Lake Washington[a]	190	260	450	620
Lake Union	22	28	40	53
		tPBDE ($g\ yr^{-1}$)		
Lake Washington[a]	200	280	820	1,200
Lake Union	28	38	69	95

[a] *Note that the estimated loads include inputs estimated for Swamp Creek, which enters the Sammamish River just upstream of where the river enters Lake Washington.*

Table 10. Areal loading estimates of tPCB and tPBDE to Lake Washington and Lake Union from local drainage basins.

	25th-percentile	Median	Mean	75th-percentile
		tPCB ($g\ km^{-2}\ yr^{-1}$)		
Lake Washington[a]	0.51	0.70	1.2	1.7
Lake Union	1.1	1.4	2.0	2.7
		tPBDE ($g\ km^{-2}\ yr^{-1}$)		
Lake Washington[a]	0.54	0.76	2.2	3.2
Lake Union	1.4	1.9	3.5	4.8

[a] *Note that the estimated loads include inputs estimated for Swamp Creek, which enters the Sammamish River just upstream of where the river enters Lake Washington.*

4.3 Highway Runoff

The estimated areas of state and interstate highway bridges that contribute runoff to Lakes Washington and Union are provided in Table 11. Table 12 presents the estimated loading from state and interstate highway bridges that contribute runoff to Lakes Washington and Union. These estimates were based on the contributing area of each bridge (Table 11), a long-term annual average precipitation amount of 940 mm (37 in), and tPCB and tPBDE concentrations measured in I-90 bridge runoff during this study (see Table 1). Estimated areal loading rates from bridge runoff are provided in Table 13. Currently, no studies have been identified that would provide a basis for comparison to these results, although a previous study of runoff from the SR 520 bridge indicated that high volume traffic surfaces can be a concentrated source of various contaminants (King County 2006).

Table 11. Contributing areas of state and interstate bridge crossings of Lakes Washington and Union.

		Contributing Bridge Deck Area	
		m^2	ft^2
Lake Washington			
	SR 520	134,438	1,447,076
	I-90	197,674	2,127,749
	Total	332,112	3,574,825
Lake Union			
	SR 520 (Portage Bay)	16,376	176,270
	I-5	64,777	697,258
	SR 99	18,201	195,916
	Total	99,355	1069444
	Grand Total	431,467	4,644,269

Table 12. Loading estimates of tPCB and tPBDE to Lakes Washington and Union from highway bridge runoff.

	25th-percentile	Median	Mean	75th-percentile
		tPCB (g yr^{-1})		
To Lake Washington	1.7	2.8	2.9	4.1
To Lake Union	0.52	0.83	0.87	1.2
		tPBDE (g yr^{-1})		
To Lake Washington	1.3	1.9	19.	19.
To Lake Union	0.39	0.58	5.6	5.8

Table 13. Areal loading estimates of tPCB and tPBDE from highway bridge runoff.

25th-percentile	Median	Mean	75th-percentile
	tPCB (g km^{-2} yr^{-1})		
5.3	8.4	8.7	12.
	tPBDE (g km^{-2} yr^{-1})		
3.9	5.8	56.	58.

4.4 CSOs

Estimated long-term CSO flow rates for Lakes Washington and Union are provided in Table 14. Estimated tPCB and tPBDE loading from CSOs to Lakes Washington and Union is summarized in Table 15. tPCB loading estimates are based on the average CSO discharge rate to each lake and the contaminant concentrations measured in data combined from this study and another recent study conducted on CSOs discharging to the Duwamish River in southeast Seattle (53 samples from 11 CSOs; see Section 3.1). tPBDE loading is based on the CSO discharge rates and the data collected in this study.

Note that the estimated tPCB loading rate based on the mean concentration is similar to the estimate based on the 75th-percentile concentration, which indicates positive skew in the CSO tPCB concentration results. This is due to consistently high concentrations measured in a CSO at the southern end of Lake Union and relatively high concentrations observed in a CSO that discharges to the Duwamish River. PCB concentrations measured in the two other CSOs that were monitored in this study and discharge to the Ship Canal in Ballard and to Lake Washington near Seward Park are lower and similar to concentrations measured in stormwater (see Table 1).

The positive skew in the limited number of CSO samples analyzed in the two recent studies, combined with the highly episodic nature of CSOs, suggest that the CSO loading estimates are relatively uncertain.

Table 14. Estimated long-term CSO flow rates for Lakes Washington and Union.

	cms	cfs
Lake Washington	0.0055	0.190
Lake Union	0.026	0.920

Table 15. Loading estimates of tPCB and tPBDE to Lakes Washington and Union from CSOs.

	25th-percentile	Median	Mean	75th-percentile
		tPCB (g yr^{-1})		
To Lake Washington	4.9	7.6	12.	12.
To Lake Union	23.	36.	58.	59.
		tPBDE (g yr^{-1})		
To Lake Washington	3.3	8.3	14.	26.
To Lake Union	16.	39.	68.	120.

4.5 Atmospheric Deposition

The bulk deposition of tPCB and tPBDE measured in this study are summarized in Table 16. tPCB and tPBDE areal deposition rates in ng m^{-2} d^{-1} were greatest at the Beacon Hill site to the southwest of the lake, although the difference for tPCB deposition was relatively small and may not be statistically significant. The range in the rates of tPCB deposition reported in this study (2.58-4.30 ng m^{-2} d^{-1}) were somewhat higher than that reported in a recent deposition study conducted at seven locations along the Puget Sound shoreline that used similar methods (Brandenberger et al. 2010). Mean deposition rates reported by Brandenberger et al. (2010) ranged from 0.75 to 2.54 ng m^{-2} d^{-1}, with the highest rate measured at a highly urban location in Tacoma, WA approximately 35 km (22 mi) to the south of the Beacon Hill site occupied in this study.

Table 16. Atmospheric deposition rate (ng m^{-2} d^{-1}) measured in this study, including a comparison to a recent Puget Sound study.

Sand Point	Beacon Hill	Puget Sound [a]
tPCB (ng m^{-2} d^{-1})		
2.58	4.30	0.75 - 2.54
tPBDE (ng m^{-2} d^{-1})		
5.95	30.3	6.2 - 30.4

[a] Brandenberger et al. 2010 (excluding results for Padilla Bay)

The range in tPBDE deposition measured in this study is very similar to mean deposition rates reported by Brandenberger et al. (2010) for locations around Puget Sound. The lower rate of 5.95 ng m^{-2} d^{-1} measured at Sand Point is similar to many of the more rural areas monitored by Brandenberger et al. (2010) and the higher rate measured at the Beacon Hill site (30.3 ng m^{-2} d^{-1}) is similar to the highest deposition rate reported by Brandenberger et al. (30.4 ng m^{-2} d^{-1}) at their highly urban Tacoma location.

Atmospheric loading estimates to Lakes Washington and Union are reported in Table 17. Estimated loading is based on the deposition rates measured at the two stations monitored in this study and the surface areas of each lake.

4.6 Loading to Puget Sound

The lake water balance yielded a long-term flow estimate of 36.9 cms (1,400 cfs) from the Greater Lake Washington drainage to Puget Sound. This is similar to a previous estimate provided by the USACOE (Lynne Melder, Hydraulic Engineer, Seattle District USACOE) of 40.4 cms (1,426 cfs) for the period 1995-2000. As a check, a second calculation was done that used the long-term average flow, evaporation and precipitation inputs which allowed daily changes in storage to be ignored. This method provided an estimated long-term discharge of 41.6 cms (1,470 cfs), which is within 10 percent of the estimate based on the daily water balance that included the effect of changes in storage.

Table 17. Atmospheric loading estimates of tPCB and tPBDE to the surface of Lake Washington and Lake Union.

	Minimum (Sand Point)	Mean/Median [a]	Maximum (Beacon Hill)
		tPCB (g yr^{-1})	
Lake Washington	84	110	140
Lake Union	3.6	4.8	6.0
		tPBDE (g yr^{-1})	
Lake Washington	190	590	980
Lake Union	8.3	25	42

[a] Range based on data collected at the two stations

Average concentrations of tPCB and tPBDE measured at Station 0580 just upstream of the Locks were 0.29 (range 0.14-0.58) and 0.80 (range 0.029-2.1) ng/L, respectively (see Table 1). The average concentration of tPCB is very similar to the concentrations estimated from seasonal semi-permeable membrane device (SPMD) deployments in the Lake Washington Ship Canal conducted by Ecology (Sandvik 2008; Sandvik 2009; Sandvik and Seiders 2011; Sandvik and Seiders 2012). The range of tPCB concentrations reported in Ecology's SPMD studies was 0.12 to 0.51 ng/L. tPBDE concentrations reported in those same studies were generally lower than measured in this study. tPBDE concentrations reported in their study ranged from below detection to 0.27 ng/L.

Ecology has also analyzed whole water samples from five major rivers discharging to Puget Sound (Skagit, Snohomish, Nooksack, Stillaguamish, and Puyallup) and reported tPCB concentrations ranging between 0.003 to 0.059 ng/L and tPBDE concentrations ranging between 0.011 and 0.265 ng/L (Gries and Osterberg 2011). These Puget Sound river tPCB and tPBDE concentrations are generally lower than those observed in our study, which is not unexpected as these rivers drain large relatively undeveloped areas.

tPCB and tPBDE loading to Puget Sound from the Greater Lake Washington watershed based on the estimated long-term flow and average concentrations are 360 and 990 g yr^{-1}, respectively (Table 18). Based on the total upstream drainage area of 1,590 km^2 (614 mi^2), the estimated areal loading rate is 0.23 and 0.62 g km^{-2} yr^{-1} for tPCB and tPBDE, respectively (Table 19). Loading estimates from Lake Washington to Lake Union via Montlake Cut are also provided in Table 18 and Table 19.

Based on the range in estimated tPCB and tPBDE loading rates it appears that Lake Union contributes a significant portion of PCBs and PBDEs to Puget Sound – the mean fluvial tPCB loading rate increases by about a factor of three and the tPBDE load doubles after water passes through Lake Union (see Table 18).

In general, the tPCB loading estimate for the Greater Lake Washington discharge to Puget Sound is within the range reported by Gries and Sloan (2009) for the Green River, which discharges to Elliott Bay/Puget Sound just to the south. Their estimate was based on analysis of contaminants sorbed to suspended particulate matter and ranged from 0.14 to 1.99 g km^{-2} yr^{-1}. Estimated areal loads of tPCB from the study of five major Puget Sound rivers mentioned above ranged from 0.058 to 0.364 g km^{-2} yr^{-1} reported as the 25th and 75th percentile (Ecology and King County 2011, Gries and Osterberg 2011). Areal tPBDE loading from the same five rivers ranged from 0.118 to 0.230 g km^{-2} yr^{-1} again reported as the 25th and 75th percentile (Ecology and King County 2011, Gries and Osterberg 2011).

Table 18. Loading estimates of tPCB and tPBDE to Puget Sound from the Greater Lake Washington watershed. Estimated loading to Lake Washington and from Lake Washington to Lake Union via Montlake Cut also shown.

	25th-percentile	Median	Mean	75th-percentile
		tPCB (g yr-1)		
To Lake Washington	333	459	672	889
From Lake Washington to Lake Union	73	110	140	140
From Lake Union to Puget Sound	190	250	360	540
		tPBDE (g yr-1)		
To Lake Washington	416	1,076	2,023	2,755
From Lake Washington to Lake Union	330	650	800	940
From Lake Union to Puget Sound	280	740	990	1,400

Table 19. Areal loading estimates of tPCB and tPBDE for the Greater Lake Washington watershed. Estimated areal loading to Lake Washington and from Lake Washington to Lake Union via Montlake Cut also shown.

	25th-percentile	Median	Mean	75th-percentile
		tPCB (g km^{-2} yr^{-1})		
To Lake Washington	0.21	0.30	0.43	0.57
From Lake Washington to Lake Union	0.047	0.068	0.088	0.088
From Lake Union to Puget Sound	0.12	0.16	0.23	0.34
		tPBDE (g km^{-2} yr^{-1})		
To Lake Washington	0.27	0.69	1.3	1.8
From Lake Washington to Lake Union	0.21	0.42	0.52	0.60
From Lake Union to Puget Sound	0.18	0.47	0.62	0.85

Also shown Table 18 and Table 19 are the estimated total load (mass and areal, respectively) of tPCB and tPBDE to Lake Washington from rivers, tributary drainages, bridge runoff, CSOs and atmospheric deposition. Comparison of loading to Lake Washington to the export from Lake Washington to Lake Union indicates that from about 75 to 85 percent of the tPCB input and 20 to 65 percent of the tPBDE input to Lake Washington is deposited in lake sediments, accumulated by lake biota and possibly lost through volatilization across the air-water interface. The next step of this study will be the development of tPCB fate and bioaccumulation models that will account for contaminant loss to sediments, contaminant exchange across the air-water interface and accumulation in biota. This tool will be used to evaluate the potential for management actions to reduce health risks from consuming contaminated fish from Lake Washington.

5.0. DISCUSSION

To synthesize and better illustrate the results presented above, a chart was prepared that shows the range of tPCB and tPBDE loading estimates for each pathway for Lakes Washington and Union. Figure 12 shows the range of tPCB loading estimates, which illustrates that loading from local drainages are likely the dominant source of tPCBs to Lake Washington (left panel). However, estimated local drainage basin inputs appear to have the greatest absolute uncertainty and range from 190 to 620 g yr^{-1}. The second largest source of tPCB appears to be direct deposition to the surface of the lake followed by inputs from the two major rivers.

Although the CSO load is uncertain due to the positive skew in the observed tPCB concentration data, the CSO contribution to Lake Washington as a whole is small relative to all but bridge runoff. However, the estimated relative contribution and uncertainty in tPCB loading to Lake Union (see right panel of Figure 12) highlights the potential contribution of CSOs and local stormwater runoff loading to the apparent increase in loading between Lake Washington at Montlake Cut and the discharge to Puget Sound at the locks.

Figure 13 shows the range of tPBDE loading estimates, which illustrates that tPBDE loading estimates for Lake Washington (left panel), with the exception of loading from CSOs and bridges which are relatively low, have a great deal of uncertainty. There is not a clearly dominant source pathway for tPBDEs for Lake Washington. It appears that loading from the outflow of Lake Washington to Lake Union is the dominant source of tPBDE to Lake Union, with much smaller contributions from local drainage and bridge runoff, CSOs and atmospheric deposition.

The suggestion that local drainage basins are the most significant source of tPCBs to Lake Washington warrants further discussion. The area around the lake is substantially developed for residential, commercial, and limited industrial uses. Development around the lake accelerated during and after World War II. Some of the materials associated with this development are known PCB sources and development has also traditionally been associated with increased impervious cover that collects and routes rainfall quickly and efficiently, along with contaminants that accumulate on these surfaces, to wastewater conveyance systems, stormwater outfalls, streams and lakes.

Although the highest tPCB concentrations in this study were measured in CSOs, the next highest concentrations were measured in stormwater outfalls sampled from the I-90 bridge and six other locations draining small areas (less than 4 km^2/1,000 acres) around the lakes. The samples collected from the three tributary basins included a base flow sample – significant base flow does not typically occur in stormwater drains – and samples collected during storms that contain a mixture of base and storm flow. In general, about 70 percent of stream flow in these tributaries is base flow and the remainder (30 percent) is stormwater runoff.[21] To illustrate the dominance of stormwater runoff on tPCB load in tributary streams, the base flow separation results, along with the measured base flow

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[21] Recall Figure 6 and the definitions provided in Section 3.3.1.

tPCB concentration, were used to calculate the stormwater runoff concentration needed to match the estimated tPCB load.

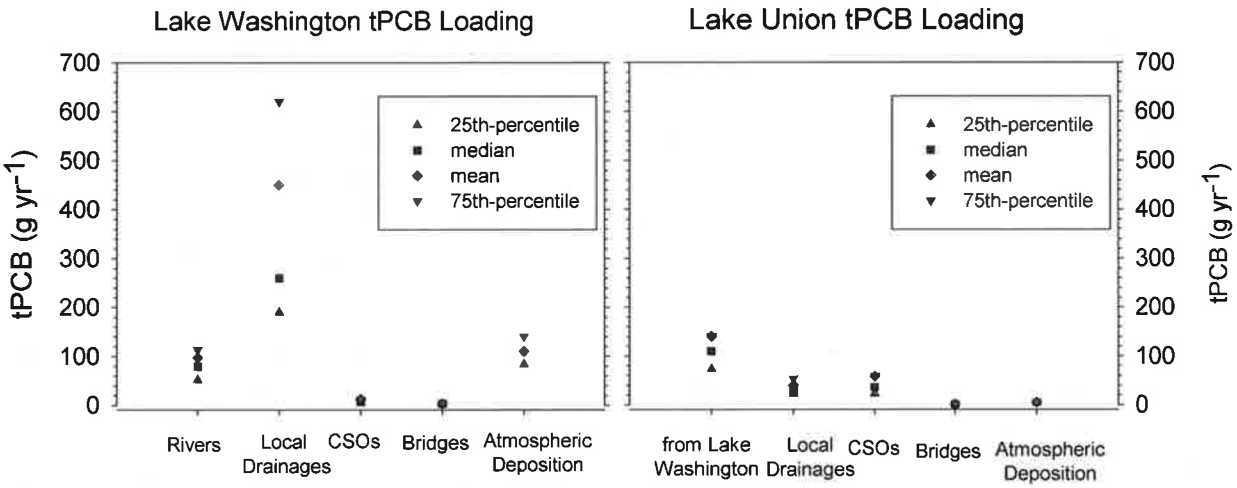


Figure 12. Range of tPCB loading estimates for Lake Washington and Lake Union.

Note: Ranges of loading from atmospheric deposition are minimum and maximum estimates based on the data from the two deposition sites monitored in this study.

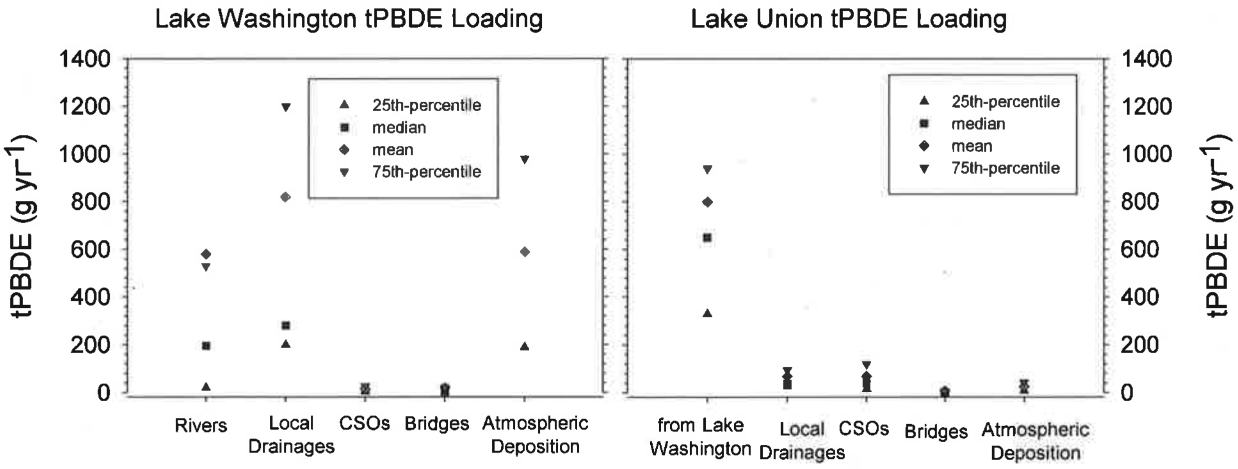


Figure 13. Range of tPBDE loading estimates for Lake Washington and Lake Union.

Note: Ranges of loading from atmospheric deposition are minimum and maximum estimates based on the data from the two deposition sites monitored in this study.

Table 20 presents a summary of these calculations, which indicate that the stormwater concentrations needed to match the estimated total tPCB loading estimate was highest for Thornton Creek and lowest for May Creek – consistent with the pattern observed in the tributary basin storm flow measurements. The estimated stormwater runoff concentrations are also generally consistent with measurements made in the stormwater outfalls sampled in this study. Based on the 18 storm events sampled from the stormwater outfalls in this study (see Table 22 in King County 2013), the 25th and 75th percentile tPCB concentrations were 1.6 and 4.7 ng/L, respectively.

The analysis presented in Table 20 also suggests that stormwater runoff contributes over 80 and perhaps even over 90 percent of the total local drainage basin load (Storm [Est]/Total Load), regardless of the level or type of development. This is in spite of the fact that stormwater runoff is only about 30 percent of the total annual tributary flow.

Table 20. Estimate of stormwater tPCB concentration needed to match estimated tPCB load from Thornton, Juanita and May creeks given base and storm flow and base flow tPCB concentration.

	Flow		tPCB Load (g yr^{-1})			tPCB Concentration	
						Observed Base Flow	Estimated Stormwater Runoff
	cms	cfs	Base Flow	Storm (Estimate)	Target Total Load	ng/L	
Thornton Creek[a]							
Base flow	0.190	6.7	6.9	52.	59.	1.1	7.6 [b]
Stormflow	0.217	7.7					(1.6 - 11) [c]
Juanita Creek							
Base flow	0.200	7.1	0.51	16.7	17.	0.081	5.4 [b]
Stormflow	0.099	3.5					(0.27-5.9) [c]
May Creek							
Base flow	0.429	15.	1.7	21.7	23.	0.13	3.4 [b]
Stormflow	0.205	7.3					(0.12-2.8) [c]

[a] *The analysis for Thornton Creek includes the estimate of stormwater bypass flow from Meadowbrook Pond to Lake Washington.*

[b] *The 75th-percentile storm flow tPCB concentrations in Thornton, Juanita and May creeks were 7.1, 3.3 and 2.0 ng/L, respectively.*

[c] *The minimum and maximum tPCB concentrations in the three storm flow samples collected from each creek during the study.*

To further evaluate the relative importance of urban stormwater runoff as significant source of tPCB to these lakes, the pooled storm event tPCB concentration statistics for the six stormwater outfalls provided in Table 22 of the companion data report (King County 2013) were used to estimate areal loading rates from a typical urban stormwater basin. Stormwater loading estimates were not calculated for each basin, primarily because flow was not measured continuously at each stormwater sampling location over the course of the study so that runoff flow could be accurately calculated. Unfortunately, it was not within the resources of this project to measure continuous flow at the stormwater outfalls.

Areal stormwater basin loading was estimated using two different precipitation runoff assumptions. The first assumption follows that used for the calculation of stormwater runoff from the bridges (i.e., all precipitation is translated into runoff) using the same estimated long term annual precipitation amount of 940 mm (37 in). This assumption may not be an unreasonable first approximation based on the results of flow gauging conducted on a small partially separated drainage basin (drainage area of 152 ac) in the University District, which is within the Central Seattle drainage basin and which drains to Lake Union (City of Seattle 2012).

The second assumption was that generated runoff would be less than the total precipitation amount. The estimated tributary basin yield of 1.4 cfs per mi^2 used for estimating ungauged drainage basin flow was used as a reasonable approximation of the second assumption. This translates to approximately 483 mm (19 in) of runoff per unit basin area. The result of these calculations and comparison to the areal loading estimates for Thornton, Juanita and May creeks is presented in Table 21. The estimated stormwater basin areal loading rates are similar to, but somewhat higher than the estimated areal loading rates for Thornton Creek and consistently higher than the estimated loadings from Juanita and May creeks. This pattern is consistent with stormwater runoff from urban drainage areas being a significant source of tPCB to urban tributary streams and to these lakes.

Table 21. Areal loading estimates of tPCB from a unit stormwater basin drainage area based on stormwater basin storm event sampling conducted for this study. Comparisons to the estimated areal loading rates for Thornton, Juanita and May creeks are also provided.

	25th-percentile	Median	Mean	75th-percentile
		tPCB (g km^{-2} yr^{-1})		
Composite Stormwater Basin	1.7	3.0	5.5	4.6
Thornton Creek	1.1	1.4	2.0	2.7
Juanita Creek	0.20	0.28	0.93	1.3
May Creek	0.37	0.67	0.66	0.95

Another potentially informative comparison is between atmospheric deposition rates measured in this study and the areal loading rates estimated for the monitored tributary drainage basins and major rivers (Table 22). It appears that atmospheric deposition rates based on measurements made near the lake in Seattle are generally similar to the areal loading rates from the more highly developed basins (Thornton and Juanita creeks) and are higher than the areal loading rates from the less developed May Creek basin. Areal loading rates from the major rivers are generally much lower than the observed atmospheric deposition rates.

There are at least two, not necessarily mutually exclusive explanations for these observations. It is possible that atmospheric deposition declines as a function of distance from highly developed commercial/industrial areas. May Creek and the two major river basins include less developed rural areas. This phenomenon has been suggested in other studies (Brandenberger et al. 2010, Melymuk et al. 2012). It is also possible that the greater area of soils and forests in less developed basins are more effective at retaining and storing deposited contaminants than developed areas with extensive impervious cover that is connected to stormwater conveyance networks that efficiently deliver water and associated contaminants directly to receiving streams and lakes.

Also note that even though atmospheric deposition rates are similar to areal loading rates in developed drainage basins, this does not preclude the possibility of significant direct inputs from local sources such as leaking transformers, abrasion of contaminant containing building materials, etc., since even in highly developed areas there are soils and often some trees that can sorb and store contaminants deposited or generated from within the drainage basin. In general, the emerging conceptual model, at least for PCBs, is that much of the current PCB load is primarily from local sources stored in building and construction materials containing PCBs and leakage from PCB containing electrical equipment (Diamond et al. 2010; Robson et al. 2010). The relative contribution from these sources in the Greater Lake Washington watershed remains unknown.

Table 22. Comparison of tPCB and tPBDE areal atmospheric deposition rates measured at Sand Point and Beacon Hill to mean areal loading rates estimated for the Thornton, Juanita and May creeks and the Cedar and Sammamish rivers.

Atmospheric Deposition						
Sand Point	Beacon Hill	Thornton Creek	Juanita Creek	May Creek	Sammamish River	Cedar River
		tPCB (g km^{-2} yr^{-1})				
0.94	1.6	2.0	0.93	0.66	0.052	0.074
		tPBDE (g km^{-2} yr^{-1})				
2.2	11.1	3.5	2.0	0.53	0.61	0.38

6.0. CONCLUSIONS

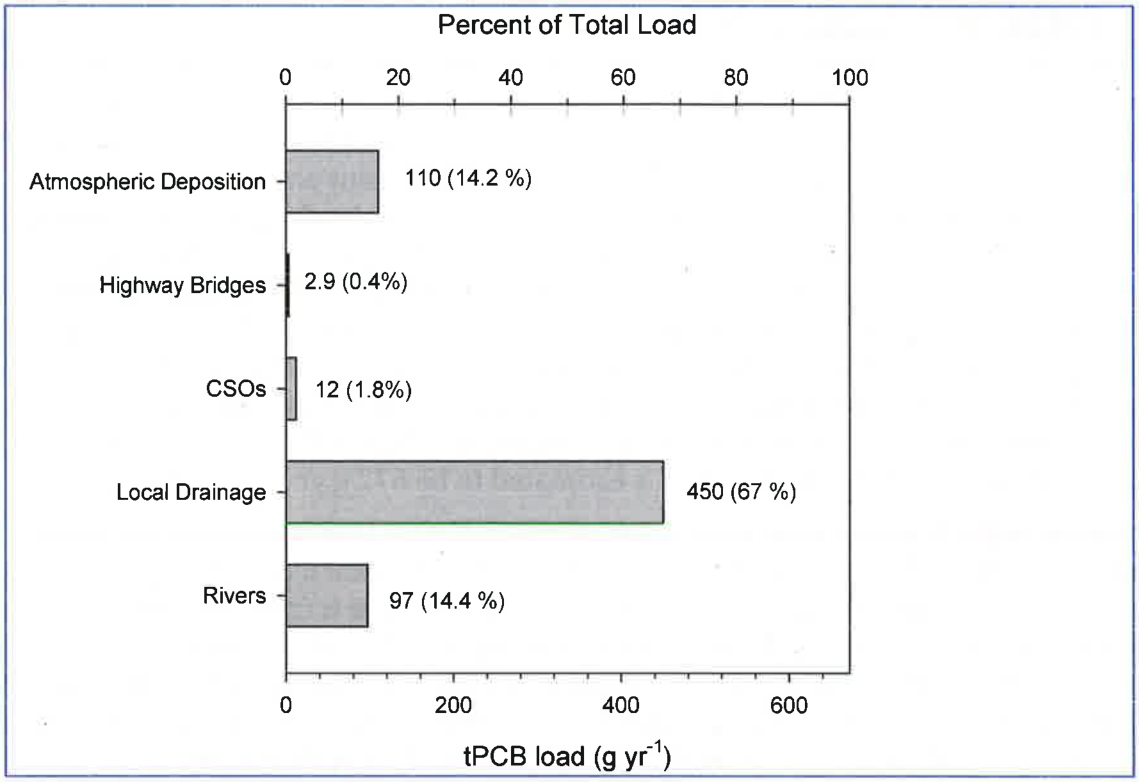
The current best estimates of tPCB loading to Lakes Washington and Union are shown in Figure 14. These estimates suggest that local drainage basins contribute about 67 percent of the total tPCB load to Lake Washington. The next most significant pathways appear to be atmospheric deposition to the surface of the lake and major river loading; each accounting for ~14 percent of the total loading. This suggests that over 95 percent of the loading to Lake Washington can be accounted for from these three pathways. Based on the analyses in this report, there appears to be a large range in the plausible estimates of local drainage basin loading, but even the lowest estimates are above the uncertainty range in the next highest loading estimate. Depending on the true local drainage tPCB loading contribution, local drainage basin loading may be more or less significant. Total tPCB loading from all of the assessed pathways to Lake Washington is estimated to be 672 g yr^{-1}.

For Lake Union, input (export) from Lake Washington (140 g yr^{-1}) appears to be the most significant source of tPCB, contributing about 57 percent of the total load (244 g yr^{-1}). CSOs appear to be the next highest contributor (~24 percent), but there is considerable uncertainty in this estimate. Local drainage basin loading, which is almost exclusively stormwater runoff, is estimated to contribute approximately 16 percent, so together these three pathways are estimated to deliver about 97 percent of the total load to Lake Union. CSOs and stormwater runoff from the local drainage basins, along with atmospheric deposition and bridge runoff, are the likely contributors to the apparent increase in tPCB concentration and loading between Lake Washington and the discharge through the locks to Puget Sound. Although tPCB load appears to increase between Lake Washington and Puget Sound, Lake Washington appears to be a sink for tPCBs based on the substantial reduction in tPCB load (~80 percent) observed between inputs to Lake Washington and export through the Lake Washington Ship Canal (see Table 18).

The current best estimates of tPBDE loading to Lakes Washington and Union are shown in Figure 15. tPBDE loading estimates for major rivers, local drainage basins and atmospheric deposition to Lake Washington are relatively uncertain, but the best current estimate is that they together contribute almost all of the tPBDE to the lake. Total tPBDE loading from all of the assessed pathways to Lake Washington is estimated to be 2,023 g yr^{-1}.

Lake Washington appears to be the largest source of tPBDE to Lake Union (800 g yr^{-1}), contributing about 80 percent of the total load (968 g yr^{-1}). CSO and local drainage runoff inputs have similar uncertainty, but are also estimated to contribute similar amounts – approximately 7 percent each so that most of the tPBDE loading to Lake Union is associated with those three pathways.

These tPCB loading estimates will be used in the models that will be developed in the next phase of this study to simulate the response of Lake Washington to reductions in tPCB loading that might result from various management approaches and resulting changes in concentrations in resident fish.



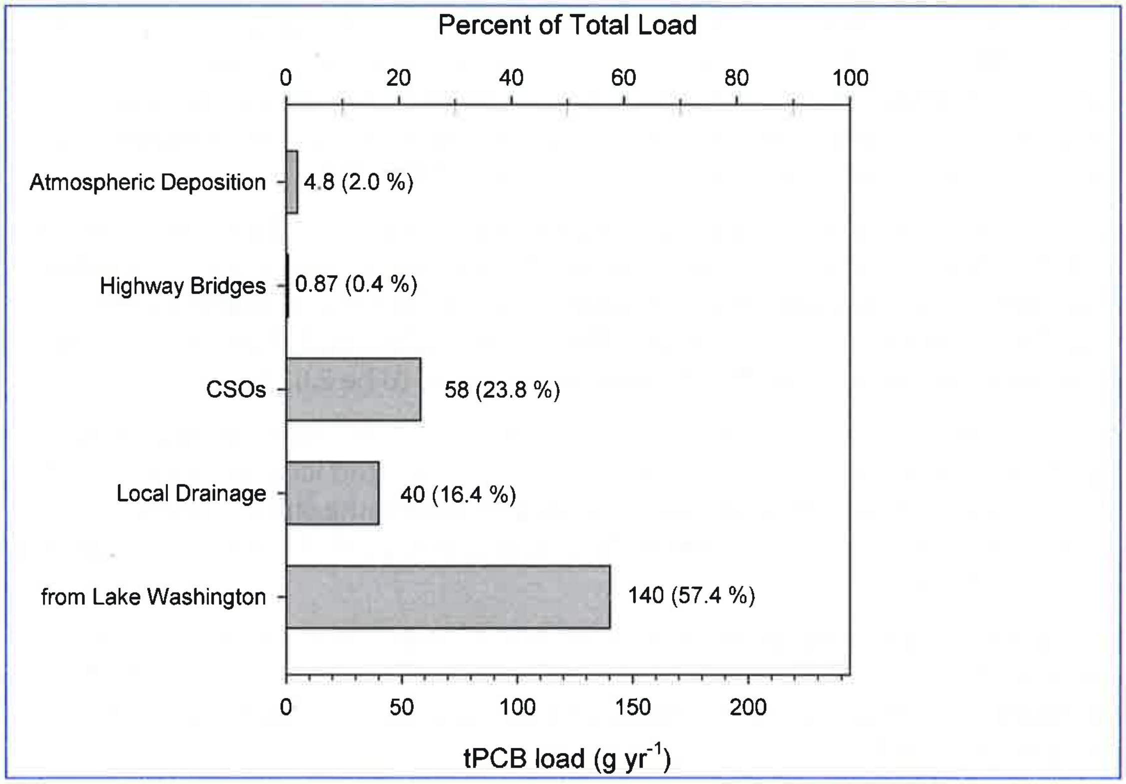
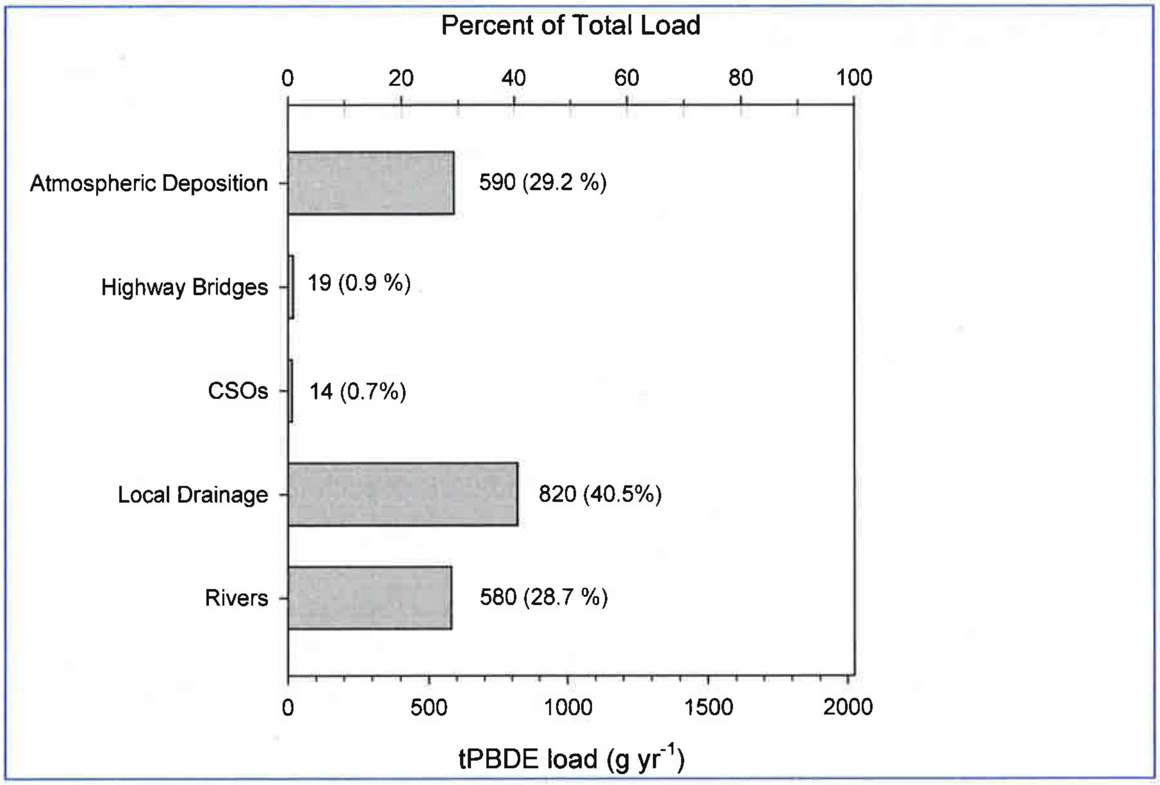


Figure 14. Bar charts showing current best estimates of the relative contribution of tPCB (g yr^{-1}, percent of total) from each pathway to Lake Washington (top) and to Lake Union (bottom).



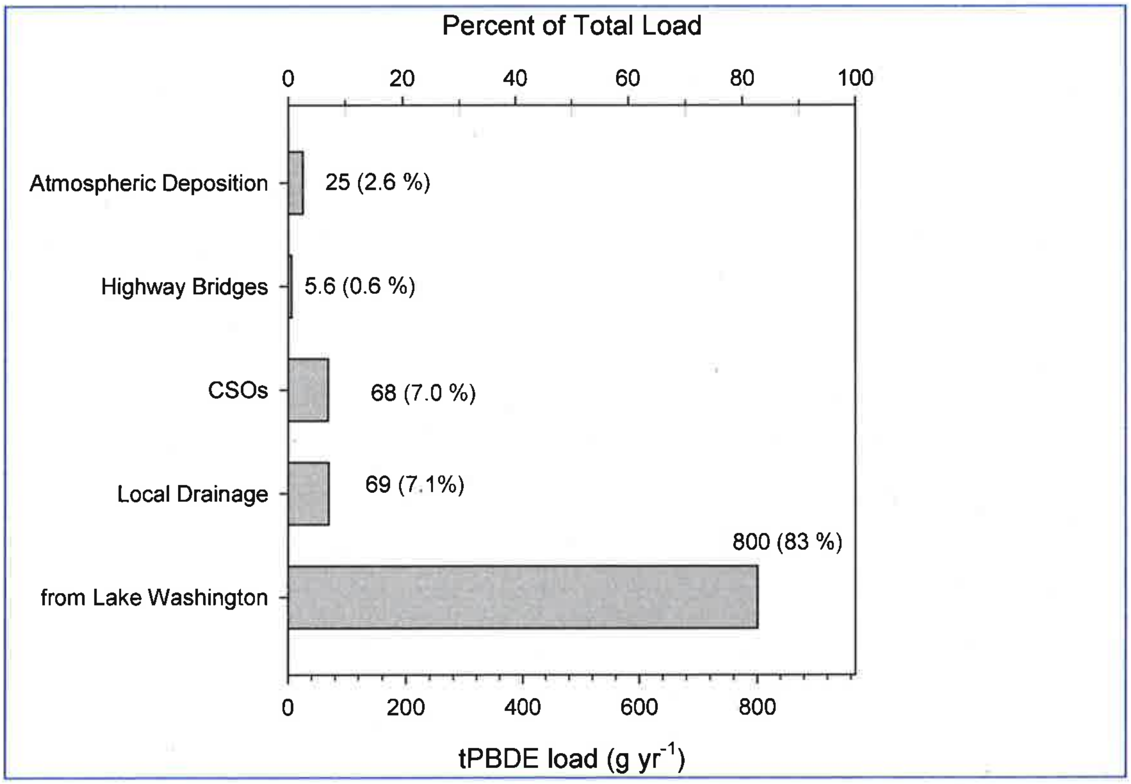


Figure 15. Bar charts showing current best estimate of the relative contribution of tPBDE (g yr^{-1}, percent of total) from each pathway to Lake Washington and to Lake Union.

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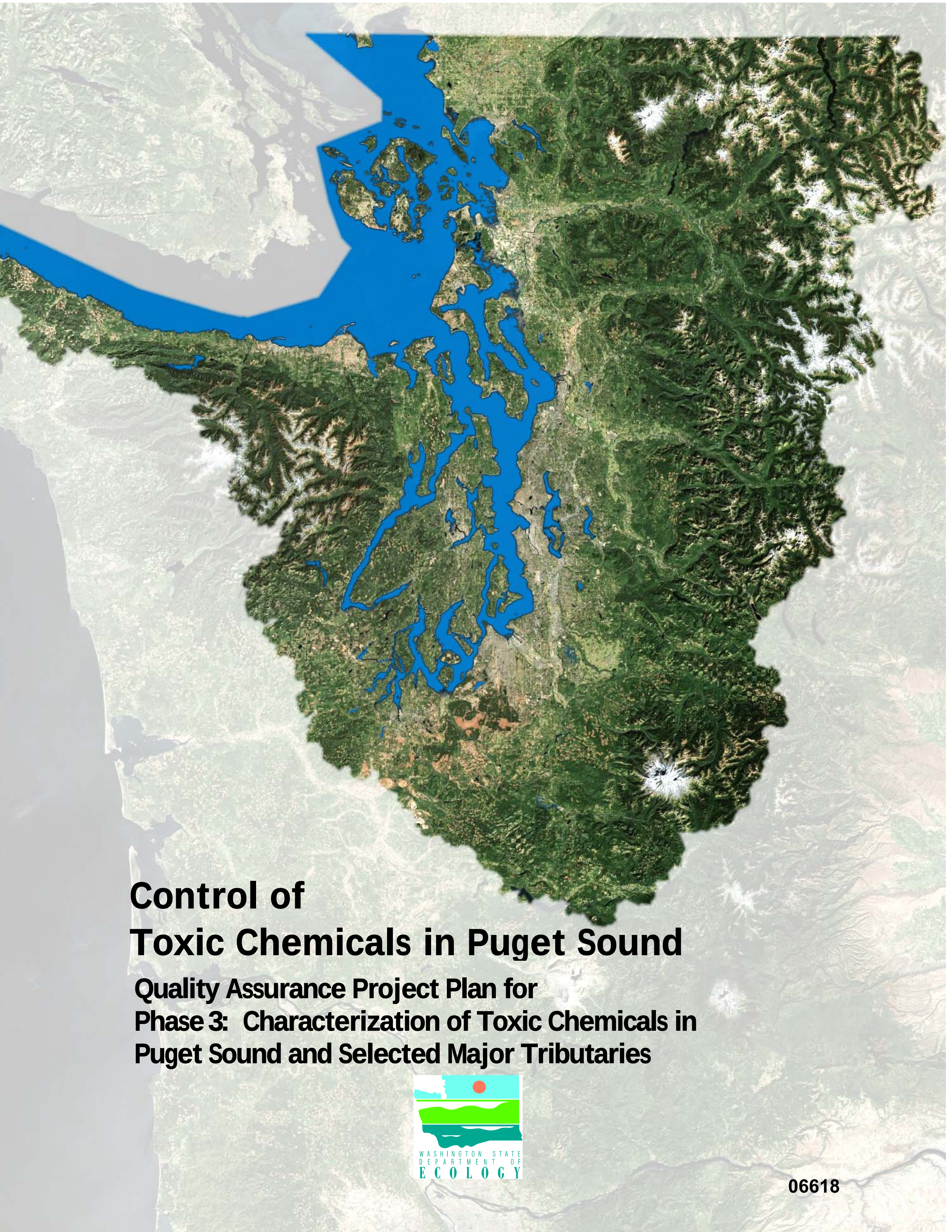

Control of Toxic Chemicals in Puget Sound

Quality Assurance Project Plan for Phase 3: Characterization of Toxic Chemicals in Puget Sound and Selected Major Tributaries

WASHINGTON STATE DEPARTMENT OF ECOLOGY

06618

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Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID, RCOO0010.

Ecology's Project Tracker Code for this study is 09-538.

Waterbody Numbers:

WA-01-1010	WA-03-1010	WA-05-1010
WA-07-1020	WA-10-1020	WA-06-0010
WA-PS-0240	WA-PS-0290	WA-PS-0250
WA-18-0010	WA-02-0020	

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Quality Assurance Project Plan

Control of Toxic Chemicals in Puget Sound Phase 3: Characterization of Toxic Chemicals in Puget Sound and Selected Major Tributaries

August 2009

Approved by:

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Signatures are not available on the Internet version.
TSU = Toxics Studies Unit.
EAP = Environmental Assessment Program.
EIM = Environmental Information Management system.

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Abstract

The Puget Sound Partnership identified the control and reduction of toxic chemicals entering Puget Sound as vital to the ecosystem's recovery and maintenance. In a multi-phase effort to develop source-control strategies for toxic contaminants, the Puget Sound Toxics Loading Analysis (PSTLA) will quantify concentrations within, and loadings to, Puget Sound, ultimately guiding management decisions.

Existing data were used to estimate chemical loadings during Phase 1 of the PSTLA. Phase 2 efforts included development of the Puget Sound Toxics Box Model to simulate chemical fate, transport, and bioaccumulation. This numerical model gives managers the ability to evaluate impacts on water, sediment, and biota under different control strategies. Initial modeling exercises indicated that additional data on toxic chemical concentrations in the marine water column, oceanic boundary waters, and major rivers discharging to Puget Sound were needed to reduce uncertainty in the model outputs.

For the present study, the Washington State Department of Ecology (Ecology) will collect seasonal water samples (June, September, and December of 2009) at three oceanic boundary sites, in four Puget Sound basins, and at the mouths of the five largest rivers discharging to the Sound. Water samples will be collected above and below the halocline at marine stations, and above tidal influence at river sampling sites. Suspended particulates will be collected during one event from the four Puget Sound basin stations and the five major rivers.

Target analyses will include metals, semivolatile organics, chlorinated pesticides, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and polybrominated diphenyl ethers (PBDEs). This information will fill identified data gaps, providing concentration and loading estimates for model input and calibration.

Each technical study conducted by Ecology must have an approved Quality Assurance Project Plan. The plan must describe the objectives of the study and the procedures to be followed to achieve those objectives. After completion of the study, a final report describing the study results will be posted to the Internet.

Background

Puget Sound Toxics Loading Analysis

The State of Washington enacted legislation in 2007 to advance efforts to restore and protect the health of the Puget Sound ecosystem by 2020. Charged with coordinating and overseeing these efforts, the Puget Sound Partnership (Partnership) identified the control and reduction of toxic chemical releases to the Sound as a priority action necessary to ensure recovery of the ecosystem.

To this end, the Washington Department of Ecology (Ecology) is working in collaboration with the Partnership, the U.S. Environmental Protection Agency (EPA), and other local, state, and federal agencies to study toxic chemical loadings to Puget Sound. This multi-year effort, the Puget Sound Toxics Loading Analysis (PSTLA), will quantify the sources of toxic contaminants that enter Puget Sound and improve understanding of how these chemicals move within the ecosystem. The collected information will guide management decisions about how to direct resources to effectively resolve toxic contamination issues.

Initial Phases

In Phase 1 of this effort, existing data were used to obtain quantitative estimates of loadings released to Puget Sound via surface runoff, atmospheric deposition, permitted wastewater discharges, combined sewer overflows, and direct spills (Hart Crowser et al., 2007).

Land use classifications were refined and roadway loadings were incorporated during Phase 2, yielding improved toxic chemical loading estimates for the entire Puget Sound Basin (EnviroVision et al., 2008).

Phase 2 also saw the expansion of numerical modeling efforts to provide insights about the relative importance of the various loading pathways. The Puget Sound Toxics Box Model is composed of three parts (Pelletier and Mohamedali, 2009):

1. Water circulation and transport box model.
2. Contaminant fate and transport mass balance model.
3. Food web transfer bioaccumulation model.

Seeded with the Phase 2 loading estimates, the Puget Sound Toxics Box Model allowed managers to investigate the response of contaminant concentrations in the water, sediment, and biota of Puget Sound under various source-control scenarios. Initial modeling exercises were performed for polychlorinated biphenyls (PCBs) due to the relative abundance of existing PCB data. Polybrominated diphenyl ethers (PBDEs) will be evaluated with the model during Phase 3.

Data Gaps and Recommended Actions

A review of readily available data collected since 1995 on selected toxic chemicals in Puget Sound and the Straits of Juan de Fuca and Georgia (Serdar, 2008) identified significant gaps and limitations in the existing data. With very few exceptions, the available data were inadequate for providing representative concentrations for model input and analyses.

Initial simulations run by the Puget Sound Toxics Box Model agreed, indicating that further data collection would improve the accuracy of model predictions. To address these data gaps, Pelletier and Mohamedali (2009) recommended the following targeted efforts:

- **Water column toxics.** Data on the concentrations of toxic chemicals in the water column throughout Puget Sound are very limited. While typical ambient concentrations are extremely low, the uptake of toxics by biota is sensitive to both the distribution and partitioning of toxics in this reservoir. Toxic chemical concentrations in the major basins of Puget Sound should be measured to facilitate improved calibration of the model.

- **Marine boundary.** Existing data from the marine waters bordering Puget Sound are scarce. The loading from the marine boundary is estimated to be comparable in magnitude to the loadings from each of the major land use types in the Puget Sound watershed, and therefore has the potential to significantly influence the concentrations of toxics in the Sound. Additional data should be collected in the Strait of Juan de Fuca and Haro Strait to improve the accuracy of the fluxes modeled through this boundary.

- **External loads.** While Phases 1 and 2 provided estimates of toxic chemical loadings to Puget Sound, surface runoff loading estimates for various land uses should be improved to reduce uncertainties in the model.

These data are needed to improve calibration of the Puget Sound Toxics Box Model and to reduce uncertainty in model predictions for the examination of toxic chemical fate and transport in Puget Sound.

Project Description

The present study is part of Phase 3 of the collaborative work on toxic chemicals in Puget Sound. The study is motivated by significant data gaps identified during the development of the Puget Sound Toxics Box Model. The study will provide an extensive set of data on toxic chemical concentrations in the water column of the major basins in Puget Sound, in the marine boundary waters of the Straits of Juan de Fuca and Haro Strait, and in the freshwater flows of five major rivers that discharge to the Sound.

Objectives

Objectives of the study are to:

- Quantify concentrations of target toxic chemicals and other water quality parameters above and below the halocline in four Puget Sound basins (Main, Whidbey, South Sound, and Hood Canal South) and in marine boundary waters (Strait of Juan de Fuca and Haro Strait).
- Measure freshwater loadings of target toxic chemicals and other water quality parameters in the five largest tributaries discharging to Puget Sound (Nooksack, Skagit, Stillaguamish, Snohomish, and Puyallup Rivers).
- Determine concentrations of toxic chemicals associated with suspended particulates in marine water and freshwater samples.
- Assess seasonal variability in concentrations and loadings of target toxic chemicals and other water quality parameters.

Parameters

Samples from the marine water column will be analyzed for an extensive suite of parameters, many of which have not historically been monitored in Puget Sound. These data will facilitate extension of the modeling framework to evaluate the fate, transport, and bioaccumulation of chemicals of concern beyond those presently used in model simulations. Target analytes will include PCB and PBDE congeners, chlorinated pesticides, polynuclear aromatic hydrocarbons (PAHs), semivolatile organics, and total and dissolved metals. Analyses will also measure total and dissolved organic carbon (TOC/DOC) and total suspended solids (TSS) to better understand partitioning and fate of the target analytes.

Freshwater (river) samples will be analyzed for the identical suite of analytes, but will incorporate additional analyses of several conventional water quality parameters. These will include water hardness and nutrients (ammonia nitrogen, nitrate and nitrite nitrogen, total persulfate nitrogen, orthophosphate phosphorus, and total phosphorus). Total petroleum hydrocarbons (TPH-gas and TPH-diesel) and hexane-extractable materials (HEM, or “oil and grease”) will also be measured to clarify and improve external loading estimates from surface runoff for oil and petroleum products.

Particulate samples from both marine waters and freshwaters will be analyzed for TOC, metals, semivolatile organics, chlorinated pesticides, and PCB and PBDE congeners.

Sampling Sites and Schedules

Marine water sampling locations will be established at the approximate centroid of each of the four Puget Sound basins of interest to represent ambient mean basin conditions. Water samples will be collected from above and below the halocline at each location. Sampling will not target or address acute localized impacts from contaminated nearshore environments. Boundary conditions for the model will be determined from the average of concentrations measured at two sites in the Strait of Juan de Fuca and one site in the Haro Strait.

Major rivers will be sampled at the first bridge crossing above marine saline influence with a companion gage station operated by the U.S. Geological Survey (USGS) or Ecology.

Water sampling at both marine and freshwater sites will be conducted on three occasions to estimate seasonal concentrations of the target parameters. Sampling will occur in June (after spring flushing), September (after first seasonal flush), and December (wet season), providing loading data for a wide range of discharge.

Suspended particulate samples will be collected from the surface and bottom waters of the four Puget Sound basins, and from the discharges of the five selected rivers. Marine particulate samples will be collected once, during the period of October to December 2009. Collection of particulate samples from the five river sites will also occur once, coinciding with the marine particulate collection.

Outcomes

The information generated by the present study will result in direct contributions to the creation and implementation of pollution-reduction strategies for toxic chemicals entering Puget Sound. Products of this study will include the following:

- **Water column toxics.** Marine water column samples from four Puget Sound basins will (1) yield baseline measurements of a large suite of toxic chemicals, and (2) provide a better understanding of present concentrations and seasonal variation. These data will be used as input and for calibration of the Puget Sound Toxics Box Model.
- **Marine boundary fluxes.** Measurements of toxic chemical concentrations in the Strait of Juan de Fuca and Haro Strait will facilitate estimation of the import and export of contaminants between Puget Sound and the ocean boundary waters. Incoming loadings from the boundary waters to Puget Sound will be estimated using bottom layer concentrations of the target contaminants and flow information generated from the circulation component of the Puget Sound Toxics Box Model. Outgoing loads will be estimated in a similar way using surface layer concentrations and flow information.

- **External loading estimates.** Water samples from the major rivers discharging to Puget Sound will support improved estimates of toxic chemical loadings to the Sound from surface runoff. Study data on contaminant concentrations and flow from the freshwater discharges will be provided electronically to Herrera Environmental Consultants for their use in the development of overall contaminant loading estimates for Puget Sound.
- **Partitioning.** Determinations of dissolved- and particulate-phase concentrations of toxic chemicals in Puget Sound waters, oceanic boundary waters, and major freshwater inputs will improve the accuracy of model predictions of chemical transport and fate.
- **Additional chemicals of concern.** Concentration measurements for an extensive suite of contaminants will allow extension of the Puget Sound Toxics Box Model beyond the initial PCB simulations to additional contaminants of concern. Preliminary exercises will be run to simulate the transport and fate of PCBs and PBDEs in Puget Sound and to estimate the net flux at the oceanic boundary.

Organization and Schedule

The following people are involved in this project. All are employees of the Washington State Department of Ecology.

Table 1. Organization of Project Staff and Responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
James M. Maroncelli Water Quality Program Phone: (360) 407-6588	Client	Clarifies scope of the project, provides internal review of the QAPP, and approves the final QAPP.
Randy Coots Toxics Study Unit, SCS Phone: (360) 407-6690	Project Manager	Writes the QAPP, conducts QA review of data, and analyzes and interprets data.
Tom Gries Toxics Study Unit, SCS Phone: (360) 407-6327	Principal Investigator	Analyzes and interprets data. Writes the draft report and final report.
David Osterberg Toxics Study Unit, SCS Phone: (360) 407-6446	Field Lead	Oversees field sampling and transportation of samples to the laboratory, records field information, and enters data into EIM.
Dale Norton Toxics Study Unit, SCS Phone: (360) 407-6765	Unit Supervisor for Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Will Kendra SCS Phone: (360) 407-6698	Section Manager for Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Robert F. Cusimano Western Operations Section Phone: (360) 407-6688	Section Manager for Study Area	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Stuart Magoon Manchester Environmental Laboratory Phone: (360) 871-8801	Director	Approves the final QAPP.
William R. Kammin Phone: (360) 407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP = Environmental Assessment Program.
SCS = Statewide Coordination Section.
QAPP = Quality Assurance Project Plan.
QA = Quality Assurance.
EIM = Environmental Information Management system.

Table 2. Proposed Schedule for Completing Field and Laboratory Work, Data Entry into EIM, and Reports.

Field and laboratory work	Due date	Lead staff
Field work completed	December 2009	David Osterberg
Laboratory analyses completed	February 2010	
Environmental Information System (EIM) database		
EIM user study ID	RCOO0010	
Product	Due date	Lead staff
EIM data loaded	July 2010	David Osterberg
EIM QA	August 2010	Dale Norton
EIM complete	September 2010	David Osterberg
Final report		
Author lead and support staff	Tom Gries	David Osterberg
Schedule		
Draft due to supervisor	May 2010	
Draft due to client/peer reviewer	June 2010	
Draft due to external reviewer(s)	Not applicable	
Final (all reviews done) due to publications coordinator (Joan)	August 2010	
Final report due on web	September 2010	

Quality Objectives

Manchester Environmental Laboratory (MEL) and their contractors are expected to meet quality control requirements of methods selected for the project. Quality control (QC) procedures used during field sampling and laboratory analyses will provide data for determining the accuracy of the monitoring results. Tables 3 and 4 show the measurement quality objectives (MQO) for the methods selected for water and particulate sample analysis.

Analytical precision and bias will be evaluated and controlled by use of laboratory check standards, duplicates, spikes, and blanks analyzed along with study samples.

Precision is a measure of the ability to consistently reproduce results. Precision will be evaluated by analysis of check standards, duplicates/replicates, spikes, and blanks. Results of duplicate (split) analyses will be used to estimate laboratory precision. Overall precision of the entire sampling and analysis process is estimated by analysis of field replicates. Field precision is the difference between laboratory precision estimates and overall precision estimates.

Bias is the systematic error due to contamination, sample preparation, calibration, or the analytical process. Most sources of bias are minimized by adherence to established protocols for the collection, preservation, transportation, storage, and analysis of samples. Check standards (also known as laboratory control standards) contain a known amount of an analyte and indicate bias due to sample preparation or calibration.

Blanks are particularly important quality control samples for low level analyses where results are expected near detection limits. Method blanks will be analyzed along with all samples to measure any response in the analytical system for target analytes. Method blanks have an expected theoretical concentration of zero. Field blanks are used to detect bias from contamination. This may include contamination from containers, sample equipment, environmental surroundings, preservatives, transportation or storage, other samples, or laboratory analysis.

Surrogates will be added to all organic samples prior to extraction. Surrogates have similar characteristics to target compounds. The recovery of surrogate spikes is used to estimate the recovery of target compounds in samples.

The lowest concentrations of interest in Tables 3 and 4 are from reporting limits MEL and their contractors have reported for water and sediment analyses from previous studies.

Table 3. Measurement Quality Objectives for Water Samples.

Parameter	Lab Control Samples (% Recovery)	Duplicate Samples (RPD[5])	Matrix Spike (% Recovery)	Matrix Spike Dups (RPD)	Surrogate Recoveries (% Recovery)	Lowest Concentration of Interest
TSS	80 - 120%	≤20%	NA[6]	NA	NA	1 mg/L
TOC	80 - 120%	≤20%	NA	NA	NA	0.10%
DOC	80 - 120%	≤20%	NA	NA	NA	0.10%
Hardness	80 - 120%	≤20%	75 - 125%	20%	NA	1 mg/L
PO_4^{-3}	80 - 120%	≤20%	80 - 120%	≤20%	NA	3 *ug*/L
TP	80 - 120%	≤20%	80 - 120%	≤20%	NA	5 *ug*/L
NO_2 + NO_3	80 - 120%	≤20%	80 - 120%	≤20%	NA	10 *ug*/L
NH_3	80 - 120%	≤20%	80 - 120%	≤20%	NA	10 *ug*/L
TPN	80 - 120%	≤20%	80 - 120%	≤20%	NA	25 *ug*/L
Metals – Marine Water						
Arsenic	85 - 115%[1]	≤20%	80 - 120%	20%	NA	0.05 *ug*/L
Cadmium	85 - 115%[1]	≤20%	75 - 125%	20%	NA	0.01 *ug*/L
Copper	75 - 125%[1]	≤20%	70 - 130%	20%	NA	0.05 *ug*/L
Lead	80 - 120%[1]	≤20%	75 - 125%	20%	NA	0.05 *ug*/L
Zinc	75 - 125%[1]	≤20%	65 - 135%	20%	NA	0.25 *ug*/L
Metals – Freshwater						
Arsenic	75 - 125%[1]	≤20%	65 - 135%	20%	NA	0.1 *ug*/L
Cadmium	75 - 125%[1]	≤20%	65 - 135%	20%	NA	0.1 *ug*/L
Copper	75 - 125%[1]	≤20%	65 - 135%	20%	NA	0.4 *ug*/L
Lead	75 - 125%[1]	≤20%	65 - 135%	20%	NA	0.1 *ug*/L
Zinc	65 - 135%[1]	≤20%	65 - 135%	20%	NA	0.5 *ug*/L
TPH-diesel	50 - 150%	≤50%	25 - 150%	50%	50 - 150%	0.15 mg/L
TPH-gas	50 - 150%	≤50%	25 - 150%	50%	50 - 150%	0.14 mg/L
HEM (“oil and grease”)	50 - 150%	≤50%	25 - 150%	50%	50 - 150%	5 mg/L
Semivolatiles (BNA)	40 - 150%	≤50%	40 - 150%	40%	10 - 150%[2]	1 - 5 *ug*/L
PAHs	40 - 150%	≤50%	40 - 150%	40%	10 - 150%[2]	0.01 *ug*/L
Chlorinated Pesticides	50 - 150%	≤50%	50 - 150%	40%	30 - 150%[2]	0.07 ng/L
PCB Congeners	50 - 150%	≤50%	NA	NA	25 - 150%[3]	10 pg/L
PBDE Congeners	50 - 150%	≤50%	50 - 150%	40%	25 - 150%[3,4]	10 pg/L

[1] = Blank spike recovery.
[2] = Surrogate recoveries are compound specific.
[3] = Labeled congeners.
[4] = BDE 209 recovery between 20 – 200%.
[5] = Relative percent difference.
[6] = Not applicable.

Table 4. Measurement Quality Objectives for Particulate Samples

Parameter	Lab Control Samples (% Recovery)	Duplicate Samples (RPD[2])	Matrix Spike (% Recovery)	Matrix Spike Dupes (RPD)	Surrogate Recoveries (% Recovery)	Lowest Concentration of Interest
TOC	75 - 125%	≤20%	NA[3]	NA	NA	0.1 *u*g/Kg
Metals[1]	80 - 120%	≤20%	70 - 130%	30%	NA	0.1-5 mg/Kg
Semivolatiles (BNA)	40 - 150%	≤50%	40 - 150%	40%	10 - 150%	1 *u*g/Kg
PAHs	40 - 150%	≤50%	40 - 150%	40%	10 - 150%	1 *u*g/Kg
Chlorinated Pesticides	50 - 150%	≤50%	50 - 150%	40%	50 - 150%	1 *u*g/Kg
PCB Congeners	25 - 150%	≤50%	NA	NA	25 - 150%[4]	0.05 *u*g/Kg
PBDE Congeners	NA	≤50%	NA	NA	25 - 150%[4-5]	0.05 *u*g/Kg

1 = Total recoverable for particulate metals.
2 = Relative percent difference.
3 = Not applicable.
4 = Labeled compounds.
5 = BDE 209 recovery between 20 – 200%.

Sampling Design

This study will generate baseline data for a suite of organic chemicals, metals, and conventionals in the marine and freshwaters of Puget Sound. The data are needed to (1) provide representative concentrations of chemicals of concern in the major basins of Puget Sound, (2) estimate the flux of toxic chemicals at the ocean boundary of Puget Sound, and (3) improve loading estimates from surface runoff to the Sound. An overview of sample collection for the study can be found in Table 5.

Table 5. Summary of Sample Collection at Marine and Freshwater Sites.

Marine Site	Water[1]		Particulates[2]	
	Below Halocline	Above Halocline	Below Halocline	Above Halocline
Hood Canal South	3	3	1	1
Puget Sound Main Basin	3	3	1	1
Whidbey Basin	3	3	1	1
South Sound Basin	3	3	1	1
Haro Strait	3	3	NA[3]	NA
Strait of Juan de Fuca North	3	3	NA	NA
Strait of Juan de Fuca at Sill	3	3	NA	NA
Total =	42		8	

Freshwater Site	Water[1]	Particulates[2]
Nooksack River	3	1
Skagit River	3	1
Stillaguamish River	3	1
Snohomish River	3	1
Puyallup River	3	1
Total =	15	5

[1] Samples collected June, September, and December.
[2] Samples collected from October to December only.
[3] Not applicable.

Marine Sampling

Marine water samples will be collected from above and below the halocline at seven locations throughout Puget Sound and its ocean boundary waters. The latitudes and longitudes of the marine sampling sites are listed in Appendix A (Table A1) and shown on Figure 1.

Marine sampling sites were selected to correspond to basin cells in the Puget Sound Toxics Box Model. Four basins were selected based on geographic distribution across Puget Sound, with priority given to basins having greater size and depth. The sampling site in each of the selected basins represents the deepest location in the approximate centroid of the corresponding model basin cell.

For the purposes of the model, the sills at Admiralty Inlet and Deception Pass were defined as the boundary for Puget Sound. Two sampling sites in the Strait of Juan de Fuca and one in Haro Strait represent the ocean boundary waters of Puget Sound. These sites in the Straits coincide with monitoring station locations established by the Joint Effort to Monitor the Strait of Juan de Fuca (JEMS).

Contaminant movements between Puget Sound basins and fluxes between ocean boundary waters and Puget Sound will be simulated using the water circulation and transport component of the Puget Sound Toxics Box Model (Babson et al., 2006; Pelletier and Mohamedali, 2009). Incoming loads at the ocean boundary will be estimated using bottom layer concentrations of target chemicals, while contaminant exports from the Sound at the ocean boundary will be similarly estimated using surface layer concentrations.

Suspended particulates will be collected by moored sediment traps in the four selected Puget Sound basins. Traps will be moored above and below the halocline, and located as near as possible to water sampling sites where water depth does not exceed 50 meters. Bottom traps will be at least 10 meters above the sediment to avoid collection of re-suspended material, and surface traps will be roughly 10 meters below the surface. Sediment traps have been used successfully in other Ecology studies measuring contaminants associated with particulates in marine waters (Norton, 2001, 1996, and 1995).

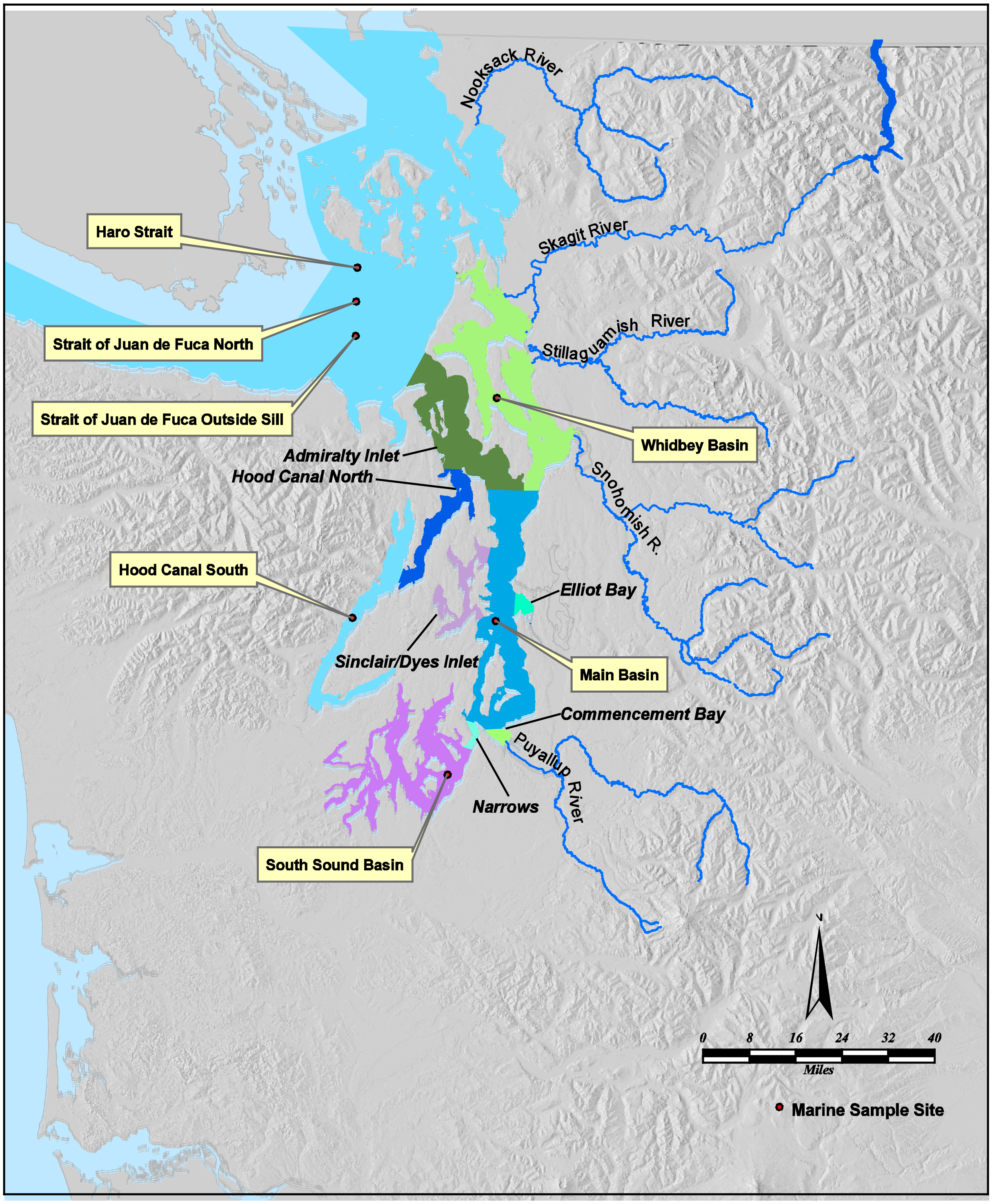

Figure 1. The Seven Marine Water Sampling Sites, Including the Four Puget Sound Toxics Box Model Basins.

Freshwater Sampling

Freshwater samples will be collected from the five largest freshwater discharges to Puget Sound (based on mean daily flow): the Nooksack, Skagit, Stillaguamish, Snohomish, and Puyallup Rivers. River sampling sites will be located at bridges over the lowest point in each drainage that allows sample collection above marine influence, co-located as close to permanent long-term flow stations as possible. River sampling sites, gaging stations, discharge, and drainage area information are described in Appendix A (Tables A2 and A3), and shown on Figure 2.

Freshwater samples will be depth-integrated composites collected at quarter points across the rivers. Individual grab samples will also be collected at quarter points along the river cross-section for HEM, TPH-gas, and TPH-diesel.

Discharge data for the time of sampling will be obtained from continuous long-term gaging stations operated by the USGS or Ecology. Loading rates will be calculated from instantaneous sample concentrations and flow. Annual loads will also be calculated using the mean sample concentrations and harmonic mean flows.

Collection of freshwater particulates will be from the same location as whole water samples. Representative samples of suspended particulates will be collected by pumping large volumes of water through continuous flow-through centrifuges. The time required to collect enough particulates to measure all target analytes will be based on TSS concentrations in the water column. Other toxic studies recently performed by Ecology have successfully used centrifuges to collect particulates (Serdar, 1997a, 1997b; Gries and Sloan, 2008).

Special Considerations for the Snohomish River

The Snohomish River begins at the confluence of the Skykomish and Snoqualmie Rivers. Most of the 20.5 river miles of the Snohomish River are tidally influenced. Water samples will be collected on the ebb tide from the Ecology long-term water quality monitoring station (Snohomish @ Airport Way) at river mile 12.7 in the city of Snohomish (Figure 2).

The only active gaging station on the Snohomish River is a USGS station located 0.1 miles downstream of the Skykomish-Snoqualmie confluence at river mile 20.4. Between the gaging station and the water sampling site, the Pilchuck River discharges to the Snohomish River at river mile 13.4, less than a mile upstream of the sampling location. The Pilchuck River has an active USGS gaging station. Therefore, flows for the Snohomish and Pilchuck Rivers will be combined for a total Snohomish River discharge at the sampling site.

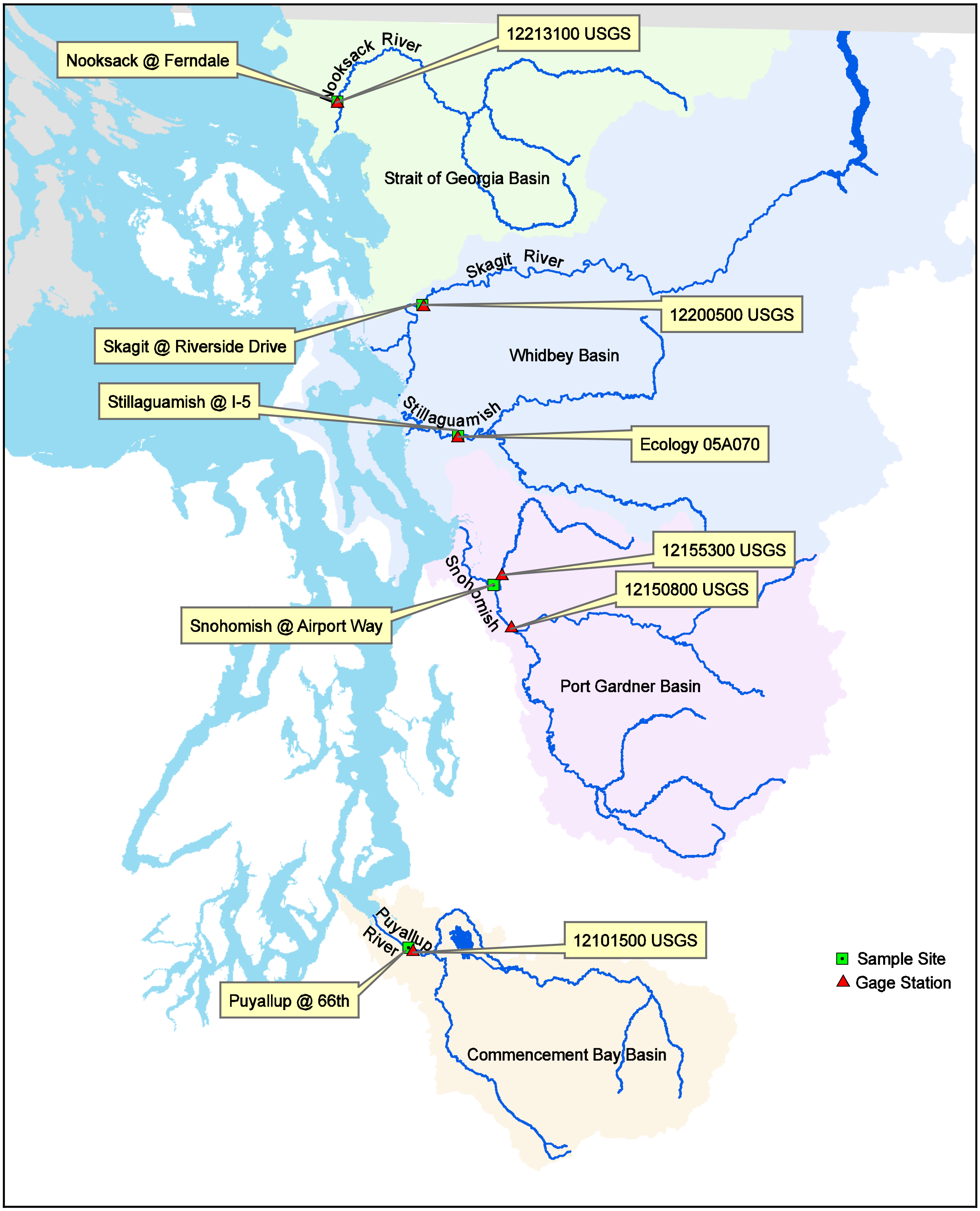

Figure 2. The Five Freshwater (River) Sampling Sites, Six Gage Locations, and Four Toxics Box Model Drainage Basins.

Sampling Schedule

Water samples will be collected at each of the seven marine and five freshwater sites on three occasions: once per month in June, September, and December of 2009. Sampling periods were selected to represent seasonal levels of contaminants over a wide range of discharge conditions. The timing of sample collection was chosen to represent contaminant concentrations following spring runoff (June), after the first flush event following the summer dry period (September), and during the wet weather of winter (December). Major river sampling will be conducted the week following the marine sampling events.

Sediment traps for collecting marine particulates will be moored in the four Puget Sound basin stations once, for a period of three months, beginning in October and ending in December 2009. Centrifugation for freshwater particulates in the major rivers will coincide with the deployment period for the sediment traps. Collection of river particulates will continue until particulate mass equals at least the minimum required for the targeted analyses. Therefore, the duration of collection will be determined by the TSS concentration in the rivers at the time of sampling.

Sampling Procedures

Marine Sampling

Water Column

The Ecology research vessel (R.V.) *Skookum* will be used as the sampling platform for the seven marine stations. The R.V. *Skookum* is a 26-foot aluminum hulled boat manufactured by Almar, equipped with hydraulic boom and winch. Boats can be a significant source of contamination when sampling for trace analytes. The hull of the R.V. *Skookum* has no antifouling coat, but has sacrificial zinc plates attached to the stern for prevention of electrolysis. Care will be taken to position the vessel down-current during sample collection. All sampling activities will be conducted on the windward side to minimize contamination from shipboard sources.

Sampling sites will be located by Global Positioning System (GPS) on board the R.V. *Skookum* and recorded in field logs. Water column samples will be collected from above and below the halocline. Historical salinity profiles will be reviewed from Ecology's Marine Ambient Monitoring Section database (www.ecy.wa.gov/apps/eap/marinewq/mwdataset.asp) at locations as close as possible to proposed sampling stations to estimate target depth requirements. A Conductivity/Temperature/Depth profiler (CTD; SBE25, Sea-Bird Electronics, Inc.) will be deployed on arrival to obtain a real-time salinity profile and confirm target depths. Collection of samples from below the halocline will precede above-halocline sampling at all locations. Sample collection depths will be recorded in field logs.

Water column samples will be collected with a pair of 10-liter, Teflon-coated GO-FLO discrete samplers (General Oceanics, Inc.). GO-FLO samplers have a *close-open-close* operation to avoid potential contamination from the microlayer at the water surface. Mounted back-to-back on a Kevlar or a like substitute rope, the samplers will be deployed in a closed position, open automatically by hydrostatic pressure release at a depth of ten meters, flush to sample depth, and close when triggered by Teflon-coated messenger. Detailed operating procedures for GO-FLO samplers are documented in Appendix D.

Immediately after retrieval of the GO-FLO samplers, they will be secured in a purpose-built storage cabinet for sample decanting. The salinity of the water in each sampler will be measured to evaluate the integrity of sampler closure. Unfiltered decanting will be conducted inside a portable glove box and will proceed in the following order: TSS, PCB and PBDE congeners, chlorinated pesticides, semivolatile organics, PAHs, and total recoverable metals. Filtration for dissolved metals will occur after all whole-water samples have been collected from the GO-FLO samplers. Filtration will employ a peristaltic pump and in-line filter following EPA Method 1669 (EPA, 1996). With the exception of a short length of MasterFlex-73 tubing in the pump head, all tubing will be Teflon. Filters will be Pall Corp., GWV high capacity capsules, 0.45-micron, or equivalent.

Table B1 in Appendix B lists the sample size, container, preservation, and holding times for each of the marine water column samples collected for the project. Approximately 16 liters of water is needed from each depth for marine samples, bottle rinses, and equipment flushes . The simultaneous deployment of two GO-FLO samplers will collect 20 liters of sample water, allowing a single cast for each sampling depth.

Following the collection of water samples from below and above the halocline, a CTD mounted on a compact rosette frame will be deployed at each station to obtain profiles of temperature, salinity, and dissolved oxygen. Field procedures for CTD operation are detailed in Appendix E. Data are recorded at eight measurements per second as the unit is lowered through the water column. The CTD and all auxiliary sensors will undergo an initial calibration prior to the first sampling event in June, and calibration samples will be collected periodically to verify continued accuracy throughout the year.

Four 1.5-liter Niskin bottles mounted on the rosette frame will collect additional water samples during the retrieval (upcast) of CTD deployments. The unit will be pre-programmed to trigger the closure of two Niskin bottles above and two Niskin bottles below the halocline corresponding to the depths of GO-FLO sampler collections. Salinity will be measured from each bottle to confirm collection depth and bottle closure. Water samples for TOC will be decanted, and samples for DOC will be filtered (following Stutes and Bos, 2007) from these Niskin bottle collections.

Particulates

Suspended marine particulates will be collected with the use of moored sediment traps. The traps consist of a straight-sided glass collection cylinder with an area of 78.5 cm^2 and a height-to-width ratio of 5. A schematic of the construction details of the traps and their moorings is presented in Figure 3. Further discussion can be found in Norton (2001 and 1996).

The four sediment trap sites in Puget Sound will be located by GPS on-board the R.V. *Skookum* and recorded in field logs. The traps will be positioned to collect particulates from above and below the halocline. Bottom traps will be moored at least 10 meters above the bottom to avoid collection of re-suspended materials. Near-surface sediment traps will use the same mooring as bottom traps, suspended by hard shell float and positioned roughly 10 meters below the surface. To meet minimum particulate mass requirements for the proposed analyses, at least two sediment traps will be deployed both above and below the halocline at each station.

Traps will be moored for a period of three months, with deployment in October and retrieval in December. If problems arise in deployment or retrieval of sediment traps, pumping and centrifugation may be conducted as an alternative collection method, generally following procedures detailed in Appendix F.

The R.V. *Skookum* will be used as the work platform for deployment and retrieval of sediment traps. At deployment, collection cylinders will be filled with two liters of high salinity water (4% NaCl) and sodium azide (2% Na_3N) as a preservative to reduce microbial degradation of the samples. Following retrieval of sediment traps, overlying water will be removed by peristaltic pump. The remaining sample will be placed in I-Chem sample jars supplied by MEL.

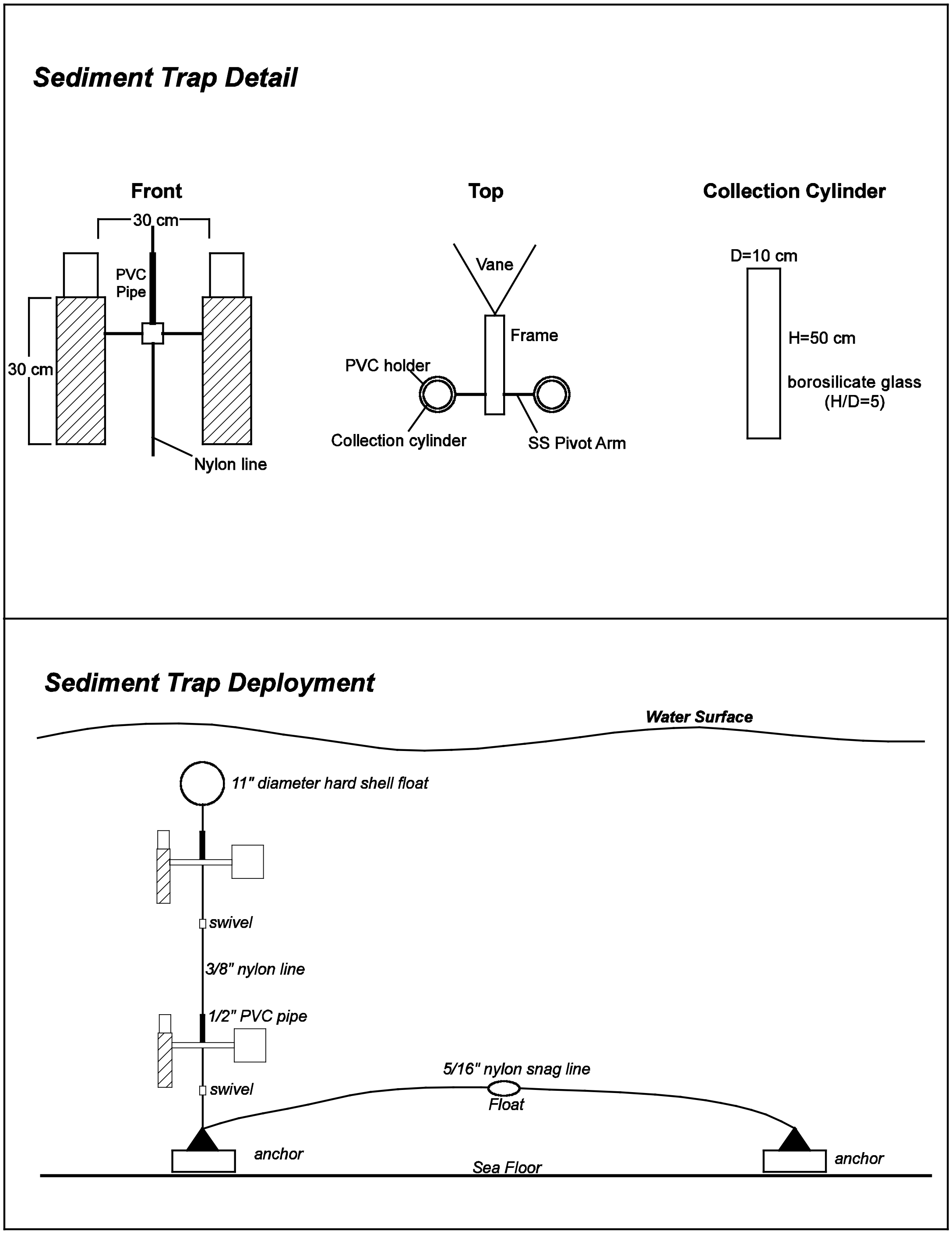

Figure 3. Schematic of Sediment Traps and Moorings.

Laboratories use dry weight sample minimums for solids to assure the lowest possible detection limits. Dry weights from wet samples are difficult to estimate, so sediment trap particulates will be centrifuged in the Ecology Headquarters laboratory before apportioning aliquots for individual analyses. If centrifuged samples are able to reach 90% solids, a minimum of 170 grams of sample from each site will be needed to complete required analyses. Following centrifugation of the sample, the particulates will be homogenized in a clean environment before aliquots are removed for TOC, metals, semivolatile organics, PAHs, chlorinated pesticides, and PCB and PBDE congener analyses. Table B2 in Appendix B lists the sample size, container, preservation, and holding times for each marine particulate sample collected during the project.

Freshwater Sampling

Water Column

Freshwater (river) sampling for most of the target parameters will be performed manually from bridges using a US DH-95 isokinetic, depth-integrating sampler (FISP, 2000). The DH-95 sampler consists of a plastic tail section and a plastic-coated bronze body into which a rigid 1-L Teflon bottle, cap, and nozzle are fitted. The nozzle points into the flow when submerged, minimizing the potential for contamination by avoiding contact of the sampled water with the sampler components. Water and suspended particulates flow through the nozzle into the collection bottle while air exhausts out a vent in the cap.

Sampling procedures for the DH-95 will be conducted according to USGS (2005) to the extent possible. A preliminary sounding will be made by lead weight to determine depth at each sampling point. During deployment, the DH-95 sampler will be lowered through the water column at a fixed rate until located within a meter above the streambed, where the sampler will then immediately reverse in direction and be raised at an equal rate. Each deployment (called a “vertical,” consisting of the complete downward and upward transit of the sampler) will be conducted at a rate that allows collection of 800 to 1000 mL of sample without overfilling the bottle. Transit rate will be dictated by the nozzle opening diameter, the river velocity, and river depth at each deployment following USGS (2005) and FISP (2000).

Verticals will be conducted at quarter points along the river cross-section. Finished samples will be manual composites of these quarter point collections (i.e., water from each quarter point will contribute one-third of the volume for analysis to the sample container). The total volume required for the target analyses is approximately 17 liters; therefore, a minimum of 6 liters will be collected at each quarter point. Table B3 in Appendix B lists the sample size, container, preservation, and holding times for each of the freshwater samples collected for the project.

Direct decanting from the sampler bottle into finished sample containers will be conducted on-site for TSS, TOC, hardness, and nutrients. Filtration of composite samples for DOC and orthophosphate will also be carried out in the field. Compositing and filtration activities for total and dissolved metals samples will be conducted within a portable glove box and will generally follow Ward (2007) and EPA (1996).

To minimize exposure to dust and particulates from the road and bridge, compositing for the most sensitive target analytes will not be conducted in the field. These analytes include semivolatile organics, PAHs, chlorinated pesticides, and PCB and PBDE congeners. Approximately 3.75 liters collected at a single quarter point will be combined in a one-gallon glass container and placed in a cooler on ice. Composite samples consisting of equal volume contributions from the quarter points for the above-mentioned analytes will then be decanted in a clean lab environment.

The only parameters that will not involve depth-integrated collection at quarter points will be TPH (both -gas and -diesel) and HEM. Sampling for these parameters will involve collection of grab samples at quarter points along the cross-section. Grabs will be collected from a depth of approximately 0.5 meters, and sampling will follow conventional practices except sample bottles will not be pre-rinsed.

Particulates

Suspended particulates will be collected by flow-through centrifuge at the river sampling sites. A detailed description of field operating procedures is documented in Appendix F. These procedures follow Gries and Sloan (2008) to the extent possible.

A pump (Model SP4, Gundfos Inc.) will be used to draw water from the location determined to be the average suspended sediment load at the site. The intake line for the pump will initially be positioned in the thalweg of the stream at 6/10 of depth. Positioning of the intake may be adjusted based on field observations and periodic measurements of water depth, velocity, and specific conductivity throughout the sampling event.

Two flow-through centrifuges (Alfa-Laval Corporate AB, MAB 103B) will receive the pumped water and remove the sediment. Removal efficiency of suspended particulates is expected to be >90%. The amount of collected sample will be monitored and removed as needed to maintain maximum retention efficiency.

River water will be centrifuged continually until the minimum amount of particulate is collected to allow analysis of all target parameters. Assuming a centrifuged sample is 90% solids, a minimum of at least 170 grams of sample from each site will be needed to complete the required analyses. The length of time centrifuges must run to collect this amount of particulate will depend on the concentration of TSS in the water column. During high or storm flows, TSS in rivers may be 50 mg/L or greater, while in low-flow periods TSS may be less than 3 mg/L. For a centrifuge operating at 360 liters/hour and 100% efficiency of particle retention, the range of time needed for collection of at least 170 grams of particulate sample at each site would be 9.4 to 157 hours for high (50 mg/L) and low (3 mg/L) TSS conditions, respectively.

When sample collection is concluded, particulates will be placed in the appropriate sample container and immediately placed in a cooler on ice. Once back from the field the particulate sample will be homogenized in a clean environment before aliquots are removed for TOC, metals, semivolatile organics, PAHs, chlorinated pesticides, and PCB and PBDE congener analyses. Table B4 lists the sample size, container, preservation, and holding times for each freshwater particulate sample collected for the project.

Measurement Procedures

The analytical parameters, sample numbers, methods, and reporting limits to be used for the study are presented in the Appendix C, Tables C1 through C3, for marine, river, and particulate samples. Method selection was based on the lowest detection limits available for the matrices. A complete analyte list for semivolatile organics, PAHs, and chlorinated pesticides can be found in Appendix C.

All sample containers will be obtained from MEL or the contract laboratories conducting the analysis and cleaned to analyte-specific standards. Chain-of-custody procedures will be followed throughout the sampling and analysis process.

All project samples will be analyzed at MEL or a laboratory contracted by MEL. Laboratories may use other appropriate methods as needed following consultation with the project manager.

Laboratories contracted by MEL must be on the Ecology list of accredited laboratories (www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html). Additionally, when available, laboratories conducting analysis for Ecology studies must be on the General Administration master contract.

Marine samples collected for metals analysis will be analyzed by Frontier GeoSciences, in Seattle, Washington. Marine and freshwater analyses of PBDE congeners will be contracted to the Pacific Rim Laboratory, in Surrey, British Columbia. Marine and freshwater analyses of PCB congeners will be contracted to Analytical Perspectives, in North Carolina.

The analytical cost for the project is estimated to be $294,208 (Table 6). The estimate includes a 50% cost discount for analysis conducted at MEL. Also included is a 25% surcharge for MEL's contracting services and data quality review for results from contract laboratories. The cost estimate assumes analysis of water samples collected on three occasions at seven marine sites (samples from two depths at each site) and at the five major rivers. Particulates will be collected once from the four Puget Sound stations (samples from two depths at each site) and from the five major rivers.

Table 6. Cost of Water and Particulate Sample Analyses (includes contract services).

Parameter	Number of Samples	Number of QA Samples	Sample Total Per Event	Cost Per Sample	Subtotal
Water					
TSS	19	3	22	11	242
TOC	19	4	23	33	759
DOC	19	4	23	35	805
Hardness	5	1	6	22	132
Nutrients (5)	5	1	6	78	468
Metals (Total and Dissolved) Marine Water:					
As, Cd, Cu, Pb, Zn	28	5	33	300	9900
Metals (Total and Dissolved) Freshwater:					
As, Cd, Cu, Pb, Zn	10	5	15	107	1605
TPH-diesel	15	1	16	104	1664
TPH-gas	15	1	16	75	1200
HEM (“oil and grease”)	15	2	17	55	935
Semivolatiles (BNA)	19	4	23	265	6095
PAHs	19	4	23	315	7245
Chlorinated Pesticides	19	4	23	250	5750
PCB Congeners	19	4	23	1250	28750
PBDE Congeners	19	4	23	750	17250
				Cost per 1 event	$82,800
				Cost per 3 events	$248,400
Particulates					
Percent Solids	13	2	15	11	165
TOC	13	2	15	42	630
Metals Total Recoverable:					
As, Cd, Cu, Pb, Zn	13	2	15	114	1710
Semivolatiles (BNA)	13	3	16	275	4400
PAHs	13	3	16	315	5040
Chlorinated Pesticides	13	3	16	250	4000
PCB Congeners	13	1	14	1250	17500
PBDE Congeners	13	1	14	750	10500
				Cost per 1 event	$43,945
Other Materials	Number of Samples	Cost Per Sample	Subtotal Per Event	Number of Events	Subtotal
Metals Filters	8	27	216	3	648
Metals Bottles and Acid	15	27	405	3	1215
				Subtotal Other Materials	$1,863
				Subtotal Water Samples (3 Events)	$248,400
				Subtotal Particulates (1 Event)	$43,945
				Grand Total	$294,208

Quality Control Procedures

Field

Table 7 shows a list of the field quality control (QC) samples and types to be analyzed for the project. Field QC samples provide an estimate of the total variability of the results, field plus laboratory. Field QC will consist of collection and analysis of replicate samples and blanks. Replicate water samples will be two samples collected one after the other as close to the same time and location as possible. Equipment blanks will consist of reagent grade water prepared by MEL or their contractor passed through the sample equipment, placed in a sample container, and returned as other samples to the laboratory for analysis.

Table 7. Field Quality Control Samples for Water[1].

Analysis	Replicates[2]	Transfer Blanks	Filter Blanks
TSS	2/event[3]	--	--
TOC	1/event	--	--
DOC	1/event	--	--
Hardness	1/event	--	--
Nutrients	1/event	--	--
Marine Metals	1/event	1/event	1/event
Freshwater Metals	1/event	1/event	1/event
TPH-diesel	1/event	--	--
TPH-gas	1/event	--	--
HEM ("oil and grease")	1/event	--	--
Semivolatiles (BNA)	1/event	1/event	--
PAHs	1/event	1/event	--
Chlorinated Pesticides	1/event	1/event	--
PCB Congeners	1/event	1/event	--
PBDE Congeners	1/event	1/event	--

[1] Includes marine and river samples.
[2] Independent sample collected at the same location.
[3] Sample collection events in June, September, and December.

All efforts will be made to avoid cross-contamination. Field staff will wear non-talc Nitrile gloves throughout the sample collection process. Immediately following collection, samples will be stored in iced coolers, until delivered to MEL.

To minimize field variability from sample collection, field samplers will be familiar with and follow methods for the collection and processing of water and particulate samples. Operating procedures are described in Appendix D for GO-FLO discrete water samplers, Appendix E for CTD deployment, and Appendix F for centrifuge operation for collection of particulates.

Additional guidance can be found in the Ecology SOPs *Manually Obtaining Surface Water Samples* (Joy, 2006) and *Collection and Field Processing of Metals Samples* (Ward, 2007), as well as PSEP (1997a and 1997b).

Any equipment used in collection or processing samples will be decontaminated prior to going to the field by washing thoroughly with hot tap water and Liquinox detergent, followed by sequential rinses of 10% nitric acid, de-ionized water, pesticide grade acetone, and finally, pesticide-grade hexane. After decontamination, sampling equipment will be air dried under a fume hood, covered with aluminum foil, and placed in a new plastic zip-lock bag until used.

Field QC for particulates will be split samples of remaining materials. Sediment trap particulates will require centrifugation back at the laboratory to concentrate solids. Until samples are processed, the total mass of particulates will be unknown. Target analytes for the study will be a higher priority for analysis than QC samples. If the particulate mass is not collected in sufficient quantity to submit QC samples for all parameters, a determination will be made at that time through consultation with the MEL as to prioritizing analyses for remaining particulates.

Laboratory

MEL routinely runs laboratory control samples for TSS, TOC, and DOC which will be satisfactory for the purposes of this project. MEL will follow standard operating procedures as described in the *Quality Assurance Manual for the Washington State Department of Ecology Manchester Environmental Laboratory* (MEL, 2006). Laboratory QC samples to be analyzed for this project are presented in Table 8.

Table 8. Laboratory Quality Control Samples for Water and Particulates.

Analysis	Method Blank	Check Standard	Duplicates	Surrogate Spikes	Labeled Compounds	MS/MSD[1]	OPR[3] Standards
Water							
TSS	1/batch	1/batch	1/batch	--	--	--	--
TOC	1/batch	1/batch	1/batch	--	--	1/batch	--
DOC	1/batch	1/batch	1/batch	--	--	1/batch	--
Hardness	1/batch	1/batch	--	--	--	--	--
Nutrients	1/batch	1/batch	--	--	--	--	--
Marine Metals	2/batch	1/batch	--	--	--	1/batch	--
Freshwater Metals	1/batch	1/batch	--	--	--	1/batch	--
TPH-diesel	1/batch	1/batch	--	--	--	--	--
TPH-gas	1/batch	1/batch	--	--	--	--	--
HEM (“oil and grease”)	1/batch	1/batch	--	--	--	--	--
Semivolatiles (BNA)	1/batch	1/batch	--	all samples	--	1/batch	--
PAHs	1/batch	1/batch	--	all samples	--	1/batch	--
Chlorinated Pesticides	2/batch	1/batch	--	all samples	--	1/batch	--
PCB Congeners	1/batch	1/batch	1/batch	--	all samples	--	each batch
PBDE Congeners	1/batch	1/batch	1/batch	--	all samples	--	each batch
Particulates							
Percent Solids	1/batch	1/batch	--	--	--	--	--
TOC	1/batch	1/batch	--	--	--	--	--
Metals[2]	1/batch	1/batch	--	--	--	1/batch	--
Semivolatiles (BNA)	1/batch	1/batch	--	all samples	--	1/batch	--
PAHs	1/batch	1/batch	--	all samples	--	1/batch	--
Chlorinated Pesticides	1/batch	1/batch	--	all samples	--	1/batch	--
PCB Congeners	1/batch	1/batch	--	--	all samples	--	each batch
PBDE Congeners	1/batch	1/batch	--	--	all samples	--	each batch

[1] = Matrix spike/matrix spike duplicate.
[2] = Total recoverable for particulate metals.
[3] = Ongoing precision and recovery.

Data Management Procedures

All field data and observations will be recorded in notebooks on waterproof paper. The information contained in field notebooks will be transferred to Excel spreadsheets after return from the field. Data entries will be independently verified for accuracy by another member of the project team.

Case narratives included in the data package from MEL will discuss any problems encountered with the analyses, corrective action taken, changes to the requested analytical method, and a glossary for data qualifiers. Laboratory QC results will also be included in the data package. This will include results for surrogate recoveries, laboratory duplicates, matrix spikes, and laboratory blanks. The information will be used to evaluate data quality, determine if the MQOs were met, and act as acceptance criteria for project data.

Field and laboratory data for the project will be entered into Ecology's EIM system. Laboratory data will be downloaded directly into EIM from MEL's data management system. Data from contract laboratories will be submitted in electronic format for inclusion into the EIM system.

Audits and Reports

MEL participates in performance and system audits of their routine procedures. Results of these audits are available upon request.

A draft report of the study findings will be completed by the principal investigator in June 2010 and a final report in September 2010. The report will include, at a minimum, the following:

- Map showing all sampling locations and any other pertinent features of the study area.
- Coordinates of each sampling site.
- Description of field and laboratory methods.
- Discussion of data quality and the significance of any problems encountered.
- Summary tables of the chemical and physical data.
- Results of the toxic contaminants related to available standards.
- Discussion of seasonal data on concentrations of toxic chemicals in marine waters and the freshwater inputs.
- Discussion of concentrations and fluxes of toxic chemicals associated with suspended particulate matter in both marine and freshwaters.
- Presentation of incoming (bottom layer) concentrations and estimated contaminant loads from ocean water to the Puget Sound, as well as outgoing (surface layer) concentrations and estimated loads for contaminant fluxes between Puget Sound and the ocean boundary.
- Discussion of toxic chemical loadings to Puget Sound from the major tributaries sampled.
- Comparison of Phase 2 loading estimates for PCBs from the Puget Sound Toxics Box Model with updated simulations generated using concentration data from the present study.
- Complete set of chemical and physical data and MEL quality assurance review in the Appendix.

Study data on contaminant concentrations and flow from the freshwater discharges will be provided electronically to Herrera Environmental Consultants for their use in development of an overall loading analysis for Puget Sound.

Upon study completion, all project data will be entered into Ecology’s EIM system. Public access to electronic data and the final report for the study will be available through Ecology’s Internet homepage (www.ecy.wa.gov).

Data Verification

Data verification is a process conducted by those producing data. Verification of laboratory data is normally performed by a MEL unit supervisor or an analyst experienced with the method. It involves a detailed examination of the data package using professional judgment to determine whether the measurement quality objectives (MQOs) have been met.

Final acceptance of the project data is the responsibility of the principal investigator. The complete data package, along with MEL's written report, will be assessed for completeness and reasonableness. Based on these assessments, the data will either be accepted, accepted with qualifications, or rejected and re-analysis considered.

Data verification involves examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. MEL's SOPs for data reduction, review, and reporting will meet the needs of the project. Data packages, including QC results for analyses conducted by MEL, will be assessed by laboratory staff using the EPA Functional Guidelines for Organic Data Review.

MEL staff will provide a written report of their data review which will include a discussion of whether (1) MQOs were met, (2) proper analytical methods and protocols were followed, (3) calibrations and controls were within limits, and (4) data were consistent, correct, and complete, without errors or omissions.

Data Quality (Usability) Assessment

After the project data have been reviewed and verified, the principal investigator will determine if the data are of sufficient quality to serve as Puget Sound and major tributary baseline data for water column toxic contaminants. The data from the laboratory's QC procedures, as well as results from field replicates, laboratory duplicates, and surrogate recoveries, will provide information to determine if MQOs have been met. A review of sample results will be performed following each seasonal sampling event to assess the need for modifications to the sampling or analysis program. Laboratory and quality assurance staff familiar with assessment of data quality may be consulted. The project final report will discuss data quality and whether the project objectives were met. If limitations in the data are identified, they will be noted.

Some analytes will be reported near the detection capability of the selected methods. MQOs may be difficult to achieve for these results. MEL's SOP for data qualification and best professional judgment will be used in the final determination of whether to accept, reject, or accept the results with qualification. The assessment will be based on a review of field replicates, along with laboratory QC results. This will include assessment of laboratory precision, contamination (blanks), accuracy, matrix interferences, and the success of laboratory QC samples meeting control limits.

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Appendices

Appendix A. Station Location Information.

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Appendix A. Station Location Information

Table A1. Sampling stations and coordinates for the marine water column.

Waterbody	Latitude	Longitude
Hood Canal South	47.55887	-123.00475
Puget Sound Main Basin	47.56157	-122.47593
Whidbey Basin	48.10833	-122.48999
South Sound Basin	47.18471	-122.63777
Haro Strait	48.41667	-123.02500
Strait of Juan de Fuca North	48.33333	-123.02500
Strait of Juan de Fuca at Sill	48.25000	-123.02500

Datum is NAD 83 HARN.

Table A2. Sampling stations and coordinates for the major rivers.

River	Latitude	Longitude
Nooksack	48.81898	-122.58010
Skagit	48.44500	-122.33510
Stillaguamish	48.19710	-122.21057
Snohomish	48.91074	-122.09852
Puyallup	48.20268	-122.29372

Datum is NAD 83 HARN.

Table A3. Flow station ID, river mile, discharge rate, drainage area, and latitude/longitude for the major rivers.

River	Gage ID	River Mile	Mean Daily Discharge[1]	Drainage Area (mi^2)	Latitude[2]	Longitude
Nooksack	12213100[3]	3.4	3,833	786	48.8190	-122.5800
Skagit	12200500[3]	15.9	16,580	3,093	48.4451	-122.3352
Stillaguamish	05A070[4]	11.1	4,696	557	48.1966	-122.2083
Snohomish	12150800[3]	20.4	9,514	1,714	47.8305	-122.0484
Pilchuck	12155300[3]	13.4	468	127	47.9349	-122.0737
Puyallup	12101500[3]	8.3	3,319	948	47.2026	-122.2937

[1] = Annual mean daily discharge in ft^3/second.
[2] = Datum is NAD83 HARN.
[3] = USGS gaging station.
[4] = Ecology flow and water quality site.

Appendix B. Sample Containers, Preservation, and Holding Times for Water and Particulate Samples

Table B1. Sample containers, requested volumes, preservation, and holding times for marine water column samples.

Parameter	Bottle Type and Volume	Sample Volume Requested	Preservative	Holding Time
TSS	1 L Poly	1 L	Cool to $\leq 6^{o}$ C	7 Days
TOC	60 mL Glass	60 mL	1:1 HCl to pH<2; Cool to $\leq 6^{o}$ C	28 Days
DOC	60 mL Glass	60 mL	Filter in field w/ 0.45 *u*m filter 1:1 HCl to pH<2; Cool to $\leq 6^{o}$ C	28 Days
Total Metals	500 mL HDPE	350 mL	HNO_3 to pH <2	6 Months
Dissolved Metals	500 mL HDPE	350 mL	Filter in field w/ 0.45 *u*m filter; add HNO_3 to pH ≤ 2; Cool to $\leq 6^{o}$ C	6 Months
Semivolatiles (BNA)	1 L Amber Glass	3 L	Cool to $\leq 6^{o}$ C	7 Days
PAHs	1 L Amber Glass	3 L	Cool to $\leq 6^{o}$ C	7 Days
Chlorinated Pesticides	1 Gallon Glass	3 L	Cool to $\leq 6^{o}$ C	7 Days
PCB Congeners	1 L Amber Glass	2 L	Cool to $\leq 6^{o}$ C	1 Year
PBDE Congeners	1 L Amber Glass	1 L	Cool to $\leq 6^{o}$ C	1 Year
Total 13.8 L				

Table B2. Sample containers, requested volumes, preservation, and holding times for marine particulate samples.

Parameter	Bottle Type and Volume	Sample Mass Requested (Wet Weight)	Preservative	Holding time
Percent Solids	2 oz Glass	50 Grams[1]	Cool to ≤6° C	7 Days
TOC			Cool to ≤6° C; may freeze at -18°C	14 Days; 6 months frozen
Metals Total Recoverable			Cool to ≤6° C; may freeze at -18°C	6 months
Semivolatiles (BNA)	8 oz Glass	250 Grams[2]	Cool to ≤6° C	14 Days; 1 year frozen
PAHs				
Chlorinated Pesticides		250 Grams	Cool to ≤6° C	14 Days; 1 year frozen
PCB Congeners		50 Grams	Cool to ≤6° C; may freeze at -18°C	1 year
PBDE Congeners		50 Grams	Cool to ≤6° C; may freeze at -18°C	1 year
Total 650 Grams				

[1] = Percent solids, TOC, and metals will be collected into one sample container.

[2] = Semivolatile organics and PAHs will be collected into one sample container.

Table B3. Sample containers, requested volumes, preservation, and holding times for freshwater (river) samples.

Parameter	Bottle Type and Volume	Sample Volume Needed	Preservative	Holding time
TSS	1 L Poly	1 L	Cool to $\leq 6^o$ C	7 Days
TOC	60 mL Poly	50 mL	1:1 HCl to pH<2; Cool to $\leq 6^o$ C	28 Days
DOC	60 mL Poly	50 mL	Field Filter w/ 0.45 *u*m; 1:1 HCl to pH<2; Cool to $\leq 6^o$ C	28 Days
Hardness	125 mL Poly	100 mL	H_2SO_4 to pH<2; Cool to $\leq 6^o$ C	6 Months
Nutrients: PO_4^{-3}	125 mL Amber Poly	125 mL	Field Filter w/ 0.45 *u*m; Cool to $\leq 6^o$ C	48 Hours
Nutrients: TP, NO_2+NO_3, NH_3, TPN	125 mL Clear Poly	125 mL	Pre-acidify w/ H_2SO_4; Cool to $<6^o$ C	28 Days
Total Metals	500 mL HDPE	350 mL	HNO_3 to pH <2; Cool to $<6^o$ C	6 Months
Dissolved Metals	500 mL HDPE	350 mL	Field Filter w/ 0.45 *u*m; HNO_3 to pH ≤ 2; Cool to $\leq 6^o$ C	6 Months
TPH-diesel	1 L Amber Glass	3 L	Cool to $\leq 6^o$ C	14 Days
TPH-gas	40 mL VOAs	480 mL	1:1 HCl to pH<2; Cool to $\leq 6^o$ C	14 Days
HEM ("oil and grease")	1 L Glass	3 L	1:1 HCl, pH ≤ 2.0; Cool to $< 6^o$ C	28 Days
Semivolatiles (BNA)	1 Gallon Glass	3 L	Cool to $\leq 6^o$ C	7 Days
PAHs	1 L Amber Glass	1 L	Cool to $\leq 6^o$ C	7 Days
Chlorinated Pesticides	1 L Amber Glass	1 L	Cool to $\leq 6^o$ C	7 Days
PCB Congeners	1 L Amber Glass	2 L	Cool to $\leq 6^o$ C	1 Year
PBDE Congeners	1 L Amber Glass	1 L	Cool to $\leq 6^o$ C	1 Year
Total 16.6 Liters				

PO_4^{-3} = orthophosphate phosphorus.
TP = total phosphorus.
$NO_{2\,+}\,NO_3$ = nitrite and nitrate nitrogen.
NH_3 = ammonia nitrogen.
TPN = total persulfate nitrogen.

Table B4. Sample containers, requested volumes, preservation, and holding times for freshwater (river) particulate samples.

Parameter	Bottle Type and Volume	Sample Mass Requested (Wet Weight)	Preservative	Holding time
Percent Solids	2 oz Glass	50 Grams[1]	Cool to $\leq 6^{o}$ C	7 Days
TOC			Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	14 Days; 6 months frozen
Metals Total Recoverable			Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	6 months; 2 years frozen
Semivolatiles (BNA)	8 oz Glass	250 Grams[2]	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	14 Days; 1 year frozen
PAHs				
Chlorinated Pesticides		250 Grams	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	14 Days; 1 year frozen
PCB Congeners		50 Grams	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	1 year
PBDE Congeners		50 Grams	Cool to $\leq 6^{o}$ C; may freeze at -18^{o}C	1 year
Total 450 Grams				

[1] = Percent solids, TOC, and metals will be collected into one sample container.
[2] = Semivolatile organics and PAHs will be collected into one sample container.

Appendix C. Laboratory Parameters, Number of Samples, and Analytical Methods for Water and Particulate Sample Analyses.

Table C1. Laboratory parameters, number of samples, and analytical methods for marine water analyses per sampling event.

Parameter	Sample Number + QA	Expected Range of Results	Reporting Limits	Sample Preparation Method	Sample Cleanup Method	Analytical Method
TSS (mg/L)	16	1.0 - 50	1.0	-	-	SM 2540 D
TOC (mg/L)	16	<1.0 - 10	1.0	-	-	SM 5310 C
DOC (mg/L)	16	<1.0 - 10	1.0	Filter 0.22 *u*m	-	SM 5310 C
Metals Total Recoverable (*u*g/L):						
Arsenic	25	0.5 - 2.0	0.05	Acid digest	-	FGS 054
Cadmium	25	0.02 - 0.20	0.01	Acid digest	-	FGS 054
Copper	25	0.1 - 1.0	0.05	Acid digest	-	FGS 054
Lead	25	0.005 - 0.20	0.05	Acid digest	-	FGS 054
Zinc	25	0.2 - 5.0	0.25	Acid digest	-	FGS 054
Metals Dissolved (*u*g/L):						
Arsenic	25	0.5 - 2.0	0.05	Filter 0.45 *u*m	-	FGS 054
Cadmium	25	0.02 - 0.20	0.01	Filter 0.45 *u*m	-	FGS 054
Copper	25	0.1 - 1.0	0.05	Filter 0.45 *u*m	-	FGS 054
Lead	25	0.005 - 0.10	0.05	Filter 0.45 *u*m	-	FGS 054
Zinc	25	0.2 - 5.0	0.25	Filter 0.45 *u*m	-	FGS 054
Semivolatiles (BNA) (*u*g/L)*	16	<1-100	0.25 - 1.0	Extraction	-	EPA 8270
PAHs (*u*g/L)*	16	<1 - 10	0.01	Solid Phase Extraction	-	EPA 8270 SIM
Chlorinated Pesticides (ng/L)*	16	0.10 - 3.0	0.10 - 3.0	EPA 3510	-	EPA 8081
PCB Congeners (pg/L)*	16	5 - 500	10	Dichloromethane Extraction	Acid/base wash	EPA 1668A GC/HRMS
PBDE Congeners (pg/L)*	16	5 - 500	10 - 250	Dichloromethane Extraction	Acid/base wash	EPA 1614 GC/HRMS

* Reporting limits and expected ranges of results will vary for different organic analytes.
SM = Standard Methods.
SIM = Selective Ion Monitoring.
FGS = Frontier GeoSciences.
GC/HRMS = Gas Chromatography / High Resolution Mass Spectrometry.

Table C2. Laboratory parameters, number of samples, and analytical methods for freshwater (river) analyses per sampling event.

Parameter	Sample Number + QA	Expected Range of Results	Reporting Limits	Sample Preparation Method	Sample Cleanup Method	Analytical Method
TSS (mg/L)	6	1.0 - 100	1.0	-	-	SM 2540 D
TOC (mg/L)	7	1.0 - 10	1.0	-	-	SM 5310 C
DOC (mg/L)	7	1.0 - 10	1.0	Filter 0.45 *u*m	-	SM 5310 C
Hardness (mg/L)	6	10 - 50	1.0	-	-	EPA 200.7 ICP
Nutrients 5 (mg/L)[1]	6	0.005 - 1.0	0.005 - 0.025	-	-	SM 4500
Metals Total Recoverable (*u*g/L):						
Arsenic	8	0.2 - 5.0	0.1	Acid digest	-	EPA 200.8 ICP/MS
Cadmium	8	0.05 - 1.0	0.1	Acid digest	-	EPA 200.8 ICP/MS
Copper	8	0.5 - 5.0	0.1	Acid digest	-	EPA 200.8 ICP/MS
Lead	8	0.04 - 0.5	0.1	Acid digest	-	EPA 200.8 ICP/MS
Zinc	8	5.0 - 10.0	5.0	Acid digest	-	EPA 200.8 ICP/MS
Metals Dissolved (*u*g/L):						
Arsenic	8	0.2 - 5.0	0.2	Filter 0.45 *u*m	-	EPA 200.8 ICP/MS
Cadmium	8	0.02 - 0.50	0.02	Filter 0.45 *u*m		EPA 200.8 ICP/MS
Copper	8	0.3 - 2.0	0.1	Filter 0.45 *u*m	-	EPA 200.8 ICP/MS
Lead	8	0.02 - 0.3	0.02	Filter 0.45 *u*m	-	EPA 200.8 ICP/MS
Zinc	8	0.4 - 5.0	1.0	Filter 0.45 *u*m	-	EPA 200.8 ICP/MS
TPH-diesel (mg/L)	16	0.1 - 50	0.05	Extraction	Acid/silica	ECY 97-602
TPH-gas (mg/L)	16	0.1 - 50	0.14	Extraction	Acid/silica	ECY 97-602
HEM (“oil and grease”) (mg/L)	16	2.0 - 150	1.7	-	-	EPA 1664A
Semivolatiles (BNA) (*u*g/L) *	7	<1 - 100	0.25 - 1.0	Extraction	-	EPA 8270
PAHs (*u*g/L) *	7	<1 - 10	0.01	Solid Phase Extraction	-	EPA 8270 SIM
Chlorinated Pesticides (ng/L) *	7	0.1 - 3.0	0.1 - 3.0	EPA 3510	-	EPA 8081 LVI
PCB Congeners (pg/L) *	7	5 - 500	10	Dichloromethane Extraction	Acid/base wash	EPA 1668A GC/HRMS
PBDE Congeners (pg/L) *	7	5 - 500	10 - 250	Dichloromethane Extraction	Acid/base wash	EPA 1614 GC/HRMS

*= Reporting limits and expected ranges of results will vary for different organic analytes.

SM = Standard Methods.
ICP = Inductively Coupled Plasma.
ECY = Ecology.
MS = Mass Spectrometry.
SIM = Selective Ion Monitoring.
LVI = Large Volume Injection.
GC/HRMS = Gas Chromatography / High Resolution Mass. Spectrometry.

Table C3. Laboratory parameters, number of samples, and analytical methods for marine water and freshwater (river) particulate analyses per sampling event.

Parameter	Sample Number + QA	Expected Range of Results	Reporting Limits	Sample Preparation Method	Sample Cleanup Method	Analytical Method
Marine	-	-	-	-	-	-
Percent Solids (%)	6	40-90%	1%	-	-	EPA 160.3
TOC (%)	8	< 1.0 - 5.0	0.1	PSEP, 1986/1996	-	PSEP, 1986/1997
Metals Total Recoverable (mg/Kg):						
Arsenic	8	1.0 - 20	0.1	SW-846 3050B	-	EPA 200.8
Cadmium	8	0.1 - 5.0	0.1	SW-846 3050B	-	EPA 200.8
Copper	8	2.0 - 50	0.1	SW-846 3050B	-	EPA 200.8
Lead	8	2.0 - 20	0.1	SW-846 3050B	-	EPA 200.8
Zinc	8	10 - 100	5	SW-846 3050B	-	EPA 200.8
Semivolatiles (BNA) (*u*g/Kg)*	9	<16 - 10,000	16 - 320	SW-846	-	EPA 8270
PAHs (*u*g/Kg)*	9	<1 - 10	0.01	Soxtherm Extraction	SilicaGel	EPA 8270
Chlorinated Pesticides (*u*g/Kg)*	9	<1 - 25	2 - 10	EPA 3541	-	EPA 8081
PCB Congeners (ng/Kg)*	8	5 - 500	3 -10	Soxhlet Extraction	Acid/base wash	EPA 1668A GC/HRMS
PBDE Congeners (ng/Kg)*	8	5 - 500	2 - 50	Soxhlet Extraction	Acid/base wash	EPA 1614 GC/HRMS
River						
Percent Solids (%)	6	40-90%	1%	-	-	EPA 160.3
TOC (%)	7	0.1 - 10	0.1	-	-	EPA 415.1
Metals Total Recoverable (mg/Kg):						
Arsenic	7	1.0 - 20	0.1	SW-846 3050B	-	EPA 200.8
Cadmium	7	0.1 - 5.0	0.1	SW-846 3050B	-	EPA 200.8
Copper	7	2.0 - 50	0.1	SW-846 3050B	-	EPA 200.8
Lead	7	2.0 - 20	0.1	SW-846 3050B	-	EPA 200.8
Zinc	7	10 - 100	5	SW-846 3050B	-	EPA 200.8
Semivolatiles (BNA) (*u*g/Kg)*	7	<16 - 10,000	16 - 320	SW-846	-	EPA 8270
PAHs (*u*g/Kg)*	7	<1 - 10	0.1	Soxhtherm Extraction	SilicaGel	EPA 8270
Chlorinated Pesticides (*u*g/Kg)*	7	<1 - 25	2 - 10	EPA 3541	-	EPA 8081
PCB Congeners (ng/Kg)*	6	5 - 2000	3 -10	Soxhlet Extraction	Acid/base wash	EPA 1668A GC/HRMS
PBDE Congeners (*u*g/Kg)*	6	5 - 2000	2 - 50	Soxhlet Extraction	Acid/base wash	EPA 1614 GC/HRMS

* = Reporting limits and expected ranges of results will vary for different organic analytes.
GC/HRMS = Gas Chromatography/High Resolution Mass Spectrometry.

List of analytes for semivolatile organics (BNA) analysis by EPA Method 8270.

Benzoic Acid [1]
Benzyl Alcohol
Bisphenol A
Butylbenzylphthalate
4-Bromophenyl-Phenylether
Di-N-Butylphthalate
Caffeine
Cholesterol [1]
4-Chloro-3-Methylphenol
4-Chloroaniline [1]
Bis(2-Chloroethoxy) Methane
Bis(2-Chloroethyl) Ether
Bis(2-Chloroisopropyl) Ether
2-Chloronaphthalene
2-Chlorophenol
4-Chlorophenyl-Phenylether
3B-Coprostanol [1]
3,3'-Dichlorobenzidine [1]
1,2-Dichlorobenzene [1]
1,3-Dichlorobenzene [1]
1,4-Dichlorobenzene [1]
2,4-Dichlorophenol
2,4-Dimethylphenol [1]
2,4-Dinitrophenol [1]
2,4-Dinitrotoluene
2,6-Dinitrotoluene
1,2-Diphenylhydrazine
2-Fluorophenol
Hexachlorobenzene
Hexachlorobutadiene [1]
Hexachlorocyclopentadiene[1]
Hexachloroethane [1]
Isophorone
p-Isopropyltoluene [1]
4,6-Dinitro-2-Methylphenol[1]
2-Methylphenol [1]
4-Methylphenol [1]
2-Nitroaniline
3-Nitroaniline [1]
4-Nitroaniline [1]
Nitrobenzene
2-Nitrophenol
4-Nitrophenol [1]
N-Nitroso-Di-N-Propylamine
N-Nitrosodiphenylamine
N-Nitrosodimethylamine
4-Nonyl Phenol [1]
Pentachlorophenol [1]
Bis (2-Ethylhexyl) Phthalate
Diethylphthalate
Dimethylphthalate
Di-N-Octyl Phthalate
Phenol
Pyridine
Triclosan
1,2,4-Trichlorobenzene[1]
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

[1] These compounds have inconsistent and poor recoveries.

Surrogates
D4-2 Chlorophenol
1,2-Dichlorobenzene-D4
2-Fluorobiphenyl
D5-Nitrobenzene
D5-Phenol
D10-Pyrene
D14-Terpenyl

List of analytes for polynuclear aromatic hydrocarbons (PAHs) analysis by EPA Method 8270 SIM.

Naphthalene
2-Methylnaphthalene
1-Methylnaphthalene
2-Chloronaphthalene
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene
Phenanthrene
Anthracene
Carbazole
Phenanthrene, 3,6-dimethyl-
Fluoranthene
Pyrene
Retene
Benzo(k)fluoranthene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenzo(a,h,)anthracene
Benzo(ghi)perylene
Chrysene
Benzo(b)fluoranthene
Benzo(a)anthracene

Surrogates
Naphthalene-D8
Acenaphthene-D10
Fluorene-D10
Phenanthrene-D10
Anthracene-D10
Fluoranthene-D10
Pyrene-D10
Chrysene-D12
Perylene-D12

List of analytes for chlorinated pesticides analysis by EPA Method 8081.

Aldrin
alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (Lindane)
Chlorpyriphos
cis-Chlordane (*alpha*-Chlordane)
trans-Chlordane (*gamma*)
Chlordane (Tech)
Dacthal (DCPA)[1]
2,4'-DDD
4,4'-DDD
2,4'-DDE
4,4'-DDE
4,4’-DDMU[1]
2,4'-DDT
4,4'-DDT
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Endrin
Endrin Aldehyde
Endrin Ketone
Heptachlor
Heptachlor Epoxide
Hexachlorobenzene
Methoxychlor
Mirex
cis-Nonachlor
trans-Nonachlor
Oxychlordane
Pentachloroanisole[1]
Toxaphene

[1] These compounds have inconsistent and poor recoveries.

Surrogates
Decachlorobiphenyl (DCB)
Dibutylchlorendate (DBC)
Tetrachloro-m-xylene (TCMX)

Appendix D. Field Operation Procedures - GO-FLO Samplers

Effective control of contamination during the collection and handling of Puget Sound water column samples is of paramount importance. Many of the target analytes are ubiquitous on the sampling platform and equipment, often at several orders of magnitude higher than concentrations expected in ambient waters. Introduction of contamination at this stage will negate all care taken in subsequent analytical steps.

These field protocols are intended to provide a step-by-step procedure for the collection of contamination-free water samples from depth in marine waters. Guidance was taken from the trace constituent sampling literature, and to the extent possible EPA Method 1669 "clean hands/ dirty hands" techniques are employed. The resulting protocols are understood to be performance-based, and modifications to the sampling procedure will be enacted if alternate techniques can be demonstrated to improve effectiveness. Performance will be measured through the collection and analysis of blanks and replicates.

Overview

While there is no "standard" method for obtaining at-depth samples of marine waters for trace constituent analyses, a proven and widespread technique involves the deployment of one or more Teflon-coated GO-FLO samplers (General Oceanics, Inc.) on a non-metallic hydrowire (typically Kevlar). The procedures for Puget Sound sample water collection are based on this "standard" foundation as follows:

Two Teflon-coated GO-FLO samplers are mounted back-to-back on a non-metallic Vectran rope and lowered by hand to a predetermined, above-halocline sampling depth. The samplers are remotely triggered by Teflon-coated messengers. A non-metallic windlass drum and Acetal sheave facilitate recovery of the GO-FLO samplers and ensure that the rope does not contact potentially contaminating materials. Once on-board, the samplers are kept in polyethylene bags and secured in a purpose-built storage cabinet to minimize atmospheric exposure.

Subsampling activities are conducted within a simple portable glove box. Water samples are decanted from each GO-FLO sampler via Teflon tubing that connects to the sampler drain valve inside the storage cabinet and to a Teflon petcock inside the glove box. In this way, sample bottles for the various analytes are filled in an environment isolated from major air- and ship-borne contamination sources.

The GO-FLO samplers undergo a short cleaning procedure and are re-deployed to collect water from below the halocline. After retrieval and subsampling activities, a CTD rosette cast is conducted using a hydraulic winch and stainless steel cable. CTD sensors record on the downcast, and Niskin bottles collect additional water samples from above- and below-halocline depths on the upcast. Discrete salinity measurements from each GO-FLO sampler and Niskin collection are compared to evaluate the integrity of sampler closure. At the completion of a sampling cruise, the GO-FLO samplers undergo rigorous cleaning and storage procedures.

Principal Equipment

- 10-liter GO-FLO samplers (2) – Teflon-coated with Teflon drain valves and air vent screws; spare parts kit.
- Vectran 12-strand rope (600 ft) – marked at 1- and 5-meter increments.
- Teflon-coated messengers.
- Snatch block and non-metal sheave – Ronstan single snatch block with Trunnion head and Acetal sheave.
- Non-metallic line weight – lead “fish” encased in epoxy resin.
- Cabinet for clean storage and transportation of GO-FLO samplers – constructed of UHMW polyethylene and Teflon materials.
- Large polyethylene bags capable of completely enclosing a single 10-liter GO-FLO sampler.
- Elasticized polyethylene “shower caps” (Saranwrap Quick Covers).
- Talc-free Nitrile gloves.
- Clinometer or like instrument.
- Refractometer or YSI Conductivity Meter.
- Marine flight compact rosette:
  - CTD – Model SBE25 (Sea-Bird Electronics, Inc.).
  - 1.5-liter Niskin bottles (4) – silicon springs and O-rings; AFM model SBE32 (Sea-Bird).
- Hydraulic winch with ~1200 ft of stainless steel aircraft cable.

General Rules

- Personnel must wear clean Talc-free Nitrile gloves during all sampling and subsampling operations. If glove contamination is detected or suspected, work must be halted, the contaminated gloves removed, and a new pair of clean gloves put on. Wearing multiple layers of clean gloves will allow the old pair to be quickly stripped with minimal disruption to the work activity.
- The upper ball valve of each GO-FLO sampler must be covered with an elasticized polyethylene “shower cap” at all times except during active deployment. The drain valve of each GO-FLO sampler must be covered with a Nitrile glove at all times except during active deployment and sample decanting.
- Samplers are transported around the vessel within polyethylene bags and are handled only by gloved personnel. When transferring the GO-FLO samplers to or from the storage cabinet, work rapidly and minimize the time that the inside of the cabinet is exposed to outside air. The samplers should never be placed directly on deck or any hard surface where foreign particles might be lodged in the ball valves and cause contamination of subsequent samples. Improper use and handling of GO-FLO samplers can result in permanent contamination.
- Ensure at all times that the Vectran 12-strand rope does not make contact with any part of the vessel (other than the Acetal sheave and windlass drum). When not in use, remove the rope from the snatch block and coil it inside a clean polyethylene bag. Place the bagged rope within a sealed plastic container to minimize exposure to air- and ship-borne contaminants.
- Store the snatch block and the line weights in clean polyethylene bags when not in use.

- All polyethylene storage bags are considered “one-time use.” That is, once a piece of equipment is removed from its storage bag, a separate clean bag must be used for subsequent storage.

Preparation

- Upon arrival at the sampling location, turn the engine off and wait 10 minutes before placing any sampling equipment in the water. Allow the vessel to drift during all sampling operations and conduct all sampling on the windward side of the vessel to minimize contamination from shipboard sources.
- Remove the snatch block from its polyethylene storage bag and secure it to the A-frame.
- Tie off the bitter end of the Vectran rope to a plastic cleat to secure it in case of mishap. Feed the working end of the rope over the sheave, being careful not to touch any metal objects that could embed foreign particles in the braid. Keep as much standing rope inside the covered plastic container as possible.
- Remove the line weights from storage bags and attach the weights to the loop eye at the working end of the Vectran rope. Lift the weights overboard and lower them into the water so that approximately 10 meters of rope extend above the weights. Secure the rope to a plastic cleat to maintain this configuration, and replace any extra rope into the rope storage box.
- Arm the GO-FLO samplers and secure each to the Vectran rope – *This is a 2-person activity and personnel must wear clean gloves*. Layering of gloves is recommended to facilitate rapid discarding of dirty/contaminated gloves. Technicians should work carefully but quickly, striving to minimize the duration of atmospheric exposure for GO-FLO samplers secured to the Vectran rope. Follow the procedures listed below for the first GO-FLO sampler, and then repeat the procedure to arm and secure the second GO-FLO sampler.
  - Technician #1 (T1) opens the storage cabinet. Technician #2 (T2) quickly removes the sampler (keeping it inside the polyethylene bag in which it was stored). T1 closes and secures the cabinet.
  - T1 places a clean polyethylene bag flat on a stable surface away from contamination sources. T2 places the GO-FLO sampler (still inside its polyethylene storage bag) on the bag.
  - T1 puts on clean gloves and reaches inside the storage bag to arm the GO-FLO sampler; contact with the GO-FLO sampler is only made by T1. T2 assists by stabilizing the sampler and manipulating the storage bag for T1.
    - Reverse the spring over the pulley to release tension.
    - Pull the pressure release valve all the way out and position the lanyard poly-balls on either side between the valve and the stainless steel frame.
    - Attach the lanyard to the plunger mechanism by inserting the slack loop into the trip release.
    - Re-span the spring by rotating it over the pulley so that the spring and the lanyards are under tension.
    - *Optional:* Test the closing mechanism to verify that it functions properly.
      - Push the pressure release valve to cause the ball valves to move to the open position.

        - Press the plunger to release the lanyard, which results in bottle closure.
        - Re-arm the GO-FLO sampler after this check.
    - T2 carries the armed sampler (still inside the storage bag) to the Vectran rope. T1 reaches inside the storage bag and checks that the protective "shower cap" and Nitrile glove are securely covering the upper ball valve and drain valve, respectively. T1 then removes the GO-FLO sampler from the storage bag. T2 discards the storage bag and secures the GO-FLO sampler to the Vectran rope at the 10-meter marking above the line weights.
    - T2 puts on clean gloves, and the above procedure is repeated for the remaining GO-FLO sampler. Mount the second sampler just below the first, with the top of its plunger mechanism approximately one meter below the base of the upper sampler.
- To prepare the samplers for serial firing, attach a Teflon-coated messenger by its lanyard to the plunger mechanisms of the upper GO-FLO sampler, and then snap the messenger onto the Vectran rope between the two samplers.

Deployment

- GO-FLO samplers armed using the above procedures are set to be deployed in a *closed* position to avoid potential contamination from the surface microlayer. If the number of line weights needed to overcome the buoyancy of the air trapped in the GO-FLO samplers becomes prohibitive, consider deploying the samplers in the *open* position. The ball valves can be easily released to the *open* position by depressing the pressure release piston. Note that the poly-balls on the lanyards are under tension and will snap quite suddenly when the pressure release piston is pressed in. Keep hands well clear of the poly-balls, and use a pen wrapped in either a polyethylene bag or a clean glove to depress the pressure valve.
- By convention, at the water surface the GO-FLO samplers are at 0 meters depth. Record the depth marking at which the GO-FLO samplers are mounted on the Vectran rope. This length of rope between the samplers and the line weights is called the "Weight Segment". In calm conditions when the rope angle (deviation from vertical) is negligible, the length of rope from the depth of the GO-FLO samplers in the water column to the surface (called the Sampler Segment) is equal to the total length of rope payed out (Total Length) minus the Weight Segment.

  Sampler Segment = (Total Length) – (Weight Segment)

- Immediately before deployment, remove the protective "shower cap" from the upper ball valve and the Nitrile glove from the drain valve of each GO-FLO sampler. Wearing clean gloves, check that all drain valves and air vent screws are tightly closed.
- Slowly lower the GO-FLO samplers by hand to ~15-20 meters depth. The hydrostatic pressure release valve should cause the ball valves to open at approximately 10 meters.
- Verify that the ball valves have opened properly: the parcel of air trapped in each sampler will be visible as it bubbles to the surface. If bubbles are not seen and there is concern that a sampler did not open, raise the rope slowly until the status of the ball valves can be assessed visually. However, note that contamination risks increase as the samplers approach the surface and the vessel. If water conditions are turbid or rough, assume that the bottle is open and accept that redeployment may be necessary. The weight of a retrieved sampler will be indicative of it being empty or filled with water.

- Lower the GO-FLO samplers to the desired sampling depth.
- Pay out additional rope as needed to adjust for significant rope angles (e.g., caused by strong currents or wind).
    - Read the Total Length and subtract the Weight Segment to determine the Sampler Segment.
    - Measure the angle of the rope from vertical (called Rope Angle) using a clinometer.
    - Calculate the actual depth of the GO-FLO samplers, the "Sampler Depth":

      (Sampler Depth) = (Sampler Segment) x cosine (Rope Angle)

    - Use the vessel's depth sounder for general verification (GO-FLO samplers should be detected by the sounder).
- Remove a Teflon-coated messenger from its storage bag, attach it to the Vectran rope, and release. This messenger will trigger closure of the upper GO-FLO sampler, followed by release of the serial messenger and subsequent triggering of the lower GO-FLO sampler.
- Allow adequate time for the messenger to reach the GO-FLO samplers before retrieval.

Recovery

- Use the windlass to recover the GO-FLO samplers, and feed the rope into the storage container as it is collected to minimize the potential for contact with contamination sources. It may be necessary to have the vessel's engine running to avoid complete draw-down of the battery by the windlass. In that case, engine assistance may only be used to raise the samplers to a depth of 10 meters. Above (i.e., shallower than) 10 meters depth, the engine must be off to avoid introducing excess contamination to the water column through which the GO-FLO samplers will travel. After the engine is off, allow at least one minute for ship-influenced water to dissipate before resuming sampler recovery.
- Once the GO-FLO samplers are retrieved to deck level, quickly inspect for leakage. If leakage is detected or suspected, prepare all samplers for re-deployment as follows:
    - Empty each GO-FLO sampler.
    - Rinse the sample chamber, the drain valve, and the air vent screw with de-ionized (DI) water.
    - Wearing clean gloves, and with the GO-FLO samplers still mounted on the Vectran rope, re-arm the samplers.
    - Re-deploy the GO-FLO samplers.
- If no leakage is apparent, immediately place clean polyethylene "shower caps" on the GO-FLO samplers' top ball valves. Rinse the samplers' drain valves with DI water and cover each with a Nitrile glove.
- Disengage the GO-FLO samplers individually and transport each to the storage cabinet. *This is a 2-person activity and all personnel must wear clean gloves*. Follow the steps below for the first GO-FLO sampler, and then repeat for the second sampler.
    - T2 supports the GO-FLO sampler to be removed, and T1 releases the screws that secure the sampler to the line.
    - While T2 holds the GO-FLO sampler, T1 places a clean polyethylene bag over the unit. T2 adjusts so that the sampler is completely contained in the bag.

    - T2 carries the GO-FLO sampler to the storage cabinet; T1 acts as a spotter. The sampler should not make contact with any part of the vessel.
    - Working quickly but carefully, T1 opens the storage cabinet and T2 places the GO-FLO sampler inside in an upright position (it should remain in the polyethylene bag). T1 secures the GO-FLO sampler inside the cabinet using bungee cords.
    - T2 puts on clean gloves, opens the GO-FLO sampler's air vent screw, and removes the glove from the drain valve. T2 removes the Teflon stopper from the port at the bottom of cabinet.
    - Inside the glove box (situated under the cabinet), T1 removes a clean Teflon tubing/petcock assembly from its storage bag. The open end of the tubing remains covered in a small plastic sheath, and the petcock remains protected by a plastic glove until subsampling activities commence. T1 feeds the tubing from inside the glove box through the port on the underside of the cabinet, and checks that the petcock inside the glove box is closed.
    - T2 receives the Teflon tubing inside the cabinet, removes the plastic sheath, and connects the tubing to the drain valve. T2 opens the drain valve, and T1 makes sure that the petcock isn't leaking in the glove box. T2 closes the cabinet.
- Wearing clean gloves, remove the line weights and place them in polyethylene bags for storage. Release the Vectran rope from the snatch block. Coil the rope, place it in a polyethylene bag, and store it within the sealed container to protect against air- and ship-borne contaminants. Place the snatch block in a polyethylene bag for storage.

Subsampling

- Begin decanting samples from the GO-FLO samplers as soon as possible to prevent settling, biological activity, or adsorptive losses.
- Prior to the cruise, pre-labeled bottles for a specific sampling location and depth (henceforth called a "set") will have been assembled in two large, layered polyethylene bags. Wearing clean gloves, remove the outer polyethylene bag and transfer the set (still contained in the inner polyethylene bag) to the inside of the glove box.
- Place a wide-mouthed waste container inside the glove box.
- The flow of water from a GO-FLO sampler is controlled from inside the glove box using the Teflon petcock. Remove the protective Nitrile glove to access a petcock. Be extremely careful, and ensure that nothing in the glove box makes contact with the exposed petcock at any time.
- Drain the first 0.5 liters of water from each GO-FLO sampler into the waste container before decanting for analyte samples.
- Decant a small (<50 mL) sample from each GO-FLO sampler, and use a refractometer or YSI Conductivity Meter to determine the salinity of the water in each sampler. Compare the salinities of same-depth GO-FLO sampler collections to evaluate the integrity of sampler closure; salinities that do not agree indicate a problem with the deployment. If salinities do not match, the GO-FLO samplers should be emptied, rinsed, and re-deployed.
- Decant water whole-water samples.

  - Remove the analyte sample bottle(s) from the set bag as they are needed, and follow analyte-specific handling procedures (e.g. bottle rinses).
  - The recommended sequence for decanting analyte samples is as follows:
    - GO-FLO sampler #1:
      1. Total Suspended Solids – 1 L
      2. PCB Congeners – 2 L
      3. PBDE Congeners – 1 L
      4. Chlorinated Pesticides – 3 L
    - GO-FLO sampler #2:
      5. Semivolatile Organics – 3 L
      6. PAHs – 3 L
      7. Total Metals – 1 L
  - After each analyte sample bottle is filled, attach a sample tag with the required identification information (e.g., date/time, location, analyte, etc.). Seal the individual bottle inside a polyethylene bag and then inside another polyethylene bag. Place the double-bagged sample bottles in the set bag.
  - *Do not* allow the mouth of an analyte bottle to contact the petcock at any time.
  - *Do not* swirl or shake the GO-FLO samplers to re-suspend settled material, as this can alter partitioning between dissolved and particulate size fractions.
- Observing "clean hands/dirty hands" guidelines, set up the in-line filtration apparatus for collecting a dissolved metals sample from GO-FLO sampler #2. Flush the metals filter and tubing with 500 mL of sample water, and then rinse the dissolved metals bottle and cap with filtrate. Collect 1 liter of filtered sample for dissolved metals determination.
- When all analyte samples have been decanted, carefully remove the set bag (filled with all of the sample bottles) from the glove box and place it in a clean, large polyethylene bag. Place completed sample set in a cooler on ice.

Between Stations or Sampling Events

- To minimize the risk of contamination to the GO-FLO samplers during short-term storage, adhere to the following precautions:
  - Store the samplers in polyethylene bag(s) inside the storage cabinet, and only remove a sampler just prior to deployment.
  - All valves (i.e., ball valves, air vent screws, drain valves) should be stored in their final closed position.
  - Cover the upper ball valve with an elasticized "shower cap," even when the sampler is inside a polyethylene storage bag.
  - Protect the drain valve by storing it covered by a Nitrile glove.
- If contamination of any GO-FLO sampler is suspected, stop using the sampler and return it to the lab for a thorough cleaning.

Extended Storage

- Prior to long-term storage, rinse the GO-FLO samplers with DI water.
- Ensure that all valves are in their final closed position.
- Cover the upper ball valve with a clean elasticized "shower cap," and place a clean Nitrile glove over the drain valve.
- Store the GO-FLO samplers in one or more clean polyethylene bag(s) within the storage cabinet, and pack the entire storage cabinet in another polyethylene bag if possible.
- If GO-FLO samplers are not to be used within 30-60 days, return the samplers to the lab and schedule a thorough cleaning and maintenance. Procedures will be guided by existing standard techniques for the cleaning of Teflon-coated sampling equipment for priority pollutant sampling.

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Appendix E. Field Operation Procedures - CTD Deployment

The Conductivity/Temperature/Depth profiler (CTD) mounted on a rosette unit is deployed as soon as possible after all subsamples have been drawn from GO-FLO samplers. Project-specific considerations for CTD deployment and Niskin bottle water collections are addressed below. Existing standard operating procedures for the compact marine flight rosette will be employed (Ecology's Marine Ambient Monitoring Section, pers. comm.), and as such are not comprehensively detailed here.

- Deployment of the CTD rosette will require use of the hydraulic winch with the vessel's engine running, creating a contamination-prone environment on-deck. Ensure that the GO-FLO samplers and all associated equipment are stored and secure prior to the CTD cast.
- Program the firing depth of the Niskin bottles to match the depth at which water samples were collected by GO-FLO samplers. Trigger two Niskin bottles at each sampling depth for redundancy.
- Secure the CTD rosette and weights (if necessary) to the stainless steel cable. Do not use the coated weights at this time, for there is a high risk of contamination from the equipment and steel cable.
- Lower the CTD rosette unit at a slow and constant rate, typically 0.5 m/s. Data recorded during the downcast will be used in later analyses; CTD and auxiliary sensor data from the upcast are discarded.
- Raise the CTD rosette unit at a velocity of approximately 0.5 m/s. Niskin bottles close at pre-programmed depths. The slow upward velocity ensures that water is obtained from a discrete depth, minimizing the vertical "smearing" of the collection through a depth interval.
- After the CTD rosette is recovered to deck level, immediately inspect the Niskin bottles for leakage. If leakage is detected or suspected, empty the Niskin bottles and prepare for re-deployment. Wait at least 5 minutes to allow quiescent conditions to re-establish before re-deploying.
- Turn off the engine off before commencing sample decanting and processing activities. Personnel must wear clean gloves during all subsampling procedures.
    - Measure sample water salinity from each Niskin bottle using a refractometer or YSI Conductivity Meter. Compare salinities of water samples collected at the same depth by Niskin bottles and GO-FLO samplers. Anomalous same-depth salinities may indicate incomplete bottle closure (and thus potential sample contamination by water from other depths), collection from the wrong sampling depth, or the influence of a dynamic water body. Discrete salinities should later be compared with the CTD salinity profile for further evaluation.
        - If Niskin sample salinities are comparable and agree with GO-FLO sampler salinities, then either Niskin bottle's contents can be used for TOC/DOC subsampling.
        - If Niskin sample salinities are comparable but disagree with GO-FLO sampler salinities:

        - ☐ The Niskin bottles or the GO-FLO samplers may have closed at the wrong depth. Consider re-deployment of the CTD rosette to evaluate further.
        - ☐ In areas affected by strong currents or wind-driven mixing, water at the sampling depth may have changed significantly between collection by the GO-FLO samplers and by the Niskin bottles. Make note of such physical factors and draw TOC/DOC subsamples from the Niskin collections, despite the discrepancy.
      - ▪ If Niskin sample salinities are *not* comparable but one agrees with GO-FLO sampler salinities, decant TOC/DOC subsamples from the Niskin bottle that has the same salinity as the GO-FLO sampler salinities.
      - ▪ If Niskin sample salinities are *not* comparable and both disagree with GO-FLO sampler salinities, new Niskin bottle samples must be collected before TOC/DOC subsamples can be drawn. The Niskin bottles may have closed at different depths, or sample integrity may have been compromised by incomplete bottle closure.
  - o Acquire water for CTD and sensor calibration by decanting from one of the Niskin bottles.
  - o Decant water from one of the Niskin bottles into TOC and DOC sample bottles. Conduct the necessary processing and filtration.
- Upload CTD data as needed (i.e., on-station, between stations, or post-cruise).
- Clear the CTD memory before the next cruise.

Appendix F. Field Operation Procedures - Collecting Suspended Sediment Using Flow-Through Centrifuges

(from Gries and Sloan, 2008)

Preparing for field work

- All equipment surfaces that will contact river water or centrifuged sediment will be cleaned appropriately (Ecology, 2006, 2008) to remove metals and organic residue:
  - Wash with phosphorus free soap (e.g., Luminox).
  - Rinse with a large volume of tap water.
  - Rinse with 10% nitric acid.
  - Rinse with deionized/distilled water and let dry.
  - Rinse with acetone and let air dry.
  - Rinse with hexane and let air dry.
  - Cover with foil.
- Replace consumables that have been used.
- Complete any maintenance or repairs.
- Assemble checklists and field logs.
- Label containers.
- Assemble field gear needed (from checklists).
- Complete field itinerary.

Set-up and pre-sampling

- Arrive at the sampling site and position centrifuge trailer so that:
  - It does not obstruct the road or bridge traffic.
  - Personnel have adequate access to the interior as well as exterior storage compartments.
  - It is easy to set up for pump sampling.
  - It is reasonably level.
- Set up centrifuge according to procedures described in operations manual (Seiders, 1990).
- Prepare tubing, attach pumps, prepare fish for deployment, and calibrate equipment.
- Start centrifuges and recycle approximately 10L of organic-free water through the entire system, including all sample tubing, for 30 minutes.
- Fill a 1L glass jar with water from the effluent (field blank).
- Profile the stream with the conductivity meter, especially near the streambed, to determine presence and extent of salt wedge.
- Profile the stream with the StreamPro according to the SOP to obtain flow and depth characteristics (minimum 4 passes).

- Use in-line sediment sensor (LISST-Streamside, Sequoia Scientific, Inc.) or turbidity meter (as surrogate) to map horizontal and vertical variability in profile of particle size distribution (PSD) in suspended sediments. Use the depth, flow, and particle size distribution/turbidity information to estimate most representative location(s) to place centrifuge intake tube. The default location will be center channel and 0.6 times the maximum depth of the freshwater layer.
- Set up tubing and pumps for sampling.
- Turn on pumps and recycle water back to the river for 10 minutes to flush the tubing, establish a constant flow, remove any bubbles in the tubing, and monitor for leaks.

Sampling

- After pumps are ready, attach tubing to the centrifuge apparatus and record in field logs: start time, tide phase (if tidal effects), stage height, centrifuge status, intake tube location, hertz, pump speed, and water flow.
- Start pumping to collect sandy suspended sediment on sieve by connecting the tubing and recording start time, tide phase, stage height, fish location, pump speed, and water flow.
- Monitor centrifuges for at least 20 minutes: influent, effluent, check for leaks, adjust flows, intake tube position, and overall operation.
- Collect samples of TSS in river water, centrifuge influent, and centrifuge effluent at designated times. Samples will be a combination of discrete and composite samples. Replicate and blank samples will also be taken.
    - Effluent water samples will be taken from a compositor located in the collection basin, while centrifuges are running.
    - Influent water samples will be taken by disconnecting the tubing just before the water enters each centrifuge. These 2 water samples will be combined into 1 influent sample.
    - Reconnect tubing to centrifuges.
- Measure flow and conductivity at designated time intervals.
- Record site conditions, weather, boat traffic, equipment performance, and any other important information in the log.
- Record changes in position of intake tube on centrifuge sample sheet including: tide phase, stage height, fish location, pump speed, water flow, and reason for relocation in the comments/notes column.
- Stop centrifuges and remove accumulation of suspended sediments using a Teflon spatula when substantial accumulation is predicted based on pumping rates and TSS. (Accumulated pellet will be removed to prevent it from contacting the discs in the bowl and decreasing retention efficiency). Place material in a pre-cleaned glass jar and seal. Put jar in cooler with ice. Record centrifuge data: stop time, elapsed time, tide phase, stage height, and total gallons pumped. Record sample data: collection time, MEL ID, sample ID, estimated amount of sample, and sample information.
- Restart centrifuges to continue collecting suspended sediment, recording the appropriate data.

- Remove sand-sized sediments from sieves when accumulation starts to restrict flow. Place sample in a pre-cleaned glass jar and put in cooler with ice. Record sieve data: stop time, elapsed time, tide phase, stage height, and estimated total gallons pumped. Record sample data: collection time, MEL ID, sample ID, estimated amount of sample, and sample information.
- Restart sieve apparatus to continue collecting sand-sized suspended sediments, recording the appropriate data.

Post-sampling

- When sampling is complete, stop centrifuges and pumps. Remove all accumulated sediments from the centrifuge and sieves, following the same procedures as removing accumulated sediments above.
- Take post-sampling flow measurements.
- Disassemble all equipment.
- Return to Ecology Operations Center and Headquarters in Lacey.

Sample processing

- Homogenize the centrifuge pellet using a stainless steel spatula.
- Split sample for analysis of study parameters.
- If needed, prioritize, with laboratory staff input, which contaminants to measure with sample mass.
- Send samples to appropriate laboratories, using chain-of-custody procedures.

Appendix G. Glossary, Acronyms, and Abbreviations

Ambient: Background (environmental).

Analyte: Water quality constituent being measured (parameter).

Bioaccumulate: Build up in the food chain.

Biota: Flora (plants) and fauna (animals).

Box model: A computer prediction tool to simulate the movement of water and pollutants within a waterbody.

Congener: In chemistry, congeners are related chemicals. For example, polychlorinated biphenyls (PCB) are a group of 209 related chemicals that are called congeners.

Flux: Amount that flows through a unit area per unit time.

Halocline: A strong vertical salinity gradient.

Loading: The input of pollutants into a waterbody.

Marine water: Salt water.

Parameter: Water quality constituent being measured (analyte).

Sediment: Solid fragmented material, that is transported and deposited by water, ice, or wind, that forms layers on the earth's surface.

Specific conductivity: A measure of water's ability to conduct an electrical current.

Thalweg: The deepest and fastest moving portion of a stream.

Acronyms and Abbreviations

BNA	Base/Neutral/Acids (semivolatile organics)
CTD	Conductivity/Temperature/Depth profiler
DOC	Dissolved organic carbon
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management system
EPA	U.S. Environmental Protection Agency
FISP	Federal Interagency Sedimentation Project
GPS	Global Positioning System
HEM	Hexane-extractable materials ("oil and grease")
JEMS	Joint Effort to Monitor the Strait of Juan de Fuca
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective

PAH	Polynuclear aromatic hydrocarbon
PBDE	Polybrominated diphenyl ether
PCB	Polychlorinated biphenyl
PSTLA	Puget Sound Toxics Loading Analysis
QAPP	Quality Assurance Project Plan
QC	Quality control
RPD	Relative percent difference
SOP	Standard Operating Procedure
SPM	Suspended particulate matter
TOC	Total organic carbon
TP	Total phosphorus
TPH	Total petroleum hydrocarbons (-gas and –diesel)
TPN	Total persulfate nitrogen
TSS	Total suspended solids
USGS	U.S. Geological Survey

NO_2 - NO_3	Nitrite and nitrate nitrogen
NH_3	Ammonia nitrogen
PO_4^{-3}	Orthophosphate phosphorus

As	Arsenic
Cd	Cadmium
Cu	Copper
Pb	Lead
Zn	Zinc

mg/L = milligram/liter (parts per million)
*u*g/L= microgram/liter (parts per billion)
ng/L = nanogram/liter (parts per trillion)
pg/L = picogram/liter (parts per quadrillion)

From: Don.Essig@deq.idaho.gov
To: Niemi, Cheryl (ECY)
Cc: Michael.Mcintyre@deq.idaho.gov; mary.anne.nelson@deq.idaho.gov; Miranda.Adams@deq.idaho.gov; Jeffrey.Fromm@deq.idaho.gov; Barry.Burnell@deq.idaho.gov; Douglas.Conde@deq.idaho.gov
Subject: RE: talk about human health criteria topics
Date: Thursday, September 06, 2012 1:16:50 PM
Attachments: image001.png
image002.png
image003.png
4-Stage process to new CWA HH criteria.docx

Cheryl,

Sorry for the delay. I was working on the attached and wanted to finish it so I could attach it to this reply. It just documents a process or way of organizing steps & questions that have been kicking around in my head. Getting it on paper relieves some head pressure, and allows me to share it with you and others, for refinement.

I am sure we'll all be talking a lot. It is probably better if we cross-pollinate as much as possible, share conundrums and possible solutions. So to that end, I definitely want to be part of a conversation with you Matt and Lisa. Not sure I understand all your 'things', and hope may attached will suggest other 'things' to add to your list.

Was skimming through EPA's HH Methodology again and came across this that relates to your first point:

"AWQC for the protection of human health are designed to minimize the risk of adverse effects occurring to humans from chronic (lifetime) exposure to substances through the ingestion of drinking water and consumption of fish <u>obtained from surface waters</u>." [emphasis added]

Seems pretty clear to me AWQC are not intended to account for / regulate all sources of health risk, and it would be pretty intractable if they were.

Don't understand your second and third points, perhaps you can expound a bit.

Thanks for sharing your power point. Just started putting together one of my own, OK if I borrow from yours? Don't know who from DEQ was at the Spokane meeting, but had to be someone from our Coeur D'Alene regional office.

Don A. Essig
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Please consider the environment before printing this email.

From: Niemi, Cheryl (ECY) [mailto:cnie461@ECY.WA.GOV]
Sent: Thursday, September 06, 2012 12:44 PM
To: Don Essig
Subject: talk about human health criteria topics

Hi Don,

Hope all is well with you. Here are a couple of items:

1. I talked with Matt at EPA this morning. Asked him if he and Lisa would be interested in talking about some of the things that we have been mentioning and that we know will come up in the HHC rule-making process. These include things like:

   - Role of CWA in public health protection
   - Temporal and geographic scope of the CWA
   - How explicitly do states spell out the different factors that drive their risk management decisions when it comes to HH criteria adoption
   - If a chemical is both a carcinogen and a non-carcinogen do we use the most stringent criteria based on the RfD and the CSF? (Many states have 10^{-5} for PCBs – does that protect against non-cancer effects and if so have any states addressed this directly? Matt is looking into this.)

We will be talking about these and more at our rule-making policy forums, and I expect you will too.

Matt thought it would be good for the four of us to talk first and then bring in more people if we need to find out more info about or define these further prior to rule-making workshops.

What else should we add to the list? I am particularly interested in being very clear about where we have flexibility and where requirements are in law or regulation.

What do you think?

2. FYI - My power point presentation (on human health criteria) from last week's workshop is up at http://www.ecy.wa.gov/toxics/fish_publicinvolvement.html. I think someone from IDEQ was at the meeting in Spokane, but don't have a name. The workshop was videoed - is in progress of being set up - the whole thing will be on the web at some point.

Weather below!

Cheryl

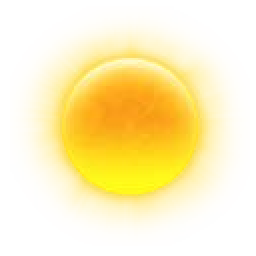
Beautiful Olympia Weather

PREVIOUS
Right Now
Right Now
NEXT
Hourly Forecast
Hourly Forecast

Forecast for Today

Updated: Sep 6, 2012, 10:06am PDT

Day Sep 6



83°FHigh

Sunny

Chance of rain:
0%
Wind:
NE at 9 mph
Humidity:
45%
UV Index:
6 - High
Snowfall:
0 in

Sunny. Warm. High 83F. Winds NE at 5 to 10 mph.

Night

49°Low

Clear

Chance of rain:
0%
Wind:
NE at 7 mph
Humidity:
63%

Cheryl A. Niemi

Surface Water Quality Standards Specialist

Department of Ecology

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Olympia WA 98504

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cheryl.niemi@ecy.wa.gov

From: Don.Essig@deq.idaho.gov
Sent: Tuesday, June 24, 2014 9:38 AM
To: Niemi, Cheryl (ECY)
Subject: FW: EPA's Position on general population FC survey

FYI. May have forwarded this in the past, but this is the conversation between Barry and Christine is was referring to. Just inquired of Barry if he ever responded to Christine in writing, in a manner like Sen Ericksen's questions.

From: Barry Burnell
Sent: Friday, March 15, 2013 11:36 AM
To: Don Essig; Michael Mcintyre; Douglas Conde; Mary Anne Nelson; Miranda Adams; Jeffrey Fromm
Cc: Curt Fransen; Jess Byrne
Subject: RE: EPA's Position on general population FC survey

Christine just called and her message was two part. That EPA would not help fund the general population survey design. That EPA could help with a high fish consumer survey design. I got her to confirm that this included the resident angler survey design. I informed her that DEQ's position was that the core questions to get at a fish consumption rate should be compatible between all of the fish consumer surveys.

I also questioned how Region 10 could have a policy different than headquarters. She told me they region 10 was pursuing some rational about having region wide approach. I asked her if she realized that Idaho did not have ocean front property and that a region wide approach did not seem appropriate to Idaho. She understood the geography, but none the less EPA was still pursuing a regional approach.

The final discussion point that came out was basically EPA taking the position that the high fish consumption populations need to be protected at 10x-6. I again asked her how region 10 could be narrowing and restricting states from the national policy, and got the response that all states should follow what Oregon approach.

Seems like policy calls are being made by EPA without consulting DEQ and that Region 10 is trying to convince headquarters to go along with them.

From: Don Essig
Sent: Thursday, March 14, 2013 12:21 PM
To: Barry Burnell; Michael Mcintyre; Douglas Conde; Mary Anne Nelson; Miranda Adams; Jeffrey Fromm
Subject: EPA's Position on general population FC survey

Just got off a call with Lisa Macchio and Matt Szelag of EPA and Cheryl Niemi of WADOE on fish consumption rates and surveys. Cheryl had set up the call and invited me as her and I have been talking, collaboratively chewing if you will, on various questions, such as the need for data on fish consumption rates for the general population. Two very important things emerged from the call.

First, EPA has taken the position that there is no value in a general population fish consumption survey and Idaho (or WA) should not do such a survey and that EPA will not support our efforts to do a general population survey. Involved in the decision were both EPA region 10 and headquarters.

I asked what 'will not support' means. At the very least it means no financial support, no surprise there. However, when I pressed Lisa about whether it meant we could count on continued help from Lon, for example to follow through on orchestrating a conversations with Dr. Amy Subar at NCI to help us, Lisa said she could not answer, did not know. When I explained to Lisa that Idaho was not planning to do just a general population survey, but also a recreational angler survey and that we think the design should be a common design even if the target populations are different and asked whether that mattered - if EPA's would give us no support even for the recreational survey because we are set on doing a general population survey - she said she did not think EPA had yet thought this through that far.

This is disconcerting to me. Lack of financial support is one thing, turning a cold shoulder so to speak is another. I worry that EPA might even go so far as to speak badly of our efforts to others, such as tribes perhaps, saying they think we are wasting time and money, or even saying so publically. That would definitely be even worse.

So really want to know the extent of EPA's lack of support, hope it is only no funding. I understand Christine is planning to call you Barry, and would ask that you try to clarify with her and if need be argue to limit EPA's lack of support to only no funding.

Secondly, Lisa said that part of EPA region 10's rationale for the lack of value in a general population survey was that Idaho's water quality standards applied the 10-6 cancer risk factor to all Idahoans, even high risk subgroups. I had heard this through the grapevine earlier, so looked at what our WQS say.

Here are the pertinent sections of our rules:

Footnote l. EPA guidance allows states to choose a risk factor of 10^{-4} to 10^{-6}. Idaho has chosen to base this criterion on carcinogenicity of 10^{-6} risk.

210.05.b. Human Health Criteria.

i. When numeric criteria for the protection of human health are not identified in these rules for toxic substances, quantifiable criteria may be derived by the Department from the most recent recommended criteria defined in EPA's Integrated Risk Information System (IRIS). When using EPA recommended criteria to derive water quality criteria to protect human health, a fish consumption rate of seventeen point five (17.5) grams/day, a water ingestion rate of two (2) liters/day and a cancer risk level of 10^{-6} shall be utilized.

Granted our rule language does not explicitly state the 10-6 risk factor is for the general population, but neither does it state it is for high risk groups, or all people. I would say it is more reasonable in absence of specificity to say it applies to the general population rather than an unspecified high risk subgroup. This interpretation is supported by the fact that these criteria are rooted in the NTR, and so I believe this the only fair interpretation. So EPA has interpreted our WQS contrary to how I think we would. If this is indeed the basis, or even a basis, for their disapproval and stance against a general population survey, it is something that needs to get straightened out.

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From: Niemi, Cheryl (ECY)
To: Susewind, Kelly (ECY); Gildersleeve, Melissa (ECY)
Subject: Just FYI - Suppression info from EPA
Date: Wednesday, October 01, 2014 12:46:19 PM

Just FYI - info from EPA below.

Cheryl A. Niemi

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From: Don.Essig@deq.idaho.gov [mailto:Don.Essig@deq.idaho.gov]
Sent: Tuesday, September 30, 2014 1:24 PM
To: Niemi, Cheryl (ECY)
Subject: FW: Call from Lisa and Lon on suppression

FYI.

From: Don Essig
Sent: Tuesday, September 30, 2014 2:00 PM
To: Barry Burnell; Michael Mcintyre; Douglas Conde (Douglas.Conde@deq.idaho.gov); Jeffrey Fromm; Miranda Adams; Josh Schultz
Subject: Call from Lisa and Lon on suppression

Lisa and Lon called me just now to say they had talked a bit after our call yesterday and talked with headquarters and are prepared to make these three points about suppression of fish consumption in our meeting on Thursday:

1) Suppression is multi-faceted, has several causes (various forms of reduction in quality and quantity basically)
2) EPA is not sure how suppression should be factored into criteria but stand by the statement in their Human Health FAQs, *"It is also important to avoid any suppression effect that may occur when a fish consumption rate for a given subpopulation reflects an artificially diminished level of consumption from an appropriate baseline level of consumption for that subpopulation because of a perception that fish are contaminated with pollutants"*
3) Jeff Bigler of EPA-HQ is working on a revision to EPA's 1998 guidance on conducting fish contaminant surveys, to address suppression and how to estimate it.

Don A. Essig
WQS / Idaho DEQ
208-373-0119

Keep in mind that all of the water we have today is all of the water that ever was and all of the water there will ever be.

From:	Braley, Susan (ECY)
Sent:	Thursday, January 09, 2014 3:07 PM
To:	Melissa McCoy; Niemi, Cheryl (ECY); Don.Essig@deq.idaho.gov
Subject:	RE: EPA's FAQs on Fish Consumption Rates
Attachments:	RE: Draft - Comments to ACWA on EPA HHC FAQ+dae.docx

Hi Melissa—Speaking for Ecology, we never got answers from EPA on these FAQs that showed up without advance notice and with no state involvement, nor EPA follow-up that was promised in the ACWA meeting discussions (I think there were two...April 17 and then an ACWA webinar on September 18). In fact we've heard nothing as far as I know (Cheryl or Don may have had more dialogue then me so I will let them speak for themselves).

I am attaching an email string following the April 17 ACWA discussion. As Martha notes it was a somewhat disappointing dialogue. I believe at that time (April 17) we were told that EPA would take down the January 2013 FAQ and make "corrections" based on WA and ID comments, and others that came out of the AWCA discussion (well, I should say we requested that EPA take the FAQ off line until they had made corrections). At the September 18 meeting we asked again why EPA hadn't followed through with their earlier commitment to make corrections to the January 2-013 FAQs and repost. We were told that EPA would look into it. Obviously, nothing happened because the January 2013 FAQs are still on line and unchanged.

What REAQLLY needs to happen is that EPA needs to pull the 2013 FAQs and have greater dialogue with states on these very important risk-based issues, and then come out with guidance that the states can work with. They do this with other guidance documents they have developed, so this one was a mystery, why it showed up without warning or any state input at all. What we heard at the September 18 ACWA meeting from EPA was that there was some urgency because of the work Florida was doing, and thus EPA felt the need to rush out with these FAQs. We all know that with water quality standards, anything that's rushed and not vetted is likely to be in error, especially when the state agencies who implement the standards don't have an opportunity to provide input.

It has been very frustrating, especially as we get closer to developing new human health criteria and are being told that these FAQs must be followed or we risk not getting approval.

Anything you can do to facilitate further discussion would be appreciated!

Susan

From: Melissa McCoy [mailto:mmccoy@acwa-us.org]
Sent: Thursday, January 09, 2014 1:51 PM
To: Niemi, Cheryl (ECY); Don.Essig@deq.idaho.gov; Braley, Susan (ECY)
Subject: EPA's FAQs on Fish Consumption Rates

Hi Susan, Don, and Cheryl,

I got some background on EPA's FAQs on FCRs from Susan here at ACWA, and noticed that the version on EPA's website is still dated January 2013. So I wanted to check in and see if discussing these FAQs with EPA resolved your concerns, or if there is still unfinished business on this topic.

Melissa

Melissa W. McCoy, Ph.D.
Environmental Program Manager

rom: Braley, Susan (ECY)
Sent: Monday, July 28, 2014 3:53 PM
To: 'Don.Essig@deq.idaho.gov'
Subject: RE: Question on June 30th call with EPA on HHC

Yes, Melissa might be able to recall...I just remember Cheryl and I being a little stunned at the news. Why they would go to so much trouble with the 94 chems if they plan to update the methodology to boot. Sure hope we can get that on a slow track....

From: Don.Essig@deq.idaho.gov [mailto:Don.Essig@deq.idaho.gov]
Sent: Monday, July 28, 2014 3:10 PM
To: Braley, Susan (ECY)
Subject: RE: Question on June 30th call with EPA on HHC

Thanks. Good to know that it was an ACWA arranged call, a call I could have been on if not home sick. I'll inquire with Melissa McCoy, maybe she took some notes.

From: Braley, Susan (ECY) [mailto:SUBR461@ECY.WA.GOV]
Sent: Monday, July 28, 2014 4:04 PM
To: Don Essig; Niemi, Cheryl (ECY)
Subject: RE: Question on June 30th call with EPA on HHC

on—I am PRETTY sure it was the call that Melissa McCoy set up on Monday, June 30th at 10:30am PST. Jim Keating from EPA (manager, I think?) was sort of apologetic about not taking action on the FAQs sooner after we pointed out that over a year had gone by that EPA had indicated they would at least update the FAQs with a disclaimer and make a few other clarifications (none of which happened). At some point I believe Elizabeth indicated that in fact they were planning in about a year to open up the methodology. So, I think it's okay to even state something to the effect that "At a meeting with ACWA and several states regarding discussion of the HHC FAQs, EPA indicated...."

Better have Cheryl ground truth my recollection, but I'm pretty sure it was at that meeting because we were all a little shocked—esp given the recent release of the 94 chems!

Susan

From: Don.Essig@deq.idaho.gov [mailto:Don.Essig@deq.idaho.gov]
Sent: Monday, July 28, 2014 2:17 PM
To: Niemi, Cheryl (ECY)
Cc: Braley, Susan (ECY)
Subject: Question on June 30th call with EPA on HHC

Cheryl,

I know you are on vacation, but I'll queue this up for your return, or maybe Susan can answer. Was the June 30th call with EPA HQ you mentioned, in which EPA said they were considering announcing revision of their 2000 HH methodology within 8 months, a call between DOE and EPA, or was it an ACWA call?

Want to make the comment I shared with you last Friday, that EPA should hold off on its current HH criteria updates if it intends to soon update its methodology, but not sure how to state my knowledge of their plans. This is what I have now:

PCBs in Municipal Products

REVISED

Pg. 12 Revised
July 21, 2015

Ecology Municipal Stormwater Grants of Regional or Statewide Significance
Grant No. G1400545

Prepared by:

City of Spokane
Wastewater Management Department

Contents

PCBs in Municipal Products

INTRODUCTION

Polychlorinated biphenyls (PCBs) are a toxic manmade chemical found ubiquitously in the environment. Historically, PCBs were primarily used in coolants and lubricants in electrical equipment, such as transformers and capacitors. In the United States, PCBs were largely sold under the trade name Aroclor. Direct production of PCBs was halted in the US in the 1970's due to evidence of human toxicity and persistence in the environment. Since that time, however, PCBs have been incidentally produced in a multitude of manufacturing processes as an unintended byproduct of processes that use heat, chlorine, and carbon.

The Washington State 2008 303(d) list holds 113 Category 5 listings for PCBs, covering 59 waterbodies. Several segments of the Spokane River are included in this list. The City of Spokane has performed stormwater sampling in several of its outfalls that drain to the Spokane River. PCBs were detected in each sample, with a typical sample in the range of 7,000 picograms per liter (pg/L), or parts per quadrillion (ppq).

Once thought to be only a legacy contaminant, PCBs have been found in numerous commercially available products. These PCBs are not intentionally produced, but are rather unintended byproducts of the manufacturing process. Materials containing less than 50 parts per million (ppm) are not considered "PCB-contaminated" under the Toxics Substances Control Act (TSCA) (40 CFR 761.3). For comparison to water quality considerations, 50 ppm is equivalent to 50,000,000,000 ppq. The current Washington State human health surface water quality standard for PCBs is 170 ppq (derived from the National Toxics Rule, 40 CFR 131.36). The Spokane Tribe adopted a water quality standard of 1.3 ppq due to higher fish consumption rates used to derive the standard.

Many products can easily come into contact with rain water and contribute to PCB concentrations in stormwater runoff. Municipalities are concerned about the presence of PCBs in commonly used products such as road paint, asphalt sealers, pesticides, and de-icer, to name a few. However, limited data is available as to the concentration of PCBs in products used for road and facility maintenance.

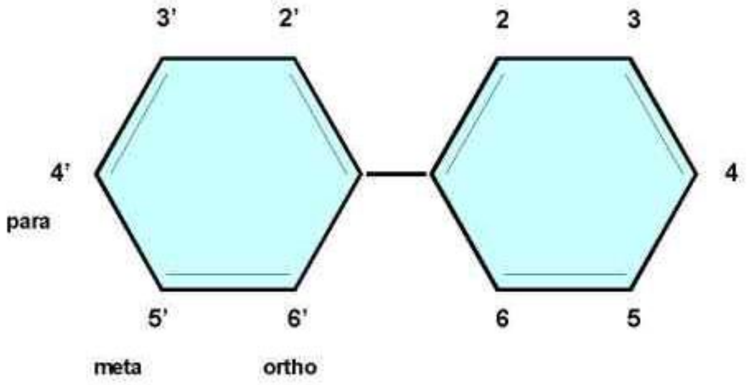
Nearly 50 product samples were collected and analyzed for PCBs using EPA Method 1668C. This method is capable of detecting low concentrations of PCBs for all 209 congeners. The majority of samples were composed of roadway, pipe, and vehicle maintenance products. Because PCBs are also ubiquitously detected in sanitary wastewater samples, five personal care products were sampled as well.

PCB 101

Chemical Structure

PCB molecules are composed of two joined benzene rings with varying degrees of chlorination, as depicted in Figure 1. PCBs can have between one and ten chlorine atoms. There are 209 different arrangements of this molecule, each known as a congener. Congeners are named PCB-1 through PCB-209, with greater numbers corresponding to greater degrees of chlorination. Homologues are the group of PCB molecules having the same degree of chlorination. For example, monochlorobiphenyls (monoCB) is the group of PCBs having one chlorine, dichlorobiphenyls (diCB) are the group of PCBs having two chlorines, etc.

MonoCBs = 1 chlorine
DiCB = 2 chlorines
TriCB = 3 chlorines
TetraCB = 4 chlorines
PentaCB = 5 chlorines
HexaCB = 6 chlorines
HeptaCB = 7 chlorines
OctaCB = 8 chlorines
NonaCB = 9 chlorines
DecaCB = 10 chlorines (PCB-209)



Structure of Polychlorinated Biphenyl (PCB) Molecule

Figure 1. (EPA, 2010b)

During the laboratory analytical process, some congeners cannot be distinguished from one another and are quantified as a complex of more than one congener. These are known as coeluting congeners, and are denoted with a slash in the figures in this report (e.g. 5/8).

Aroclors

Monsanto was the major US manufacturer of PCBs, and sold them under the trade name Aroclor until 1977 (Erickson, 1986). Aroclors were made of standard PCB mixtures to achieve the desired chemical properties. Each type of Aroclor was given a 4-digit identification number, with the second two digits indicating percentage of chlorine by weight (ASTDR, 2000). For example, Aroclor 1254 contains about 54% chlorine by weight. Homologue patterns for standard Aroclor mixes are shown in Appendix A. Homologue patterns for environmental and product samples can be compared to homologue patterns for Aroclors to give clues as to whether the PCB content may be a legacy Aroclor or not.

METHODOLOGY

Product Selection

Municipalities use numerous products in the roadway environment for construction, traffic safety, and maintenance purposes. Little is known about the PCB content in these products. To help guide product sampling, a literature search was performed to determine the potential for products to contain PCBs. In general, processes that involve chlorine, carbon, and high temperatures have the potential to inadvertently produce PCBs (Munoz, 2007).

Numerous studies have associated pigments with inadvertent PCB production (Christie, 2014; Ecology, 2014; Hu and Hornbuckle, 2010; Rodenburg, 2012). In particular, yellow pigments and white pigments (titanium dioxide) are associated with PCB-11, 206, 208, and 209. Yellow, orange, and red products that are derived from azo pigments (monoazo (Hansa Yellows and azonaphthols) and diarylide yellows) are associated with inadvertent PCB production, as are phthalocyanine blues and greens. Therefore, many items sampled for this study contained colored items. Various yellow and white road paints were sampled as well as hydrant paint and utility locate paint. Personal care products were selected that contain pigments.

Inadvertent PCB production is also associated with the manufacture of a multitude of various other chlorinated chemicals. Table 1 shows chemicals associated with various products that can be exposed to stormwater or enter the wastewater system:

Table 1. Example of Chemicals Associated with Inadvertent PCB Production

Chemical	Associated Products
Ethylenediamine	Surfactants, fungicides, fuel additives, EDTA, hair care products, soaps
Ethylene dichloride	Polyvinyl chloride (PVC), solvents
Phenylchlorosilanes	Silicones: lubricants, adhesives, coatings, hoses
Chlorinated benzidines	Pigments
Chlorinated paraffins	Flame retardants in plastics, paints, adhesives, sealants, and caulks
Glycerol/Glycerin (synthesized by epichlorohydrine)	Toothpaste, numerous personal care products, antifreeze, resins

(Information in this table adapted from Munoz, 2007)

One of the most consistent illicit discharge complaints received by the City of Spokane is vehicles dripping fluids onto the roadway. In 2011, the City sampled various off-the-shelf motor oils and transmission fluid to assess the potential for PCBs to enter stormwater through this pathway. PCBs were detected in appreciable concentrations in each of the samples, as shown in Table 2. Because PCBs are known to be present in these materials, additional motor oils and other petroleum products were sampled for this product sampling study.

Table 2. Oil and Transmission Fluid Sample PCB Concentrations (City of Spokane, 2011)

Sample	Total PCB, micrograms per kilogram (ppb) (EPA Method 1668)
Pennzoil SAE5W-30	37.8
Quaker State SAE5W-30	14
Valvoline Mercon V	49.5
Red Line D4 Automatic Transmission Fluid	8.8
Valvoline Full Synthetic 5W-30	116

One of the objectives of this project is to inform municipalities across the state. To gain a better understanding of which products and brands are most widely used, a survey was distributed across the state to willing participants. Ten jurisdictions responded, 6 from eastern Washington and 4 from western Washington. Results of the survey showed that one traffic paint brand is commonly used on both sides of the state under a state contract with WSDOT. Other product brands varied widely across the region, and the brand names used by the City of Spokane were not uncommon, so the products available at the City of Spokane were sampled.

Quality Assurance Project Plan (QAPP)

A QAPP was prepared for this project and approved by Ecology prior to the collection of samples (LimnoTech, 2014). A copy of the QAPP is available upon request.

Experimental Design

Ultra clean sampling techniques were followed to reduce the chance of sample contamination from ambient sources. Samples were collected August to October, 2014. Products were placed directly into laboratory-prepared sample jars whenever possible. Where equipment was necessary to remove the sample from its container and place it into the sample jar, clean decontaminated equipment was used.

Each product was assigned a three-digit Product ID number. Liquid and gel samples were placed in 40-milliliter glass vials. Solid samples were placed in 4-ounce glass jars. Pipe samples were wrapped in aluminum foil. Spray paint samples were sent to the laboratory in the original spray cans. All readily available product information was recorded at the time of sampling, including product type, brand name, lot number, manufacture date and country of origin in addition to standard sampling information such as time and date, sampler, and sample location.

Four field replicate samples were collected for field sampling quality control purposes. Replicate samples were collected for product ID 001, 003, 008, and 018.

A chain of custody form was filled out for each sample batch. Samples were packed into coolers, chilled to a maximum of four degrees Celsius, and shipped to Pacific Rim Laboratories for analysis. Samples were analyzed using EPA Method 1668C for all 209 PCB congeners.

Laboratory Quality Control

The laboratory maintains internal quality control procedures, including method blanks, laboratory control samples, laboratory duplicates, and labeled compound, cleanup, internal, and injection standards. In addition, data verification was performed by the City's project quality assurance (QA) officer. Data was validated by both the laboratory and the QA officer and was found to be acceptable.

EPA Method 1668 detects PCBs at very low concentrations. PCBs are truly ubiquitous and can be detected in even the most pristine laboratory environment. Therefore, PCBs are frequently detected in blank samples. To account for this, any congener that was detected in a product sample that was within three times the concentration detected in the associated blank sample were removed from the total PCB value. These congeners are also not included in the graphs in this report.

RESULTS AND DISCUSSION

The results of PCB product sampling are summarized in Table B-1 of Appendix B and in more detail in the following sections. PCBs were detected in all but two of the products that were sampled in the parts per trillion to parts per million range. The units reported by the laboratory are in micrograms per kilogram (ug/kg), or parts per billion. Note that Spokane water quality standards are 1.3 picograms per liter, or parts per quadrillion. One part per billion is 1,000,000 times greater than one part per quadrillion. Therefore, products detected at these concentrations are of concern to water quality practitioners.

Traffic Marking Samples

Several traffic paint samples were collected due to the association between yellow and white pigments and PCBs. One brand of traffic paint is predominantly used by municipalities and agencies throughout the state, sold by Ennis-Flint. Various types of this paint brand are available. Product numbers 983711 and 983712, low VOC, 100% acrylic waterborne traffic line paint, were sampled from the end of a spray nozzle in a City of Spokane shop. A liquid sample, replicate liquid sample, and a dried sample were analyzed (each for white and yellow). The paint was collected in a clean glass beaker and then immediately distributed to each of the sample vials. Dried paint samples were created by City of Spokane staff by pouring a small amount of paint onto a clean Teflon liner and allowing it to dry before sending it to the laboratory for analysis. The purpose of analyzing the dried sample was to determine if some PCB congeners are volatilized after paint application. Ennis-Flint PreMark thermoplastic road striping was also sampled, both in yellow and white.

For comparison, a lesser-used brand of road paint was sampled. Sherwin-Williams Promar solvent based acrylic traffic marking paint is used by some municipalities in southeast Washington. Samples were collected for both yellow and white paint. Replicates of all of the traffic marking samples (except the dried paint) were shipped to Ecology for their own product sampling study. Results of Ecology's analysis will be reported by Ecology. Total PCBs are shown in Tables 3 and 4 along with the percentage of the three most prevalent congeners, PCB-11, 77, and 209.

Table 3. Yellow Traffic Marking

Type	Total PCB (ug/kg)	PCB-11	PCB-77	PCB-209
Ennis	0.73	7%	35%	36%
Ennis (replicate)	2.69	17%	58%	8%
Ennis (dried)	0.565	9%	39%	35%
Promar	64.88	98%	1%	0%
Thermoplastic	10.78	79%	1%	0%

Table 4. White Traffic Marking

Type	Total PCB (ug/kg)	PCB-11	PCB-77	PCB-209
Ennis	0.41	18%	0%	61%
Ennis (replicate)	0.4	23%	0%	57%
Ennis (dried)	0.38	17%	0%	69%
Promar	0.28	41%	1%	0%
Thermoplastic	3.33	22%	0%	0%

Figure 2 shows the congener patterns for both the wet and dried Ennis yellow traffic marking paint samples. Generally the same congeners were detected in each of the samples, with slightly lower concentration in the dried sample than the liquid paint sample. This suggests that some congeners may be volatilizing into the air. However, as the difference in the liquid and duplicate liquid sample show, further study would be warranted to better determine volatilization rates. The Material Safety Data Sheet (MSDS) indicates that the paint composition contains methyl alcohol, titanium dioxide, propylene glycol, 2-butyoxyethanol, and quartz. Pigment content is not listed.

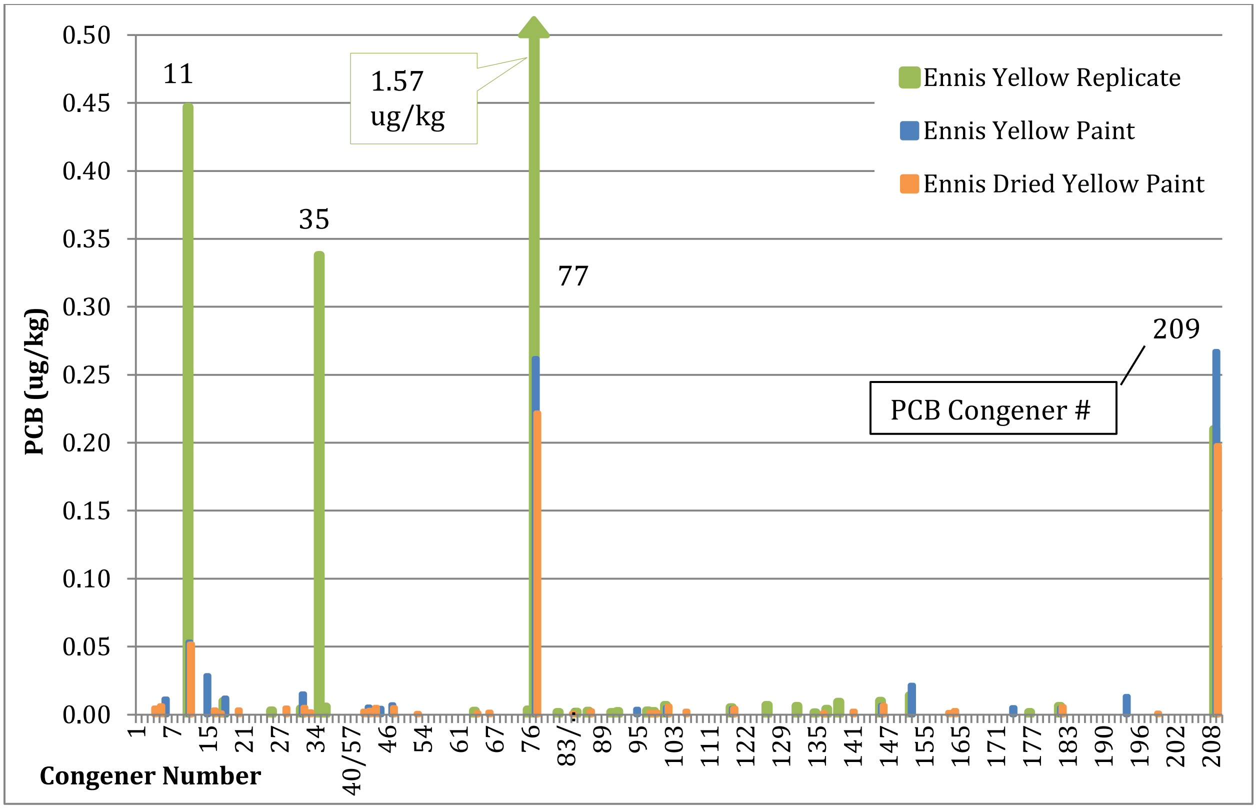


Figure 2. Ennis Wet and Dried Yellow Paint PCB Congeners

Figure 3 shows the congener patterns for the wet and dried Ennis white paint samples. The congener patterns are similar between the three samples. There is no discernible difference between the liquid and dried samples. Interestingly, PCB-11 was detected in the white paint samples in greater concentration than two of the yellow paint samples, although PCB-11 is usually associated with yellow pigment. The concentration of PCB-209 is similar between the yellow and white samples. The MSDS sheets for these products indicate that the yellow paint contains 3-7% titanium dioxide and the white paint contains 7-13% titanium dioxide.

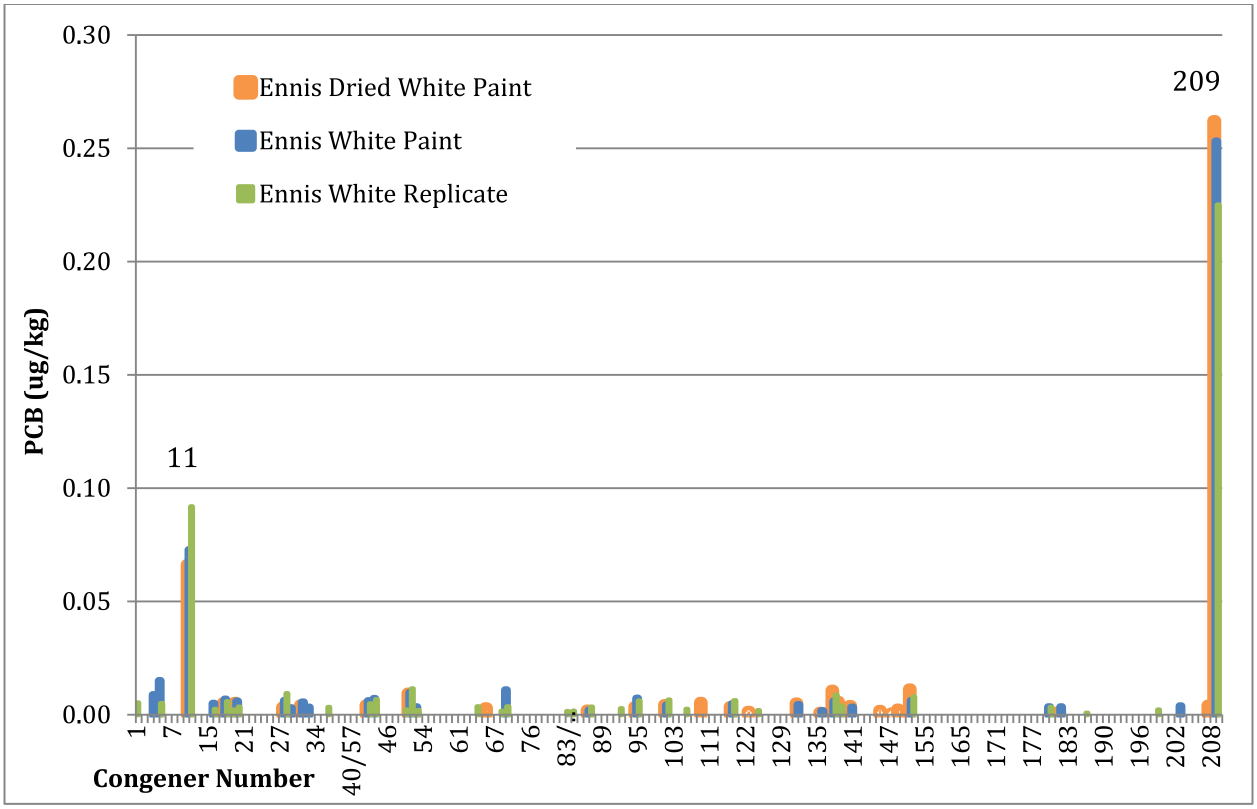


Figure 3. Ennis Wet and Dried W Paint PCB Congeners

Sherwin-Williams Promar yellow and white paint samples are shown in Figure 4. PCB-11 was detected in the yellow paint sample at a significant concentration of 63.8 ug/kg. PCB-35 and 77 were detected similar to the Ennis paint, but PCB-209 was not detected. The MSDS indicates that both white and yellow paints contain ethylbenzene, xylene, acetone, quarts, and titanium dioxide (2% titanium dioxide by weight for yellow and 4% for white). Both yellow and white paints contain approximately 55% pigment by weight.

Figure 5 shows congener patterns for the yellow and white Ennis-Flint PreMark thermoplastic tape samples. Total PCBs are greater than the paint samples (see Table 4 and 5), and there are more congeners detected. Most of the congeners are in the mono-CB through tetra-CB range (having one through four chlorine atoms). The MSDS for this product indicates that it contains the following components in increasing order of concentration: pigments, alkyd resins, polymers, fillers, and glass beads.

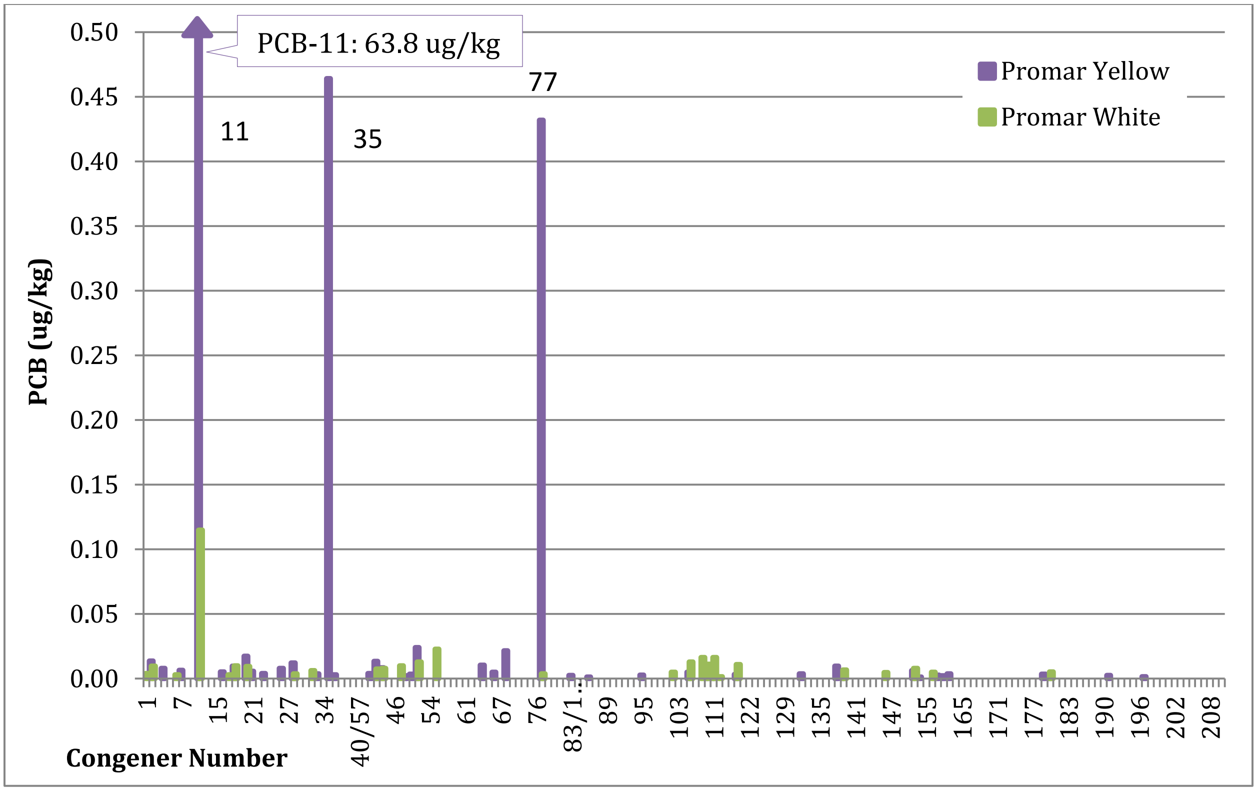


Figure 4. Sherwin-Williams Promar Yellow and White Paint Congeners

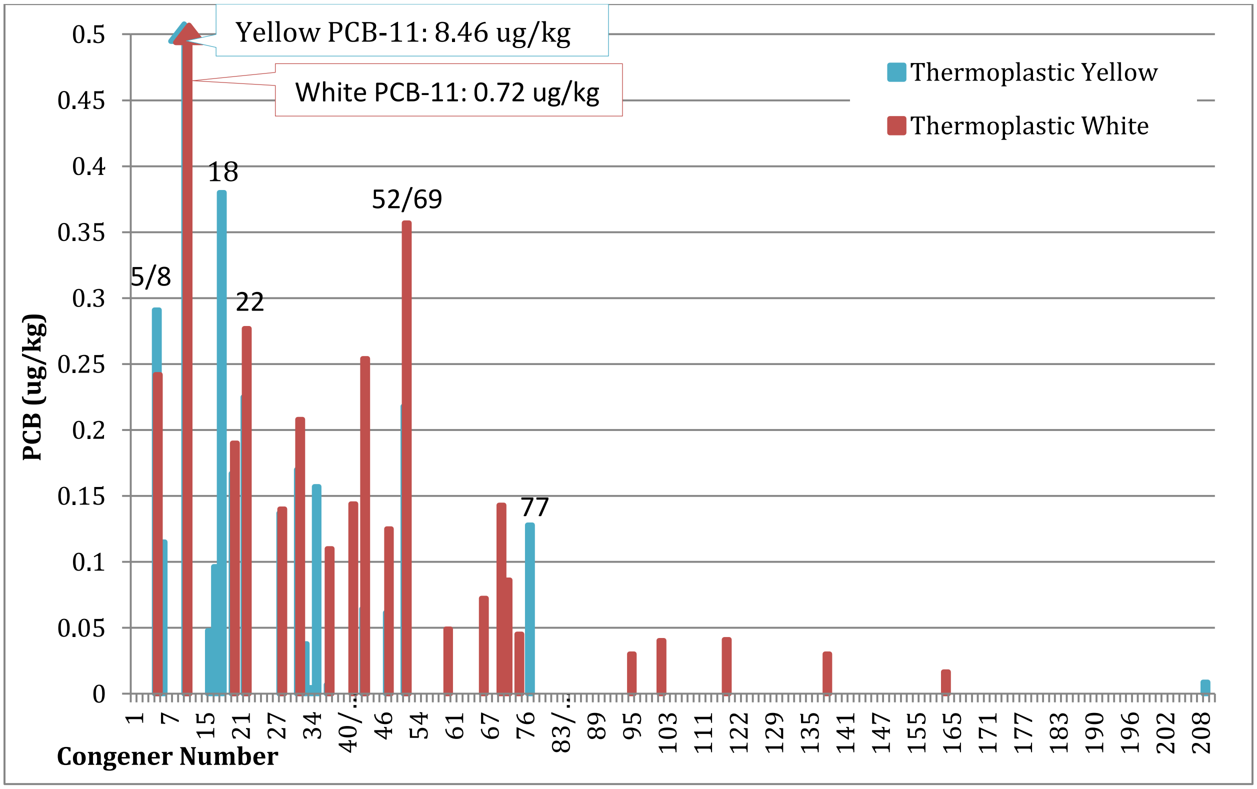


Figure 5. Ennis PreMark Thermoplastic Tape Congners

For samples that have a wide array of PCB congeners, such as the white thermoplastic tape sample, a homologue pattern graph can be a useful tool. These graphs depict the percentage of various homologues that make up the total PCB sample. Figure 6 shows the homologue patterns for both the yellow and white thermoplastic tape samples. The white thermoplastic tape, in particular, has a similar homologue and congener pattern to Aroclor 1016 (Appendix A). Yellow thermoplastic tape also has a similar pattern, but is dominated by PCB-11, a diCB. Aroclor 1016 was one of the lesser used Aroclor mixtures and was used in capacitors.

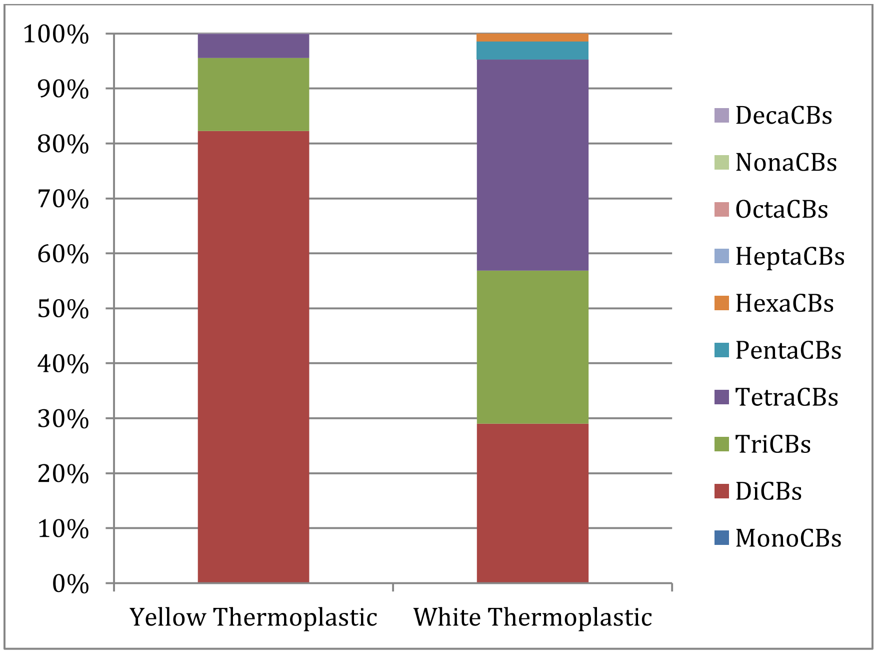


Figure 6. Thermoplastic Tape Homologue Patterns

Hydrant and Utility Locate Paints

Two additional types of paint commonly used on or near roadways were sampled. Fire hydrants are re-painted periodically using spray cans, typically in an aluminum color on the barrel and red on the nozzles. Rustoleum Professional High Performance Enamel Fast-Dry spray paint in Silver Aluminum was sampled. The product contains acetone, liquefied petroleum gas, toluene, xylene, aluminum flake, and ethylbenzene. Total PCBs detected in the sample were **0.0032 ug/kg**, consisting of only the congener PCB-19.

Utility locate paint is sprayed on or near the roadway frequently to mark underground utilities in a variety of colors, including pink, white, green, blue, purple, yellow, orange, and red. The green color denoting sewer utilities was sampled. The product sampled was Rustoleum Industrial Choice Solvent-Based Precision Line inverted marking paint in safety green. The total PCBs detected were **21.527 ug/kg**.

Ingredients listed on the green utility locate paint MSDS include acetone, liquefied petroleum gas, aliphatic hydrocarbon, limestone, xylene, modified alkyd, barium sulfate, talc, naptha (petroleum, hydrotreated light), titanium dioxide, ethylbenzene, and toluene. Most of the ingredients listed on the MSDS (with the exception of titanium dioxide) are not specifically listed as having the potential to inadvertently produce PCBs in the Munoz (2007) paper, although there may be unlisted intermediate compounds that may produce PCBs. The most likely source of PCB is the pigment, and is most likely a phthalocyanine green based on the presence of PCB-11, 206, 207, 208, and 209. Titanium dioxide may also be contributing to the PCB-206, 208, and 209. On the Rustoleum product website, "phthalo green" is a common pigment used in various paint products, although not specifically listed for this product. The pigments used are proprietary information and would not be shared by the company.

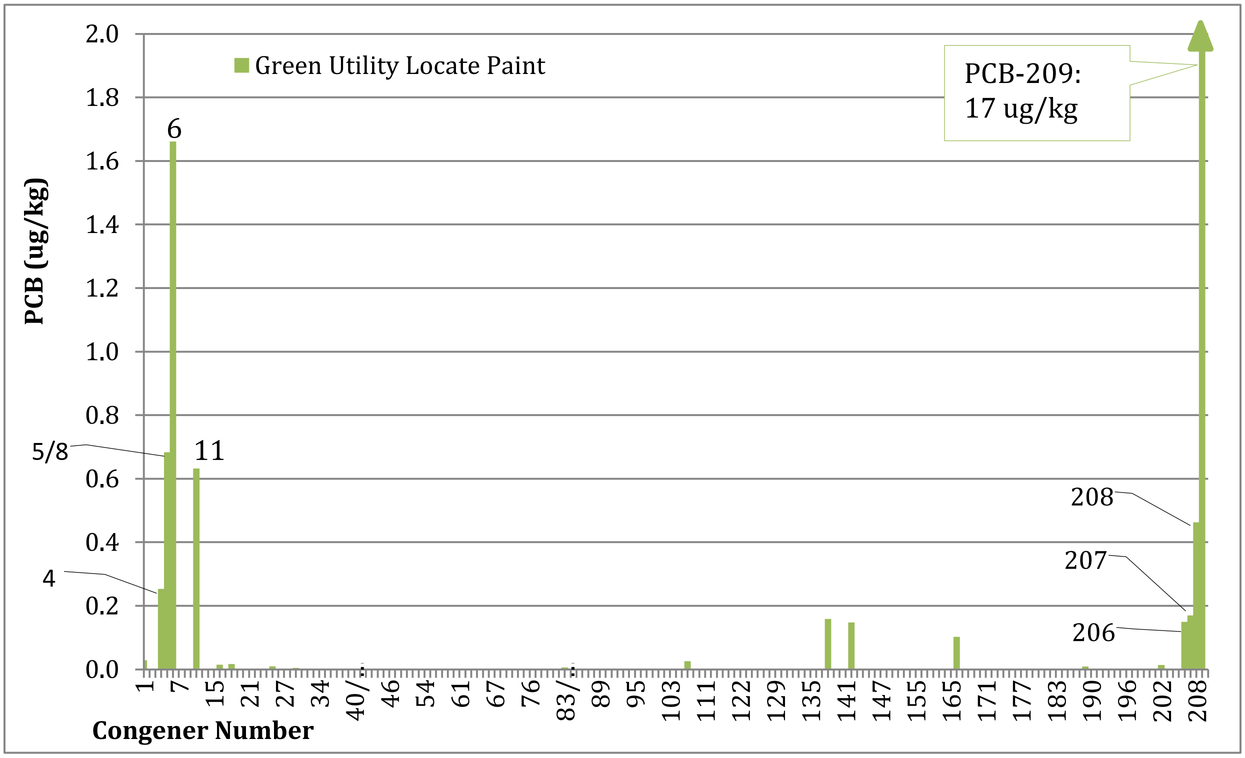


Figure 7. Green Utility Locate Paint Congeners

Deicer

The City of Spokane uses FreezeGard magnesium chloride for roadway deicing. Of the municipalities surveyed, most in eastern Washington use magnesium chloride while most in western Washington use calcium chloride. The Washington State Department of Transportation (WSDOT) Eastern Region uses an enhanced salt brine with sugar beet boost. Both the City of Spokane and WSDOT deicers were sampled. Total PCBs are shown in Table 5.

Table 5. Deicer Total PCB

Sample	Total PCB (ug/kg)
Magnesium Chloride	1.332
Magnesium Chloride Replicate	1.952
SB Boost	0.038

The magnesium chloride is sourced from naturally occurring minerals in the Great Salt Lake.

The magnesium chloride samples were dominated by tetraCBs, while the SB Boost sample congeners were distributed between the triCB to heptaCB range. Homologue patterns are shown in Figure 8 and congener patterns are shown in Figure 9.

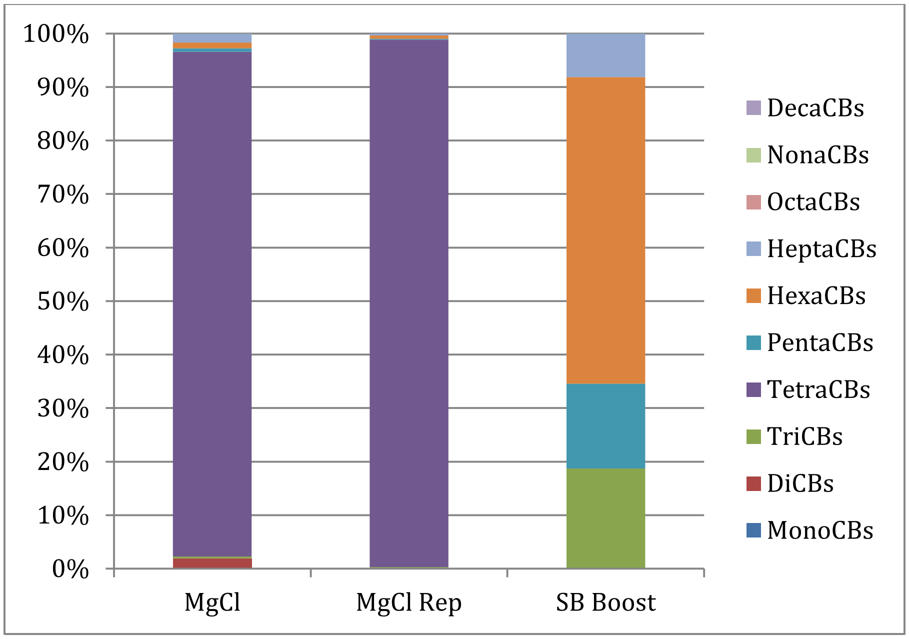


Figure 8. Deicer Homologue Patterns

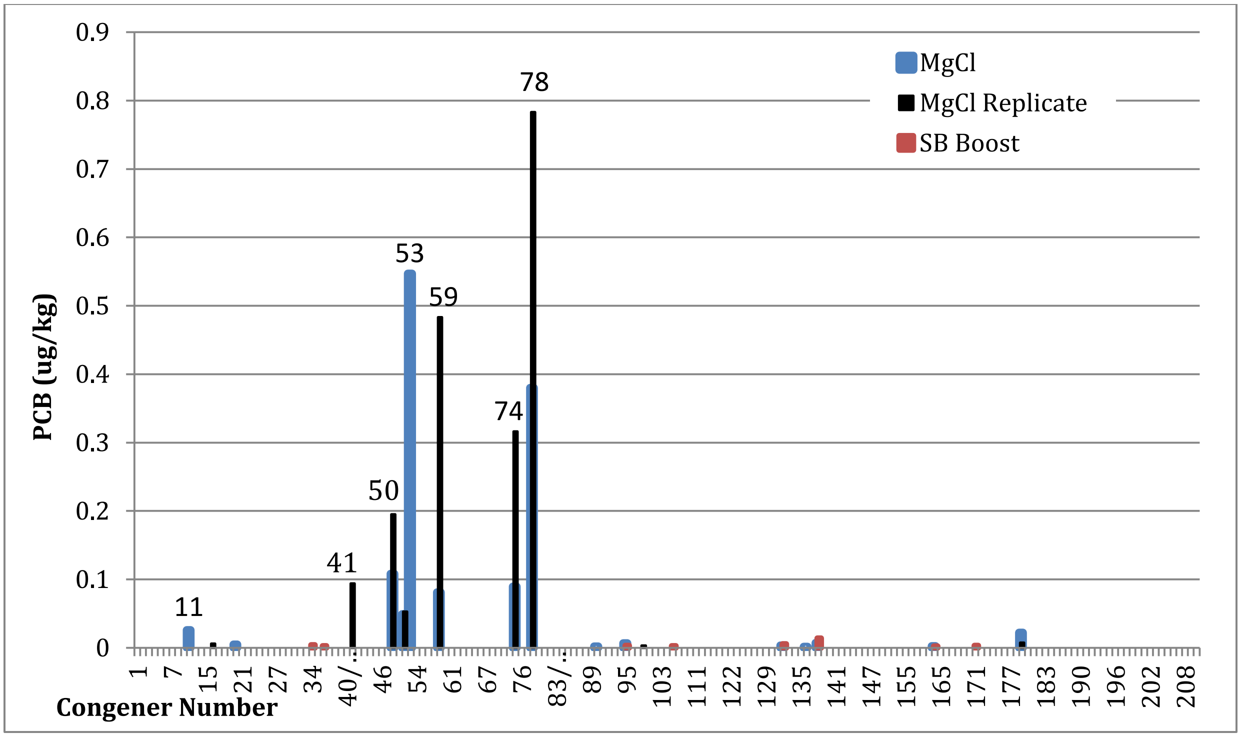


Figure 9. Deicer PCB Congeners

Antifreeze

Antifreeze mixtures may contain inadvertently generated PCBs, particularly those made with glycerol (also known as glycerin) synthesized from epichlorohydrine (Munoz, 2007). Kool Green Extended Life antifreeze was sampled, which contains a yellow color. The MSDS indicates that it contains ethylene glycol, diethylene glycol, and proprietary additives, inhibitors, and dye. The ethylene and diethylene glycols and glycerol have a similar chemical structure, but are not the same compound. Total PCB detected in the sample was **0.018 ug/kg**. Despite its yellow color, PCB-11 was not detected in the sample.

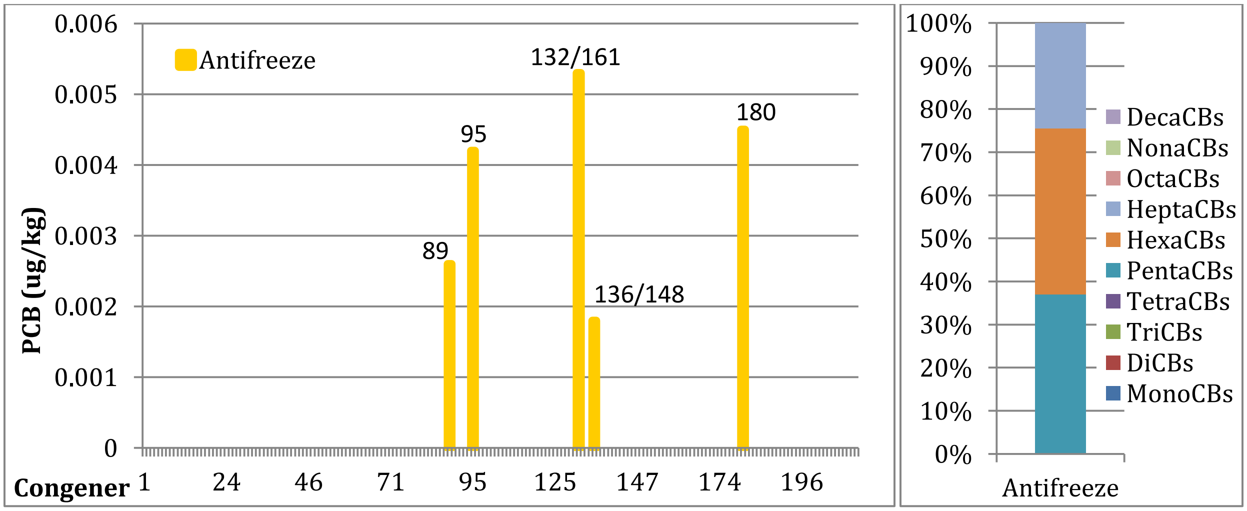


Figure 10. Antifreeze PCB Congeners and Homologue Patterns

Pesticides

Three types of pesticide and one adjuvant were sampled, including Weedar 64 (2,4-D formula), Portfolio 4F, Roundup Pro Max, and the adjuvant Crosshair. The chemical processes that make up chlorinated pesticides have been broadly determined by EPA to have a high potential for inadvertent PCB generation (Munoz, 2007).

PCBs were **non-detect** in the Weedar 64 sample and laboratory duplicate. None of the congeners were flagged for blank contamination. The main ingredients listed on the MSDS are 2,4-dichlorophenoxy acetic acid (2,4-D), dimethylamine salt, and trade secret inert ingredients. Interestingly, chemicals with similar structures to 2,4-D, including trichlorophenoxy acetic acid and dichlorophenyl acetic acid are listed as having the potential for inadvertent PCB generation, but 2,4-D is not (Munoz, 2007).

The total PCBs detected in the Portfolio 4F sample were **6.89 ug/kg**. The majority of this sample was composed of the coeluting congeners PCB-64 and 72. Sulfentrazone is the active ingredient in Portfolio 4F, making up about 40% of the product. Its chemical name is N-[2,4-dichloro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]phenyl]methanesulfonamide. Other ingredients include toluene and propylene glycol.

Total PCBs detected in the Roundup Pro Max sample were **0.012 ug/kg**. The active ingredient, making up about 49% of the product, is potassium salt of N-(phosphonomethyl) glycine (potassium salt of glyphosate). Glycine is listed as a chemical product having the potential to contain inadvertently generated PCBs (Munoz, 2007).

The sample of the adjuvant Crosshair contained **0.316 ug/kg** total PCBs. It is composed of methyl ester, modified soybean oil. Soybean oil can be modified through a number of different processes. One option is to synthesize it from epoxidised soybean oil using methylene chloride (Xu et al., 2011). If this process was used, it could possibly be the pathway for inadvertent PCB generation because chlorine is introduced in the process. Glycerine is also a byproduct of this process, which is also listed as a potential inadvertent PCB generating substance when a chlorinated compound is used (Munoz, 2007). Figure 11 shows the congeners detected in the pesticide and adjuvant samples.

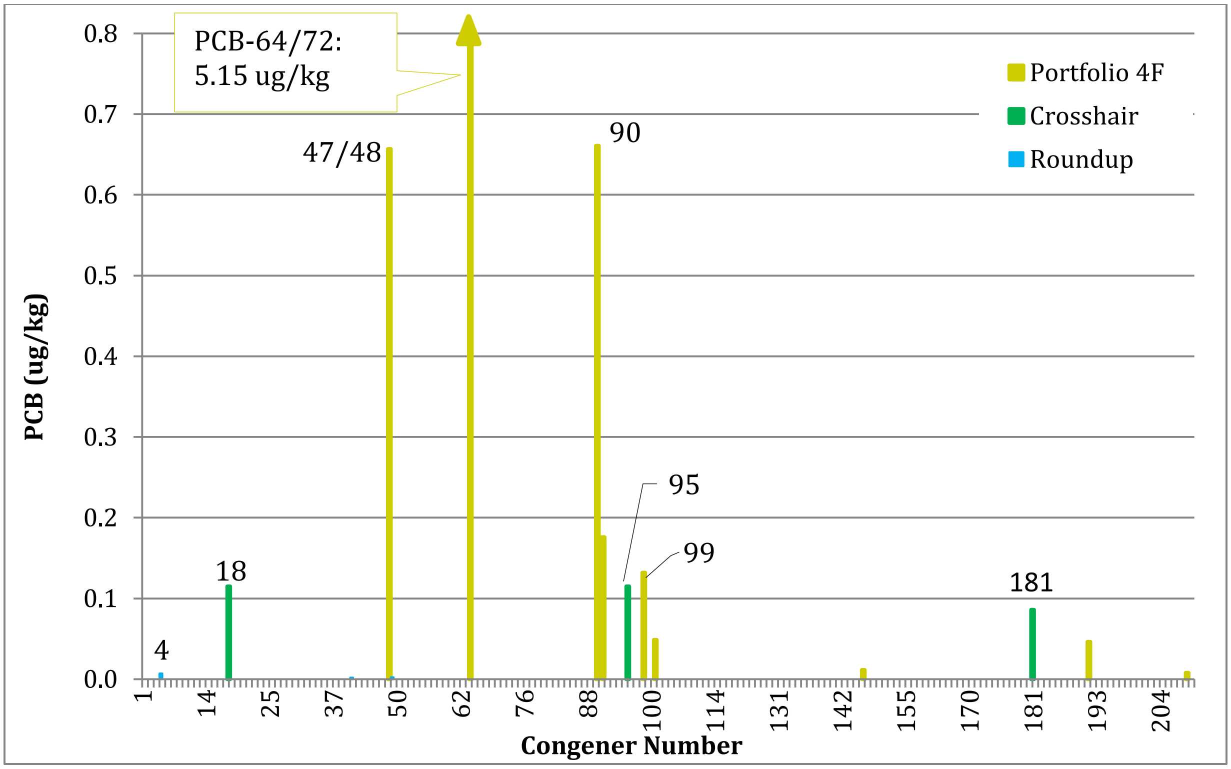


Figure 11. Pesticide and Adjuvant Congeners

Motor Oil and Lubricant

The Fleet Maintenance department primarily uses ConocoPhillips Firebird SAE 15W-40 Heavy Duty EC oil to maintain the City's vehicle fleets. This oil is made from greater than 50% re-refined base stocks. Because this same oil is used in many vehicles and serviced at the same shop, there was an opportunity to sample the same type of oil both before use and after an oil change for comparison. Additionally, Valvoline Full Synthetic SAE 5W-30 was sampled off-the-shelf from a local automotive store. This oil was sampled by the City in 2011 and contained the greatest concentration of PCBs of the oils sampled (see Table 2). A lubricant, MP Gear Lube SAE 85W-140 by Phillips 66 was also sampled. Total motor oil and lubricant PCB concentrations sampled in 2014 are shown in Table 6.

Table 6. Motor Oil and Lubricant Total PCBs

Sample	Total PCB (ug/kg)
Firebird 15-40 Bulk	0.856
Used Firebird 15-40 Bulk	0.502
Used Firebird 15-40 Bulk Replicate	2.375
Valvoline Full Synthetic 5-30	0.969
Gear Lube	0.623

There was a wide range of PCB congener distribution for the various oil and lubricant samples. Most of the congeners were in the low to mid chlorinated range. The used Firebird motor oil sample and its duplicate were not similar to each other in total PCB concentration or congener distribution as a result of its heterogeneity.

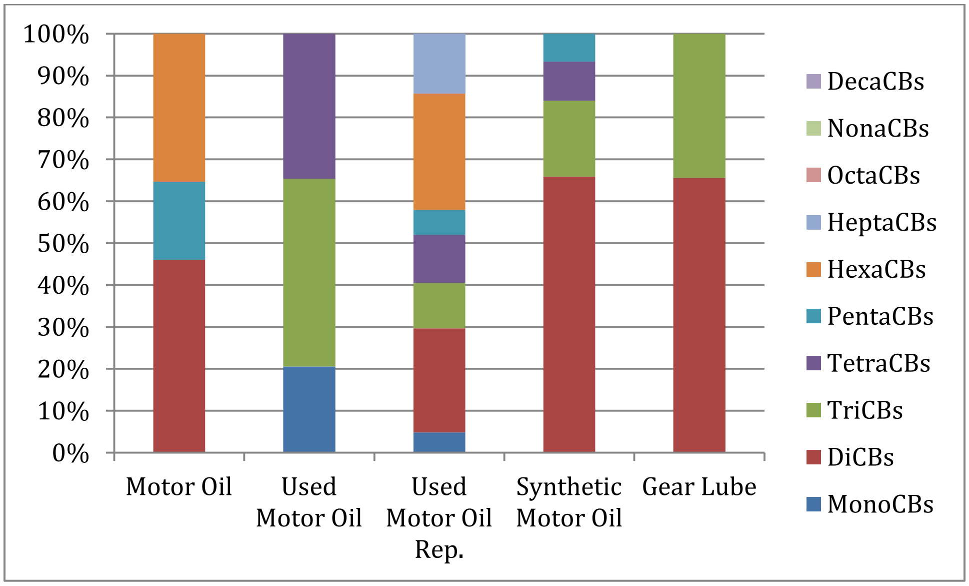


Figure 12. Motor Oil and Lubricant PCB Homologue Patterns

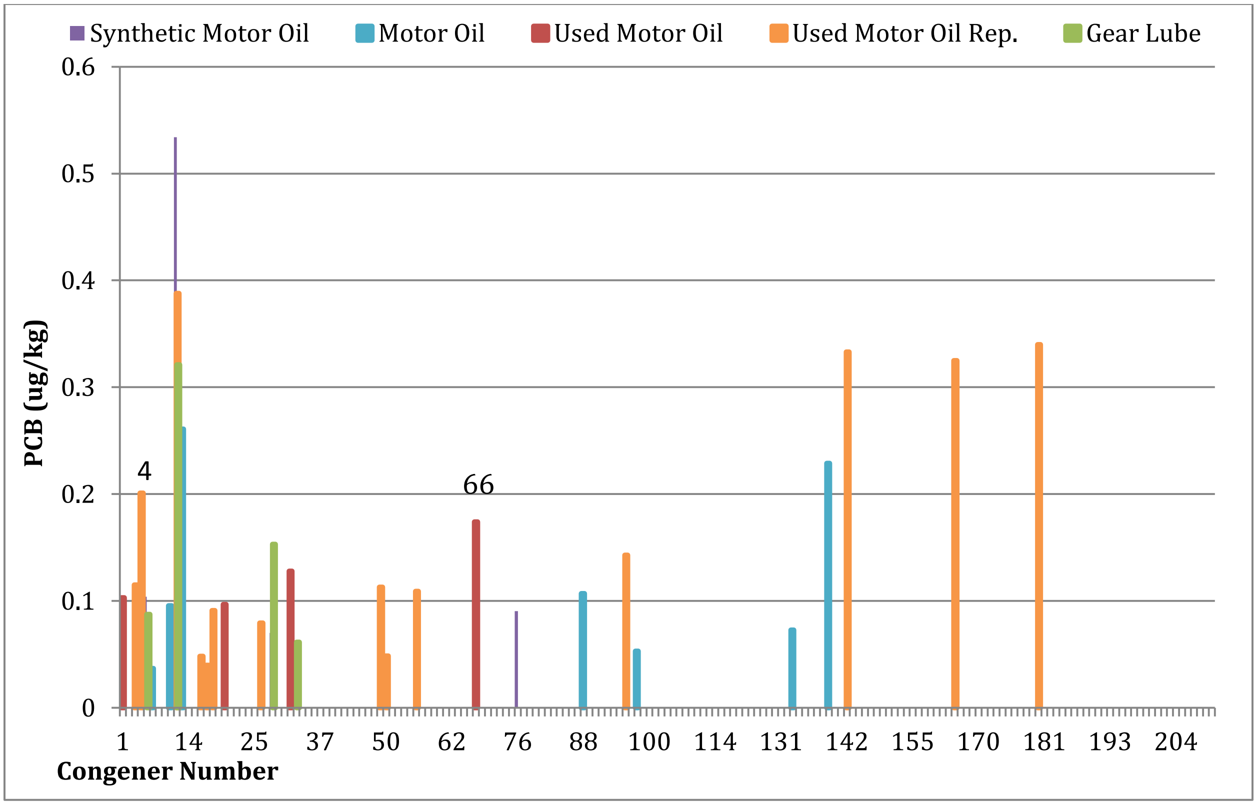


Figure 13. Motor Oil and Lubricant PCB Congeners

Gasoline and Diesel

Regular unleaded gasoline and #2 dyed diesel were sampled from the fuel tanks at the City's Riverside Park Water Reclamation Facility. The diesel sample was non-detect. During laboratory analysis, coextracting interferences resulted in the detection limits being raised to 2 ug/kg for each of the monoCB, diCB, and triCB congeners. Therefore, PCBs may still be present in diesel at less than 2 ug/kg per congener, but were unable to be detected due to interferences.

The total PCBs for the gasoline sample was **0.935 ug/kg**. Nearly all of the sample was composed of PCB-2 (0.93 ug/kg). The remainder was the coeluting congeners PCB-138 and 160.

Dust Suppressant

The City of Spokane has some unimproved roads that have not been paved and require dust control. Three forms of dust control approved for use in the City are magnesium chloride (at a different concentration than the deicer), emulsified asphalt dust abatement (EADA), and lignosulfonate. Samples were collected from each of these three dust suppressants.

The magnesium chloride dust suppressant brand is DustGard, made from naturally occurring minerals from the Great Salt Lake. EADA is a petroleum-based product, containing primarily petroleum asphalt and petroleum bitumen with water and a proprietary mix of petroleum distillates, polymer modifier, surfactants, emulsifier, and other additives. Ligno Road Binder lignosulfonate is derived from natural polymers in wood, and contains sucrose, plant fiber, and an aquatic solution according to its MSDS.

Table 7. Dust Suppressant Total PCBs

Sample	Total PCB (ug/kg)
EADA	0.091
Lignosulfonate	0.086
Magnesium Chloride	3.574

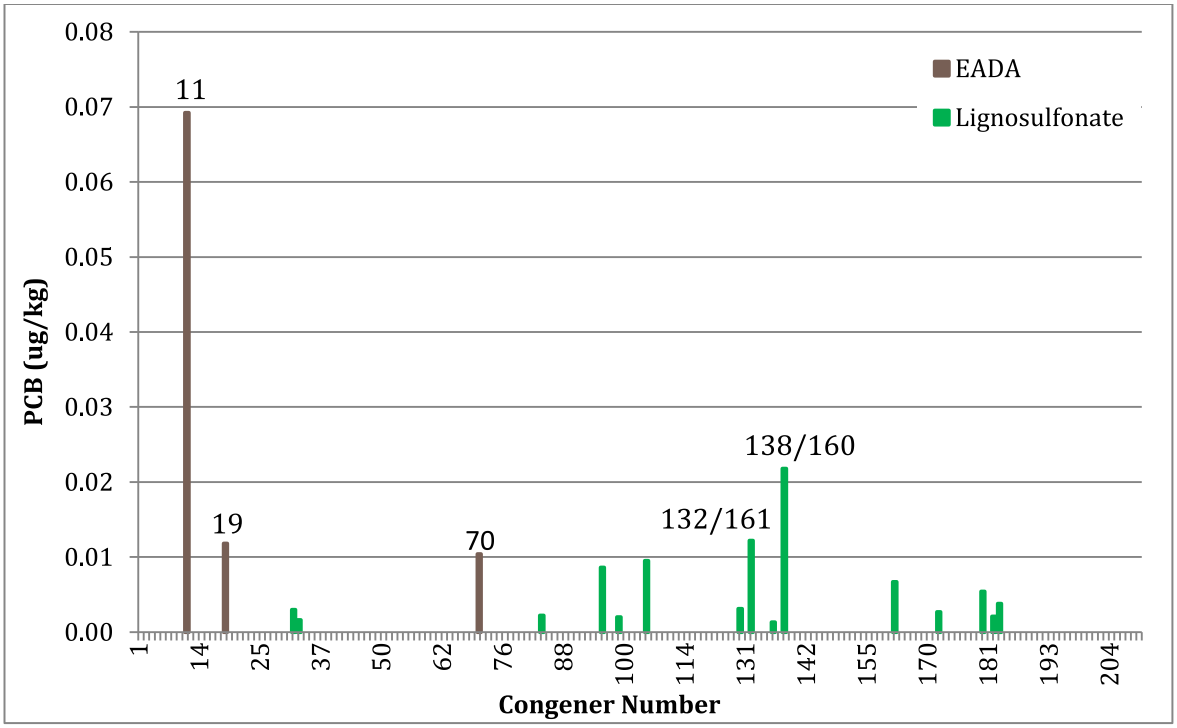


Figure 14. EADA and Lignosulfonate Congeners

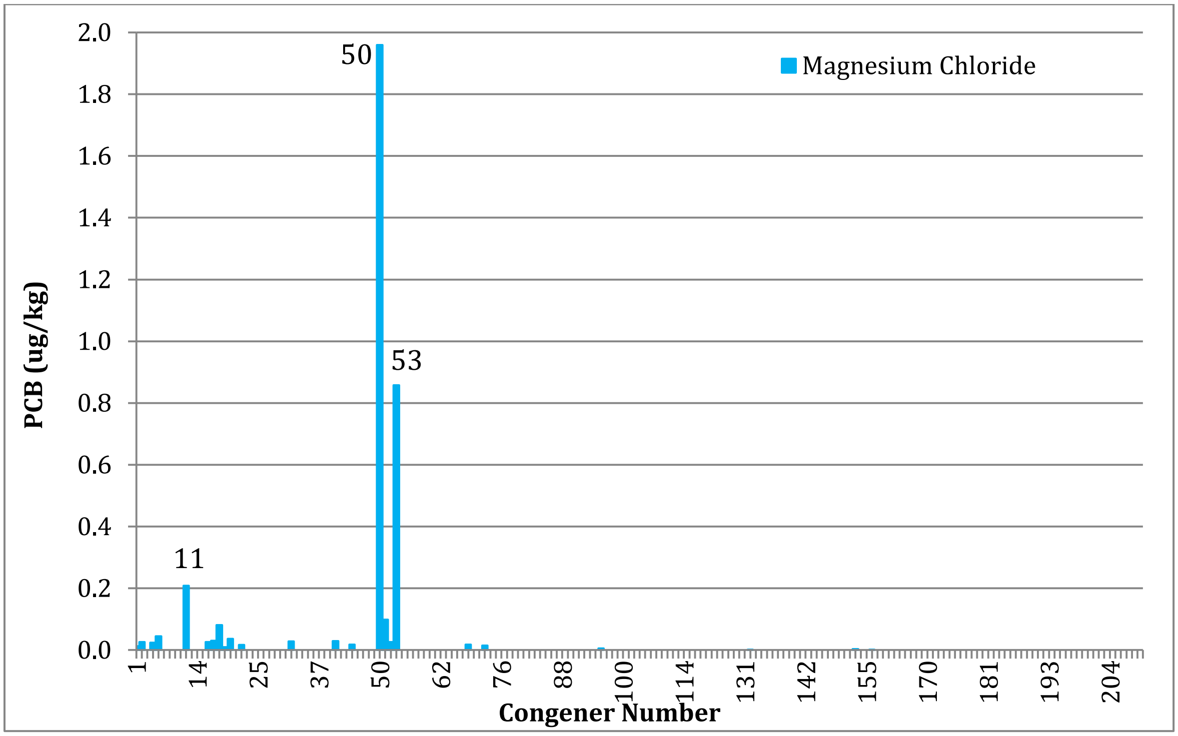


Figure 15. DustGard Magnesium Chloride Congeners

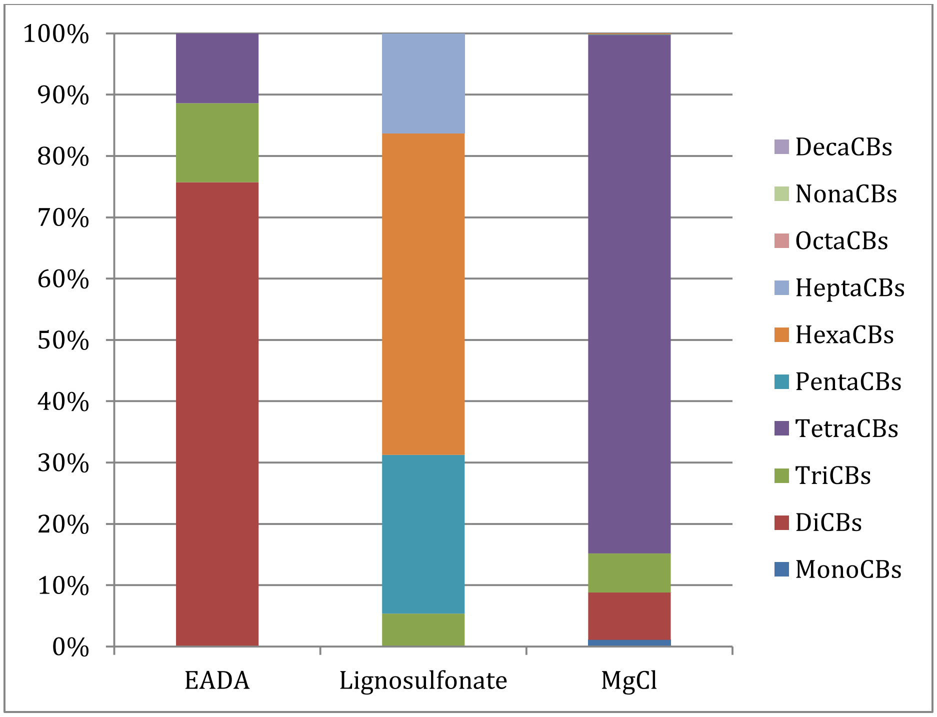


Figure 16. Dust Suppressant Homologue Patterns

The homololgue pattern for EADA is similar to synthetic oil (Figure 12), dominated by diCBs with lesser percentages of triCBs and tetraCBs. Lignosulfonate has a somewhat similar homologue pattern to Aroclor 1260, but the individual congener patterns don't match up well (see Appendix A).

Asphalt Related Products

The asphalt products that were sampled include asphalt tack, crack sealer, and an asphalt release agent. Asphalt tack is made of an asphalt emulsion, and is placed between old and new asphalt layers to adhere them to one another. The crack sealer, SA Premier, is made of asphalt, vacuum distillate, petroleum distillate, styrene-butadiene block copolymer, vulcanized rubber compound, mineral filler, methyl methacrylate, and linear low density polyethylene. The asphalt release agent brand is Soy What by TechniChem, and is "crafted from a by-product that is extracted from soybeans," according to the technichemcorp.com website. Total PCBs and congener and homologue patterns are shown in the following table and figures.

Table 8. Asphalt Related Product Total PCBs

Sample	Total PCB (ug/kg)
Asphalt Tack	0.085
Crack Sealer	7.975
Asphalt Release Agent	0.558

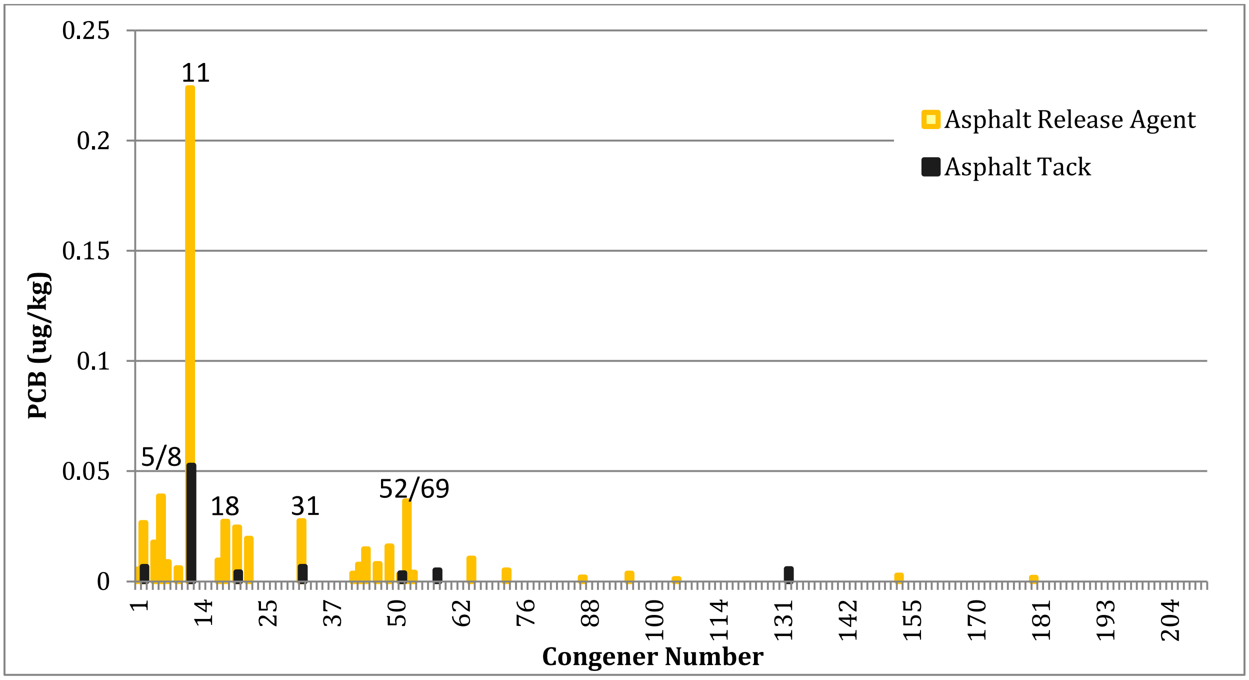


Figure 17. Asphalt Release Agent and Tack Congener Patterns

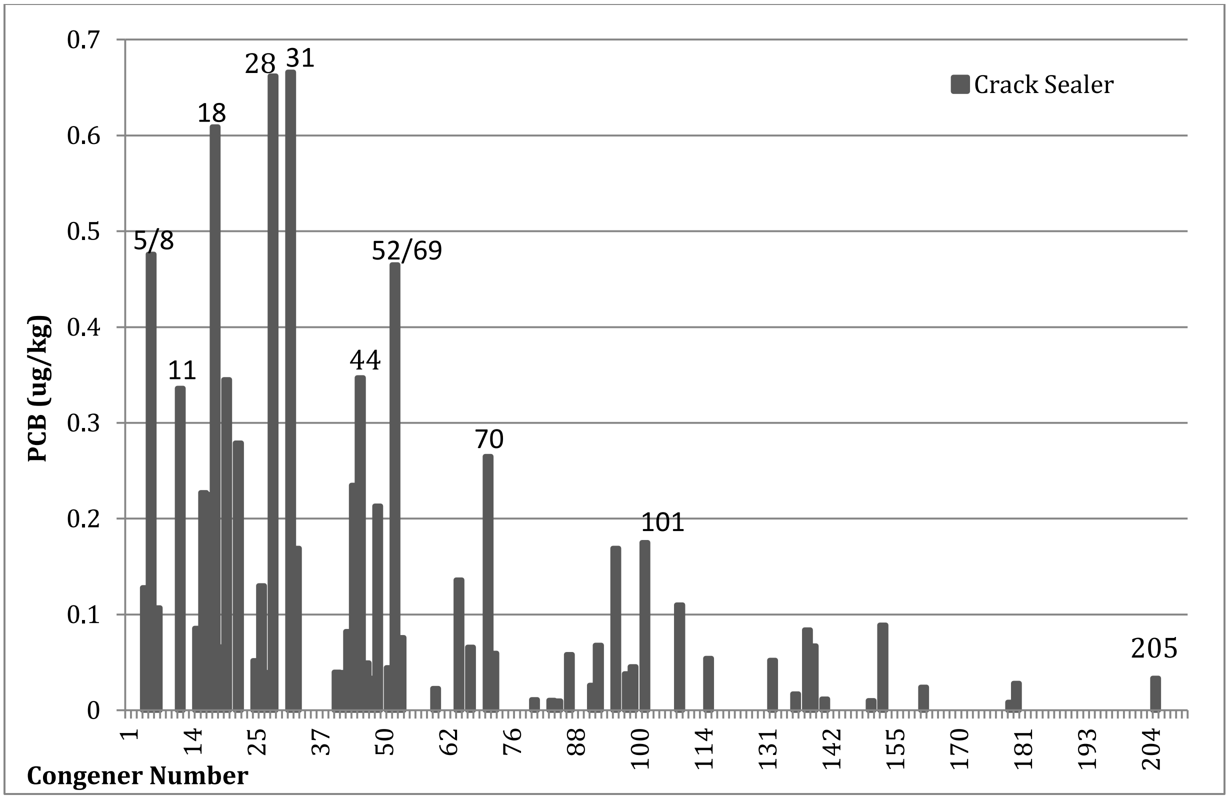


Figure 18. Crack Sealer Congener Pattern

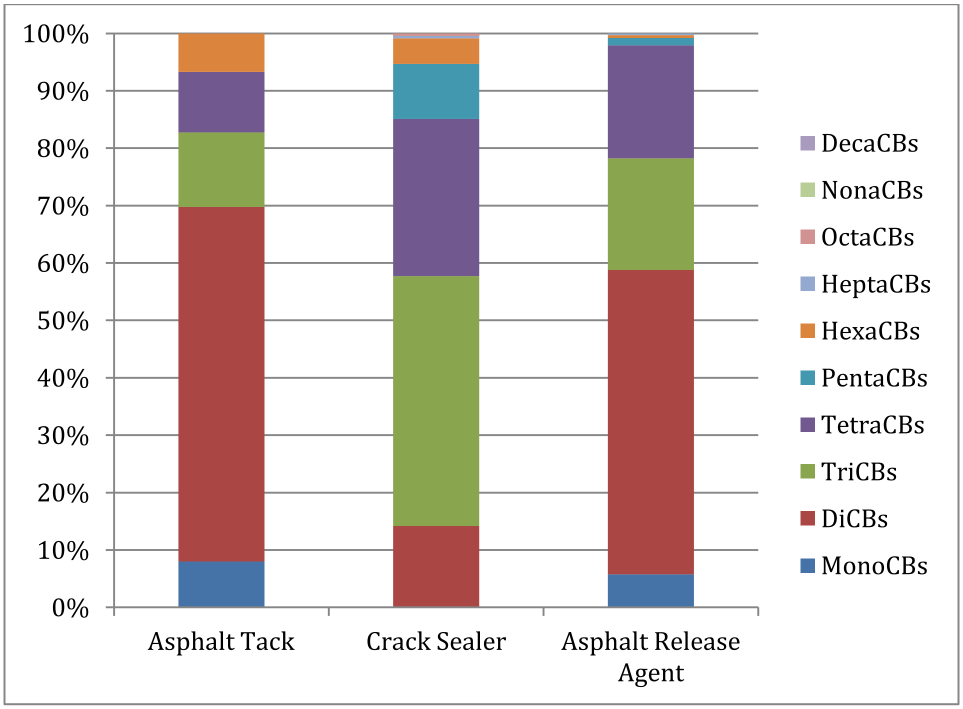


Figure 19. Asphalt Product Homologue Patterns

The crack sealer has a similar congener and homologue pattern to Aroclor 1242. The congeners from the crack sealer sample were converted to percent of total PCB by weight and are plotted against Aroclor 1242 in the same units in Figure 20. Aroclor 1242 had a wide variety of end uses, one of them being in rubbers. One of the ingredients in the crack sealer is vulcanized rubber compound. PCB-11 was detected at over 4% of the crack sealer PCB composition, but is not present in most Aroclor mixes.

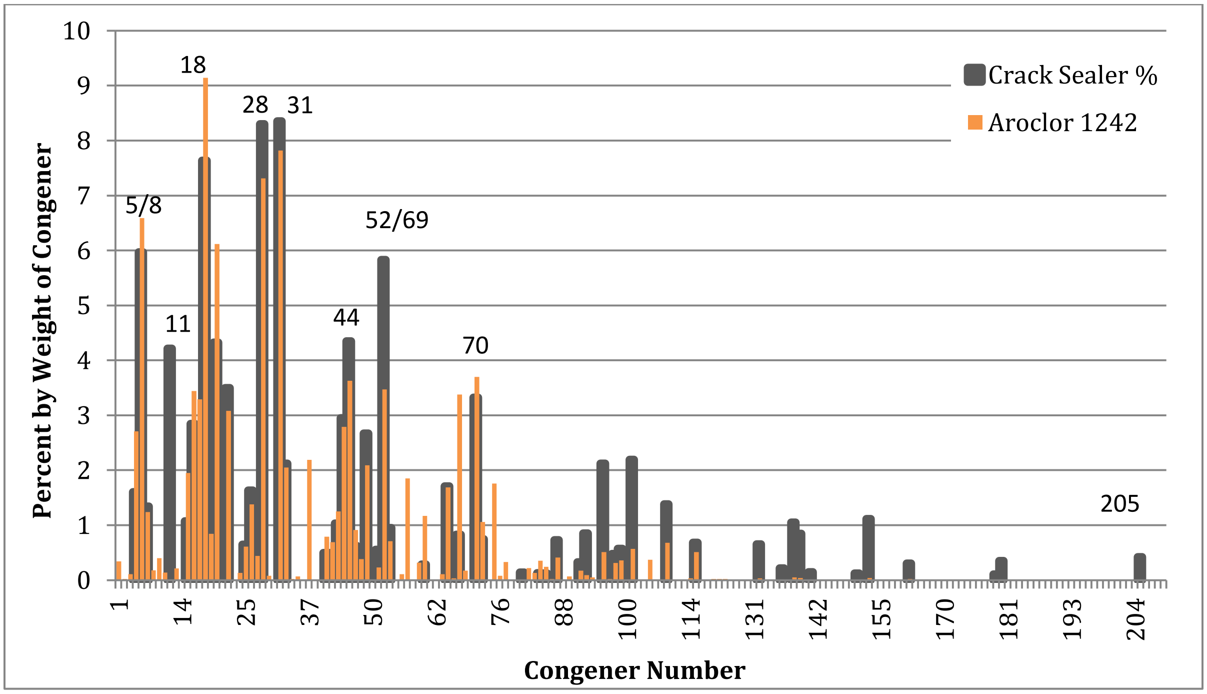


Figure 20. Crack Sealer and Aroclor 1242 Congener Distributions

Hydroseed

A hydroseed mix was sampled due to the prevalent use of hydroseed in roadside projects and its typical green coloring. The sample was collected from a new 50 pound bag of Nature's Own Hydromulch, which was not yet mixed with seed, fertilizer, or other additive. The Nature's Own Hydromulch MSDS indicates that it is composed of primarily wood fiber material with green liquid and a surfactant. The sample contained shredded colored newspaper cellulose. Total PCBs detected in the sample was **2,509 ug/kg**. The following figures show the congeners detected and homologue patterns for the sample.

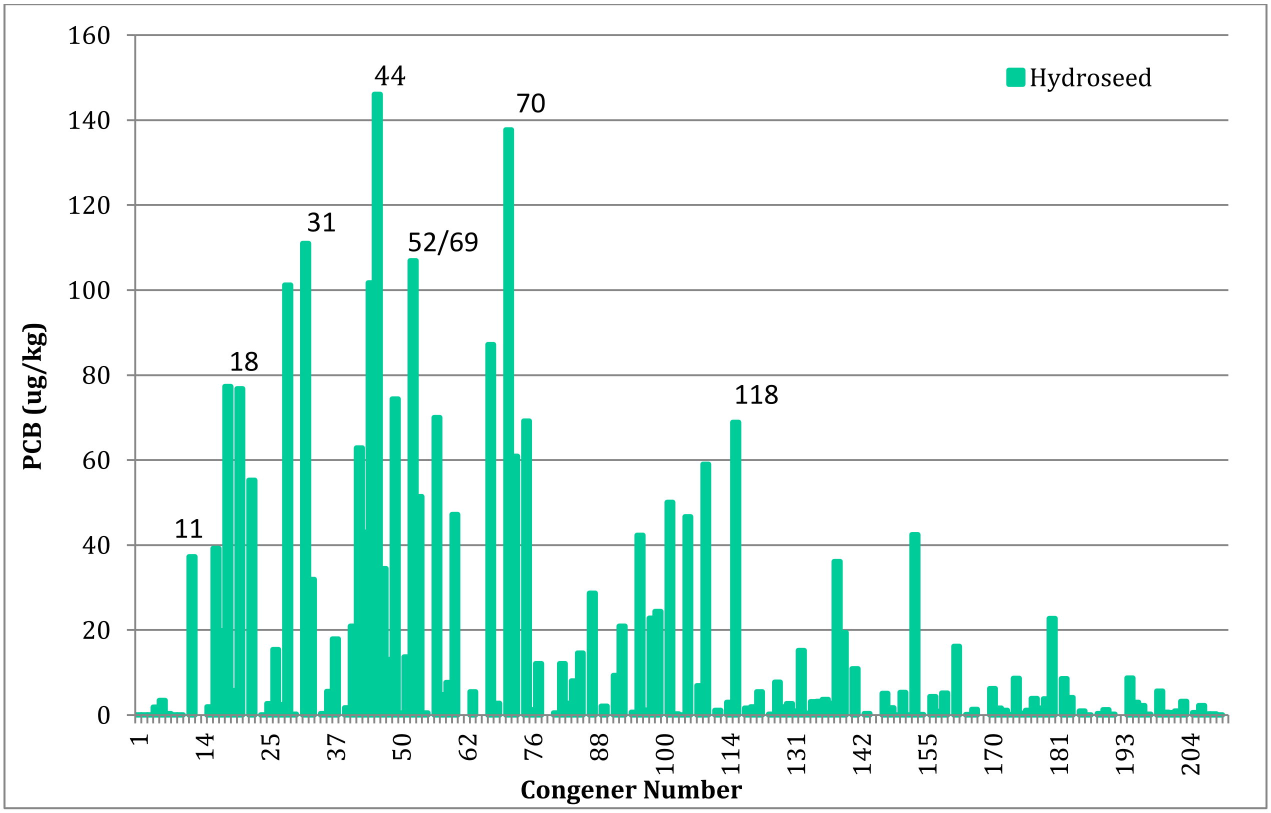


Figure 21. Hydroseed Congeners

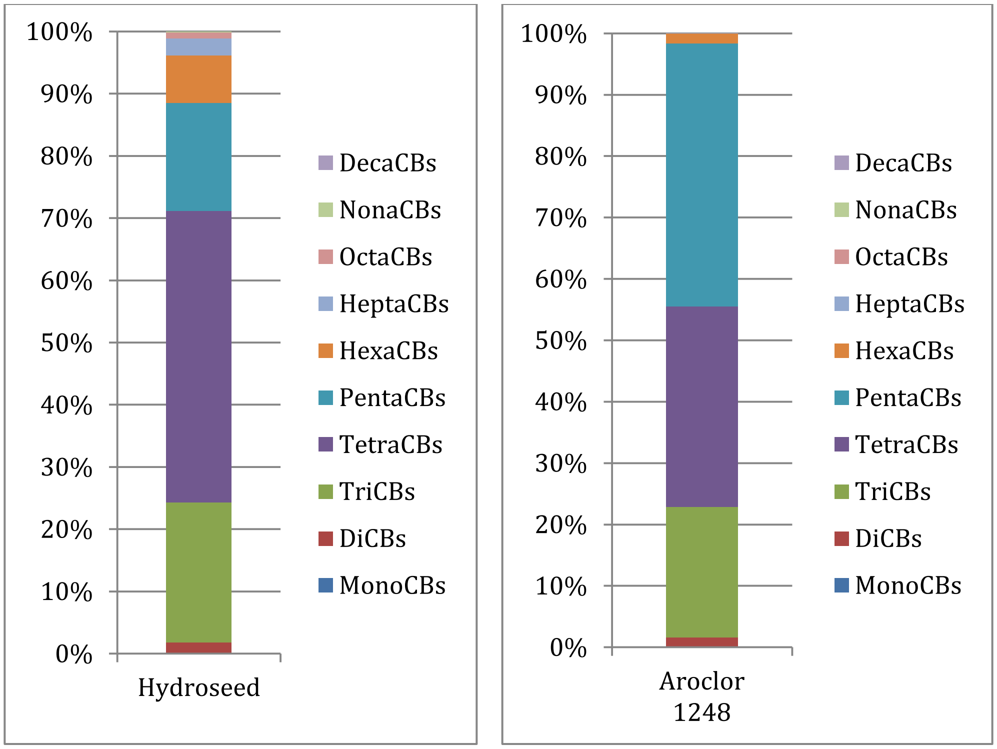


Figure 22. Hydroseed and Aroclor 1248 Homologue Patterns

In an unrelated incident, a landscape contractor received a penalty from the State of Iowa for illegally discharging a hydroseed mixture on the bank of a creek (Scriven-Young, 2010). The hydroseed contained 320 parts per billion of Aroclor 1248 as well as the pesticides DDT and DDE. Interestingly, the sample collected by the City of Spokane has a homologue pattern very similar to that of Aroclor 1248.

The hydroseed congeners from the City's sample were converted to percent of total PCB by weight and are plotted against Aroclor 1248 in the same units in Figure 23 below. The two congener patterns are quite similar. Note that PCB-11 is present in the hydroseed, but not the Aroclor. This indicates a secondary source of PCBs from pigment that is relatively minor compared to the Aroclor.

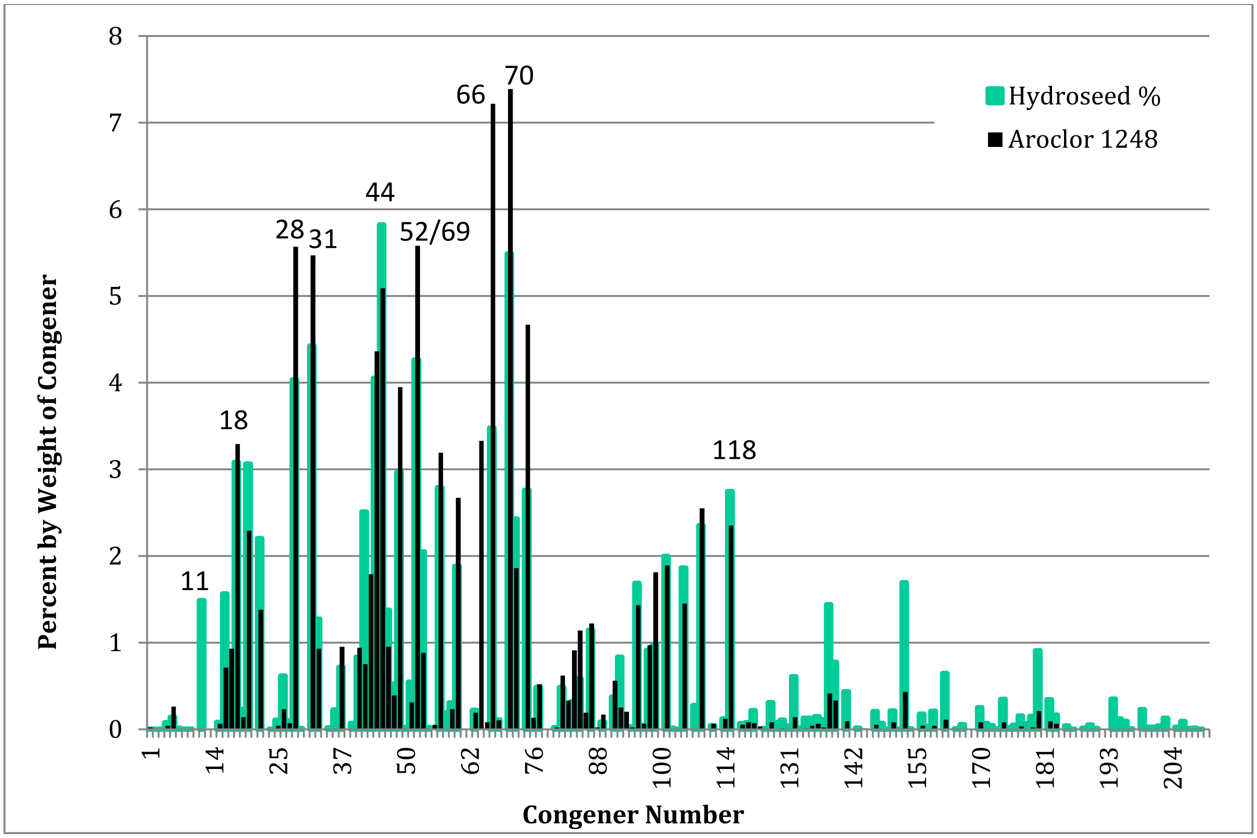


Figure 23. Hydroseed and Aroclor 1248 Congener Distributions

Pipe Material

There are hundreds of miles of PVC pipe used in the City's sanitary and storm sewer systems. Dischargers in the Spokane region have been collecting sanitary and stormwater samples for ultra low-detection PCB analysis, and many of these samples have traveled through miles of PVC pipe prior to collection. In an effort to screen the potential for PCB contribution from pipe material, PVC pipe, cast in place pipe (CIPP) liner and shortliner pipe repair materials were sampled.

The type of PVC sampled was ASTM 3034 collected from a new, unused eight-inch diameter pipe. CIPP is constructed from a felt tube saturated with resin and coated with polyurethane, and is cured inside an existing pipe. The section of CIPP liner sent in for analysis was originally collected from a construction project in northeast Spokane in April, 2013. It was kept in an office environment and not exposed to the elements after that time. Shortliner pipe repair is constructed in the same way, and made of a polyester-fiberglass liner impregnated with thermosetting epoxy resin. A test section of shortliner was cured in a new pipe on the ground surface at the City's Sewer Maintenance Department in October, 2014 for use in this sampling study.

Pieces of pipe were sent to the laboratory for analysis to help determine the PCB content in the material itself. The potential for PCBs to leach from the pipe material to stormwater and sanitary sewage is outside the scope of this project, but future analysis is warranted based on the results shown in Table 9.

Table 9. Pipe and Pipe Repair Material Total PCBs

Material	Total PCB (ug/kg)
PVC (ASTM 3034) Pipe	1.999
CIPP Liner	1.110
Shortliner	17.780

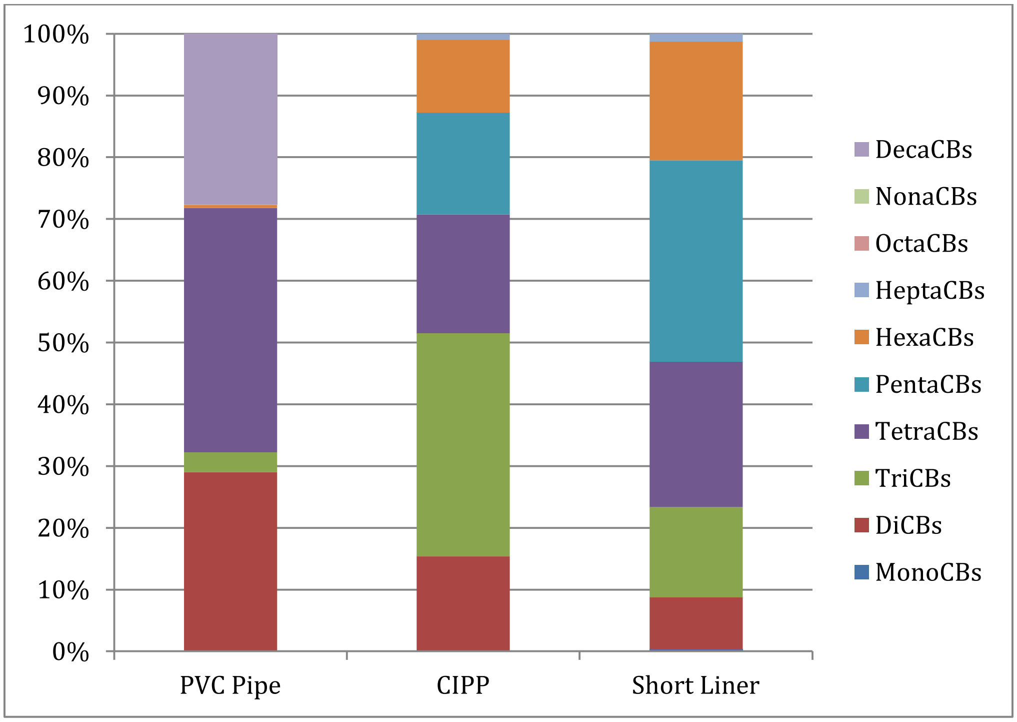


Figure 24. Pipe Material Homologue Patterns

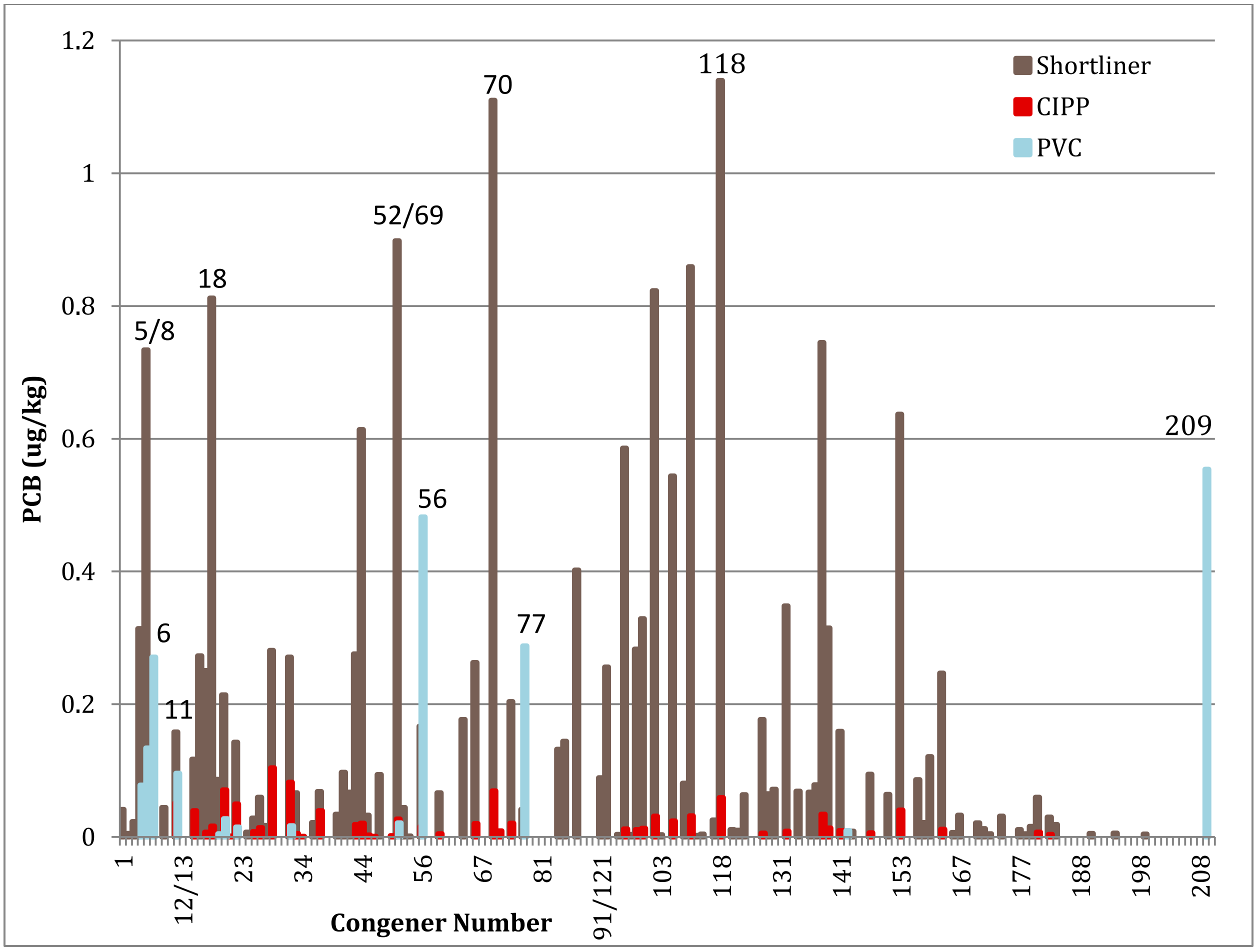


Figure 25. Pipe Material PCB Congeners

Figure 25 shows congener patterns for the sampled pipe materials. Congener distributions (percent of total PCB) for the pipe materials were then compared to congener patterns for Aroclors. The PVC and CIPP samples did not appear to correlate with Aroclor patterns. The Shortliner sample appears to correlate somewhat with a combination of two or more Aroclors. Specifically, a combination of both Aroclors 1242 and 1248 matches the shortliner sample the most closely (Figure 26).

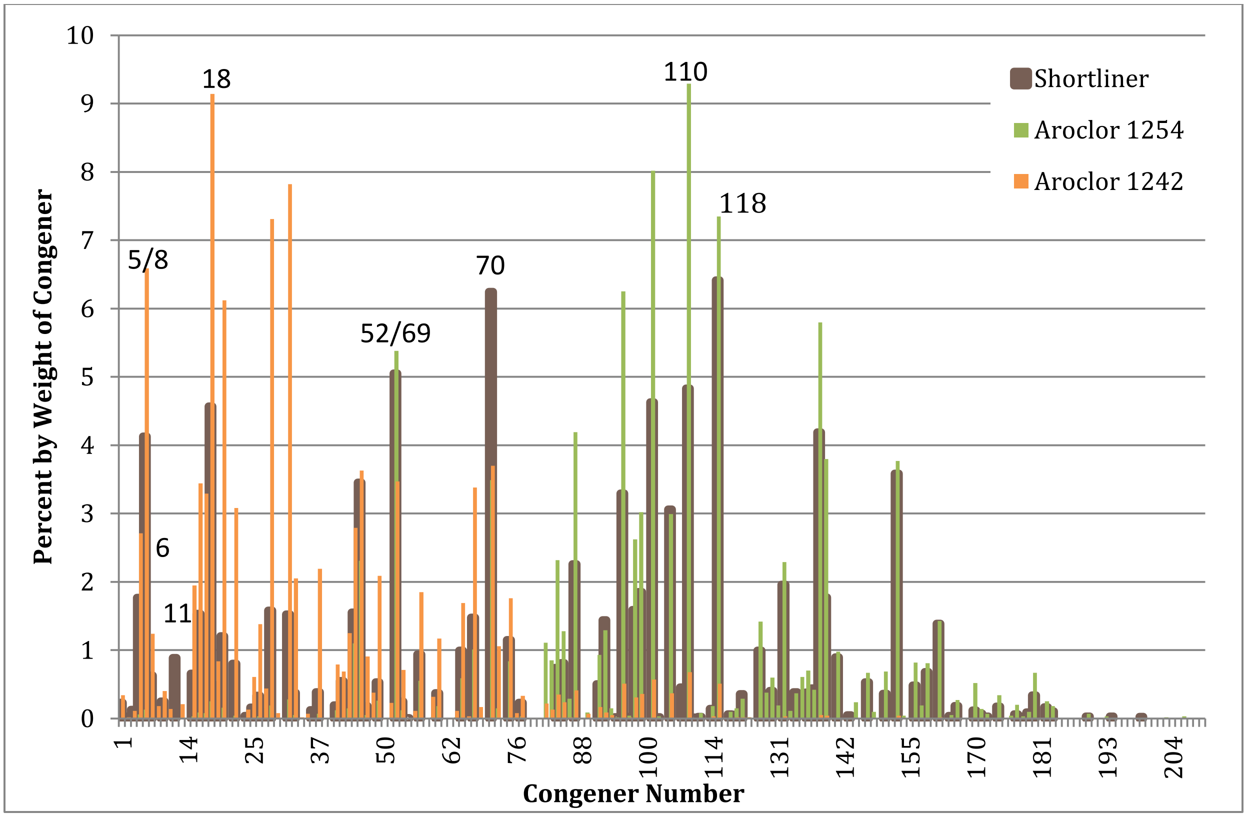


Figure 26. Shortliner Congener Distribution Compared to Aroclors 1242 and 1254

Firefighting Foam

Discharges from emergency firefighting activities are an exempt activity under the Phase II Eastern Washington Municipal Stormwater Permit. However, these discharges can easily enter a storm sewer system without proper containment and contribute contaminants to the environment. Alcoseal 3-3 Class B firefighting foam was sampled. Ingredients listed on the MSDS sheet include hydrolyzed protein, fluorosurfactants, 1,2 benzoisothiazelin, and hexylene glycol. The total PCB concentration was **0.029 ug/kg**. The associated congener and homologue patterns are shown in Figure 27.

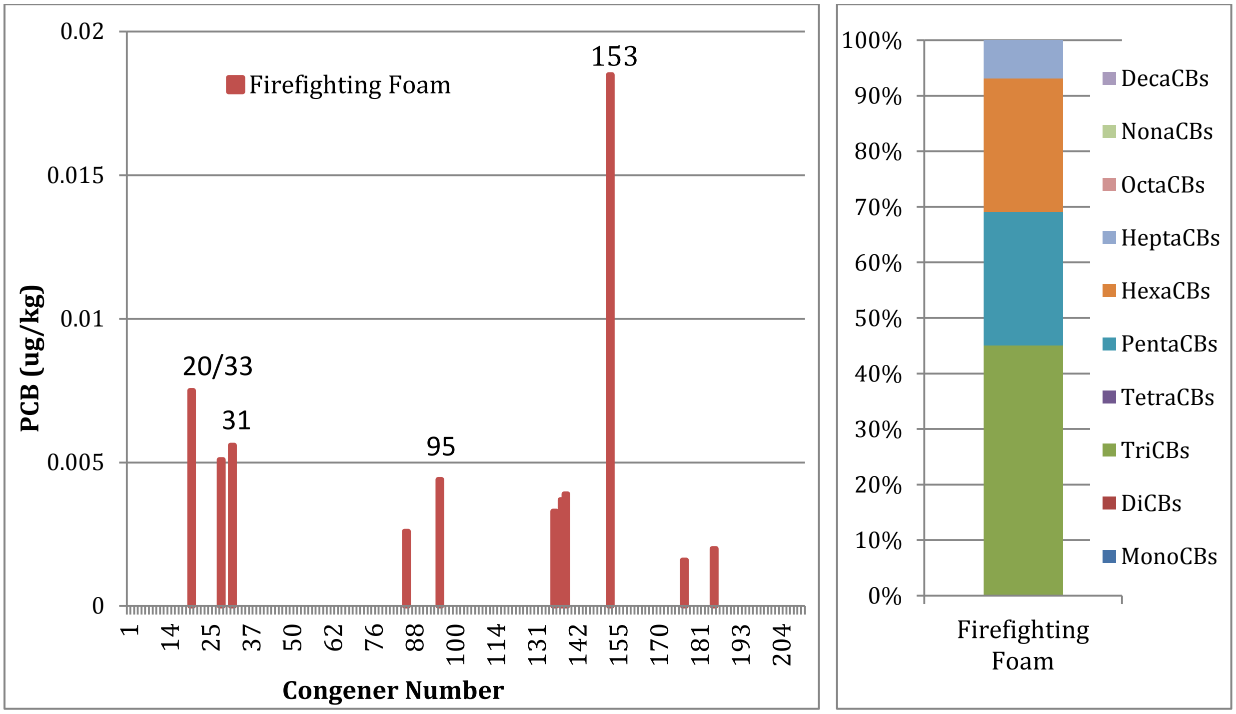


Figure 27. Firefighting Foam PCB Congeners and Homologue Pattern

Cleaners and Degreasers

Inadvertent PCB generation is possible with the manufacture of soaps, detergents, surfactants, and degreasers (Munoz, 2007). A detergent made by Hotsy was sampled as well as Simple Green degreaser.

The Hotsy Super XL detergent contained **0.003 ug/kg** total PCBs. A laboratory duplicate was analyzed, containing 0.068 ug/kg total PCBs. This product contains trisodium phosphates, alkaline builders, and surfactants. Congener distributions from the primary sample are shown in the figure below, containing only PCB-36.

The Simple Green degreaser contained **0.068 ug/kg** total PCBs, with nearly half of this total from PCB-11. The ingredients consist of primarily water with 2-butoxyethanol, ethoxylated alcohol, tetrapotassium pyrophosphate, sodium citrate, and a proprietary mix of fragrance and polymeric colorant.

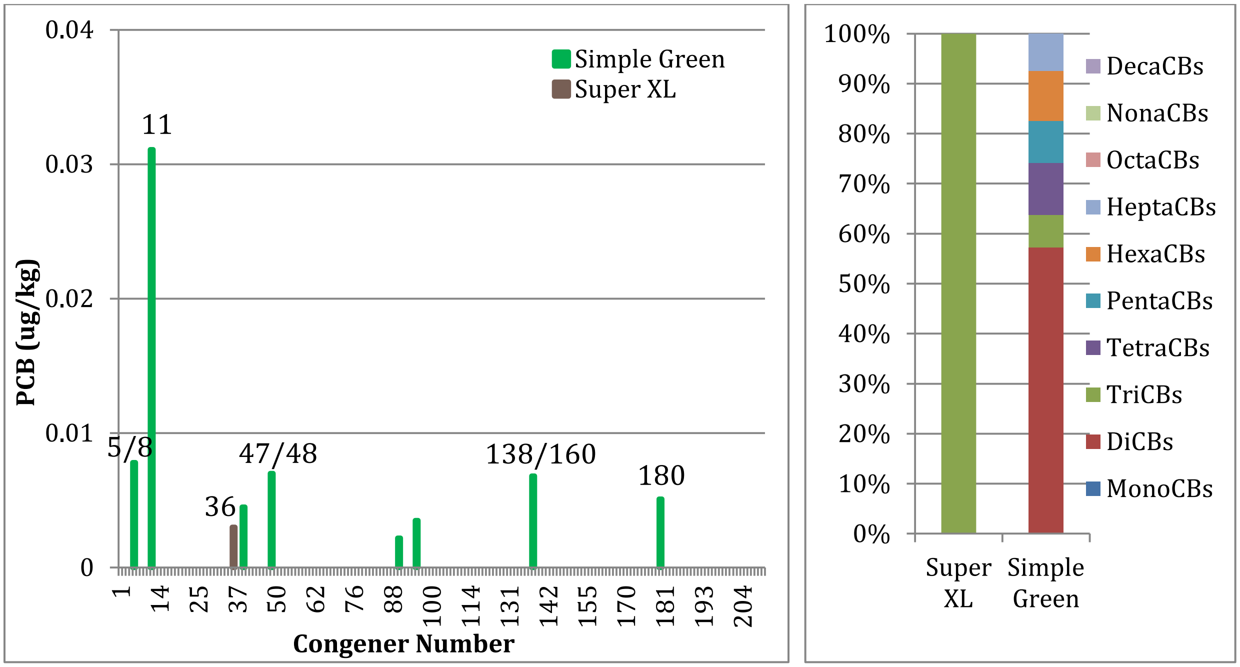


Figure 28. Simple Green and Super XL PCB Congeners and Homologue Pattern

Personal Care Products

Sampling in the storm and sanitary sewer systems over the past several years has indicated that total PCB concentrations in the sanitary sewer collection system are slightly greater than average concentrations in stormwater. So, in addition to products that can contribute PCBs to stormwater, five personal care products that may contribute PCBs to the sanitary sewer collection system were sampled. The products sampled were liquid and contained pigments. Table 10 shows the product brands sampled, total PCBs, pigments listed in the ingredients, and the so-noted 'ingredients of interest.' Many of these products have a long list of ingredients. Those ingredients that are chlorinated, contain benzene rings, or are suspected to be associated with inadvertent PCB production based on the literature search are included in Table 10 as ingredients of interest.

Table 10. Personal Care Products

Brand	Total PCB (ug/kg)	Ingredients of Interest	Pigments
Dial Antibacterial hand soap (pomegranate and tangerine)	0.037	Triclosan, tetrasodium EDTA, sodium chloride, polyquaternium-7	Yellow 6, Red 33, Red 40

Brand	Total PCB (ug/kg)	Ingredients of Interest	Pigments
Tide Original laundry detergent	0.174	Ethanolamine, Benzene sulfonic acid (sodium salt and monoethanolamine salt), disodium diaminostilbene disulfonate, dimethicone (type of silicone)	Liquitint® Blue HP (Polymeric colorant)
Dawn Ultra antibacterial dish soap	0.083	Chloroxylenol, sodium chloride	Yellow 5, Blue 1
Suave Naturals shampoo	0.058	Tetrasodium EDTA, ammonium chloride, methylchloroisothiazolinone	Blue 1, Red 33
Aquafresh Extreme Clean Whitening toothpaste	0.032	Glycerin, titanium dioxide, sodium saccharin	Red 30

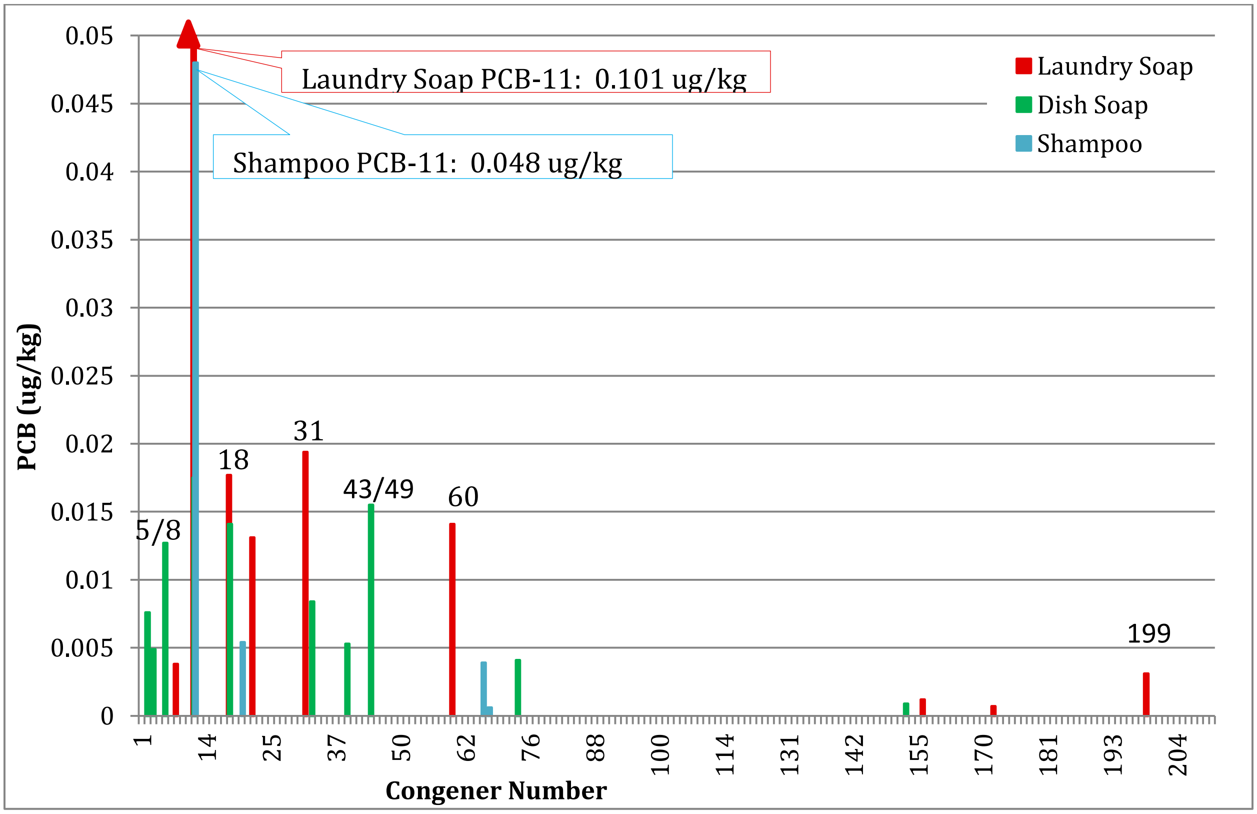


Figure 29. Laundry Soap, Dish Soap, and Shampoo Congeners

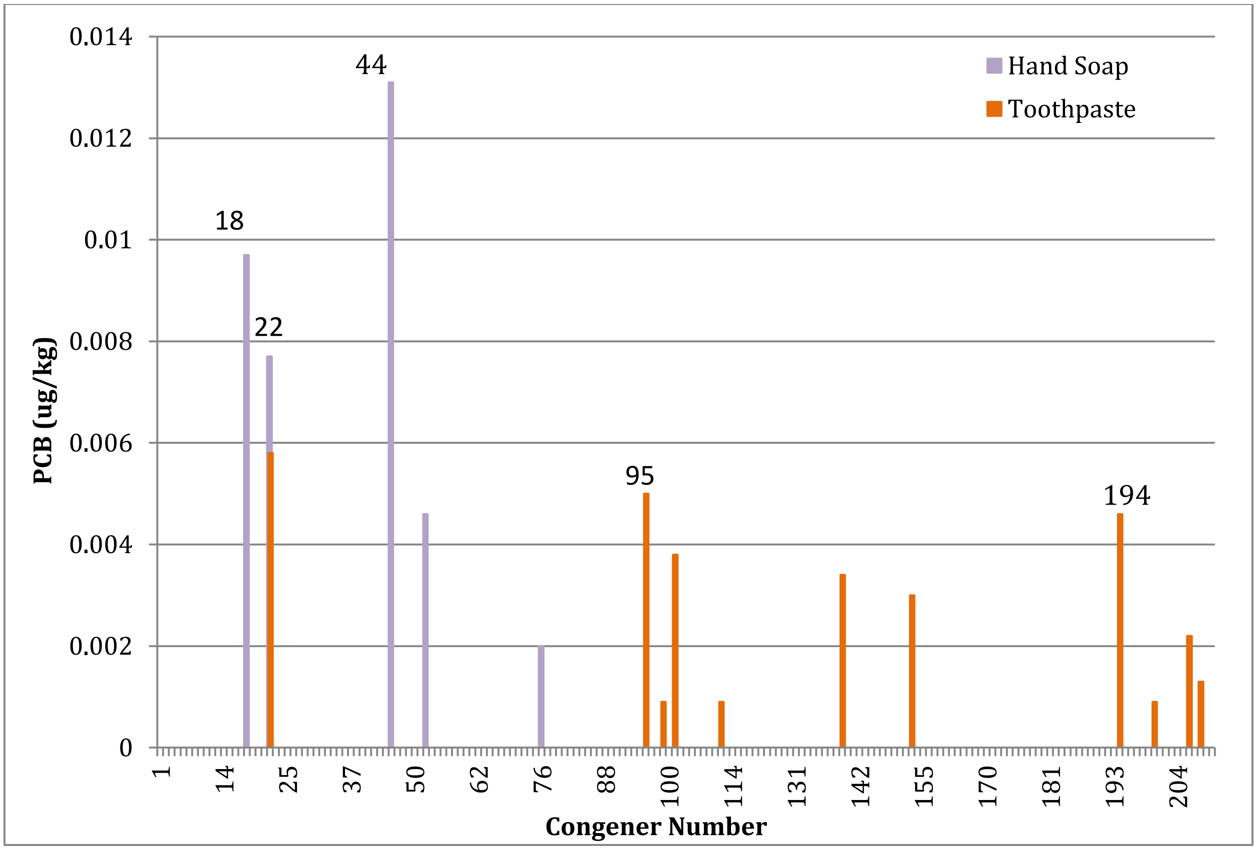


Figure 30. Hand Soap and Toothpaste Congeners

Figure 31. Personal Care Product Homologue Patterns

CONCLUSIONS

PCBs were detected in 39 of the 41 product samples, with a wide range of congener patterns. Figure 32 shows the frequency of detection of each congener in this study. The congeners most frequently detected are the coeluting congeners PCB-52/69 (detected in 30 of the samples) followed by PCB-11 and PCB-28 (detected in 25 of the samples). PCB-52 is one of the most abundant congeners found in the environment, and is found in Aroclor mixtures from 0.1% to 5.6% of the mixture by weight (Frame et. al, 1996). PCB-28 is also commonly found in Aroclor mixtures at up to 8.5% of the total mixture by weight (Frame et. al, 1996). Because PCB-11 was one of the most frequently detected congeners, and it is generally not found in Aroclor mixes, pigments are likely a common source of inadvertently produced PCBs in the products sampled.

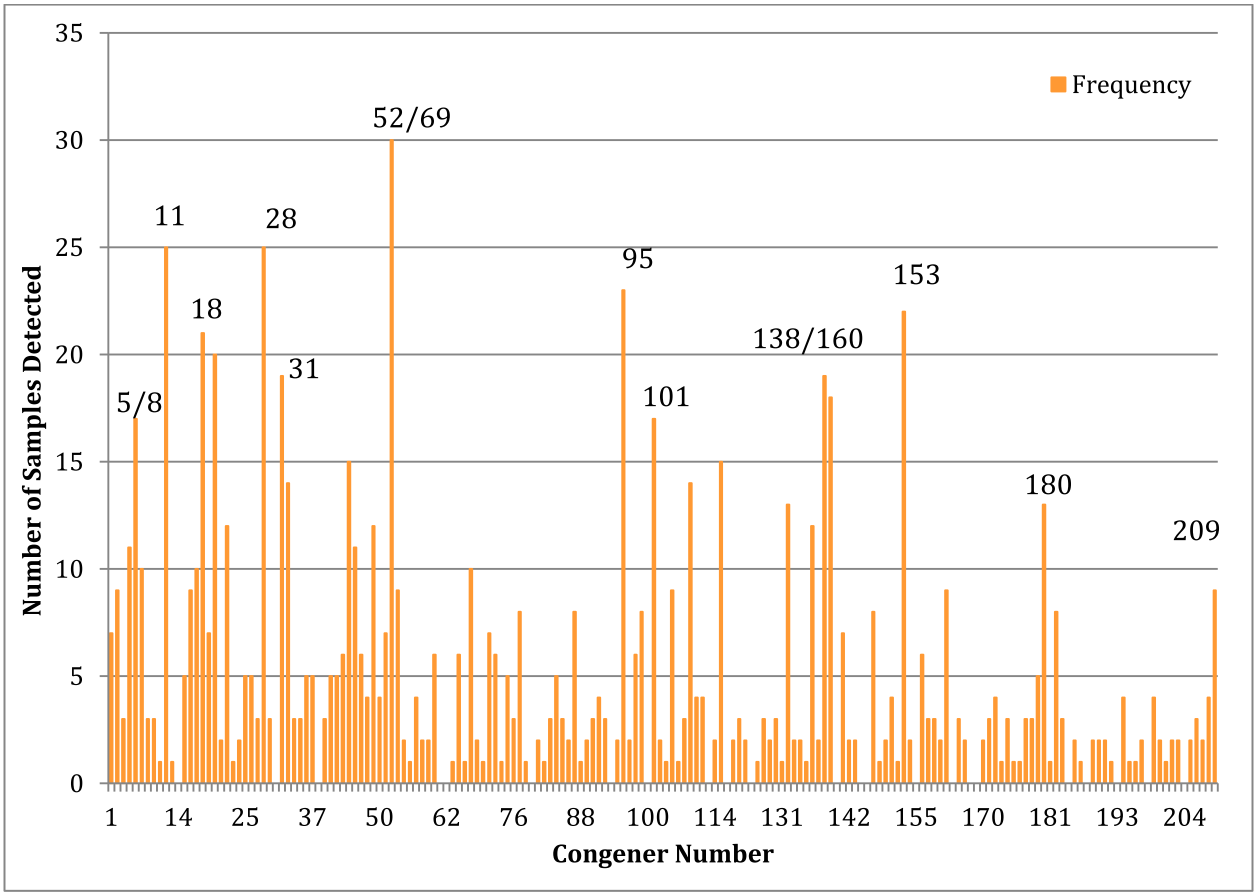


Figure 32. Frequency of Detections per Congener

The results from this report may be used for a number of PCB tracking and reduction activities. Additional research may be needed to determine potential pathways between some of the sampled products and stormwater. For PCB reduction activities, total PCB loading (volume of product used) should be assessed to aid in prioritization. Manufacturers may also be interested in exploring PCB-free alternatives where feasible.

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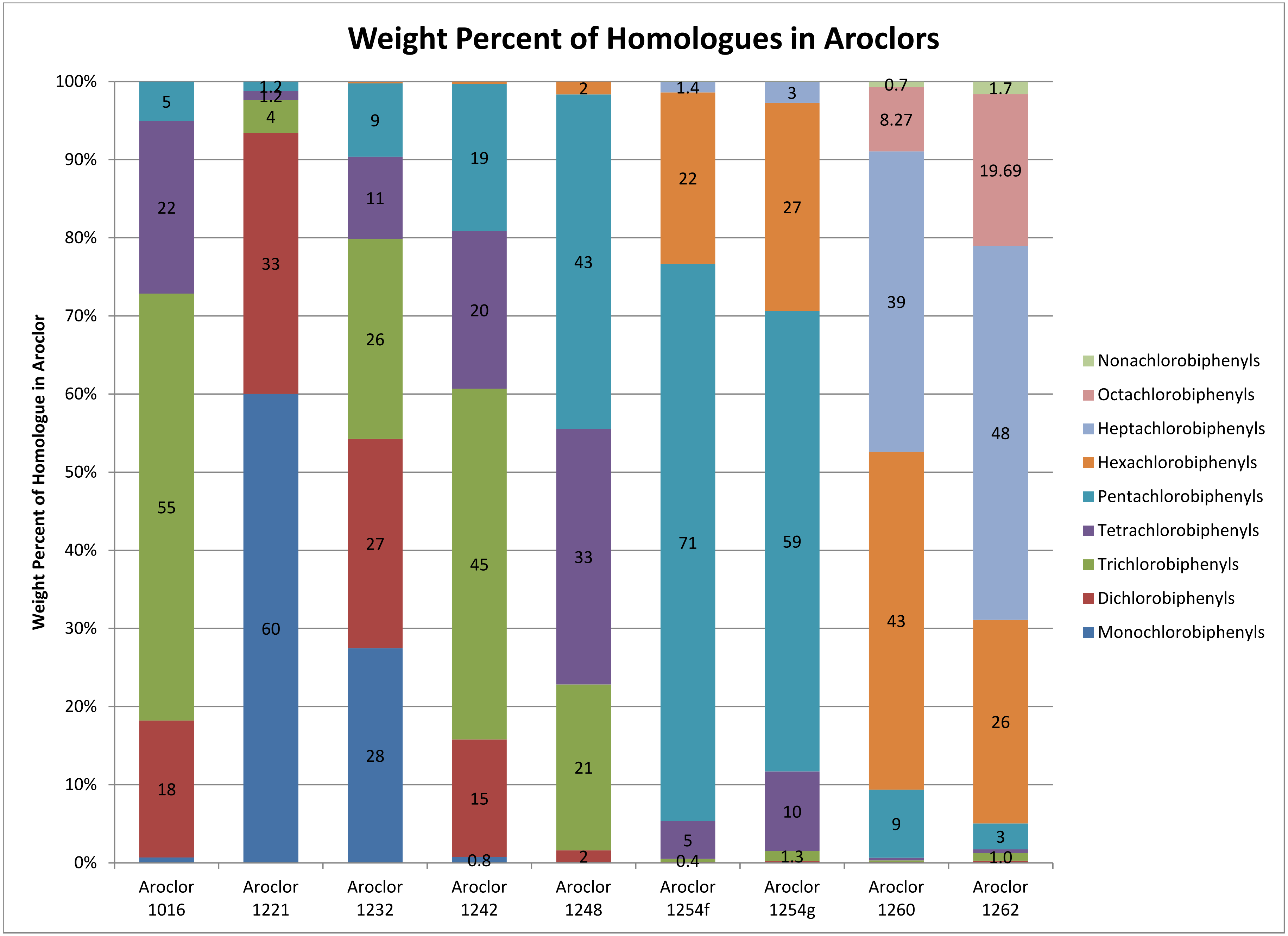
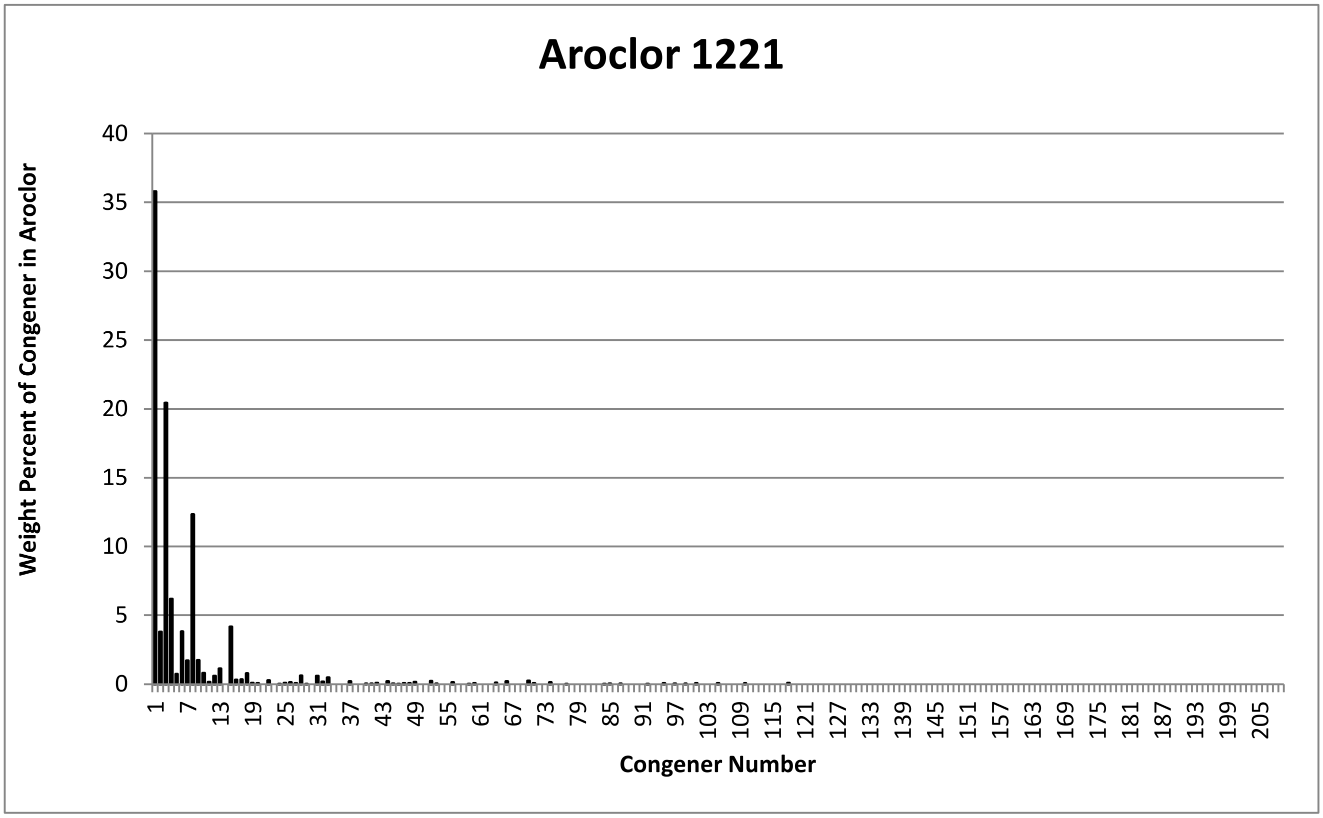
Appendix A

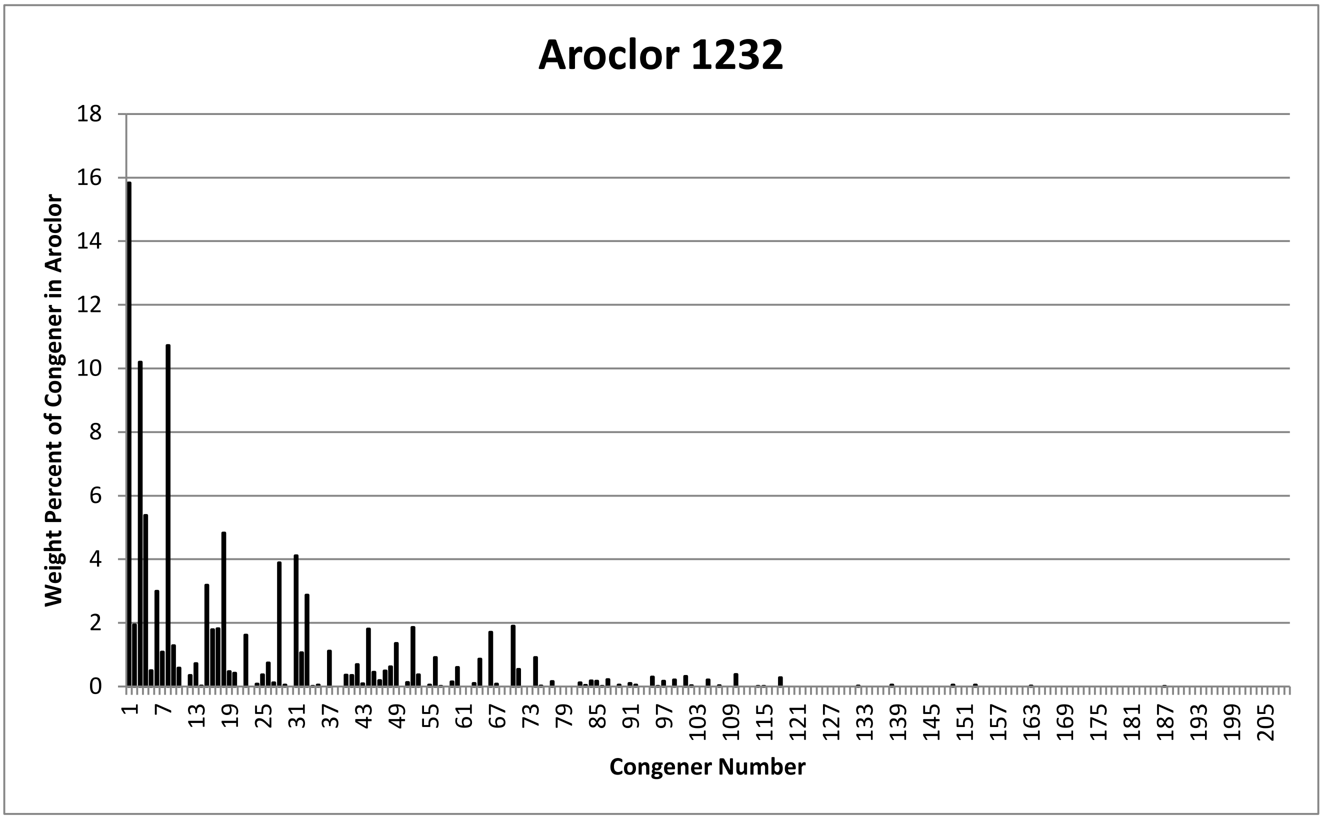
AROCLOR HOMOLOGUES AND CONGENERS



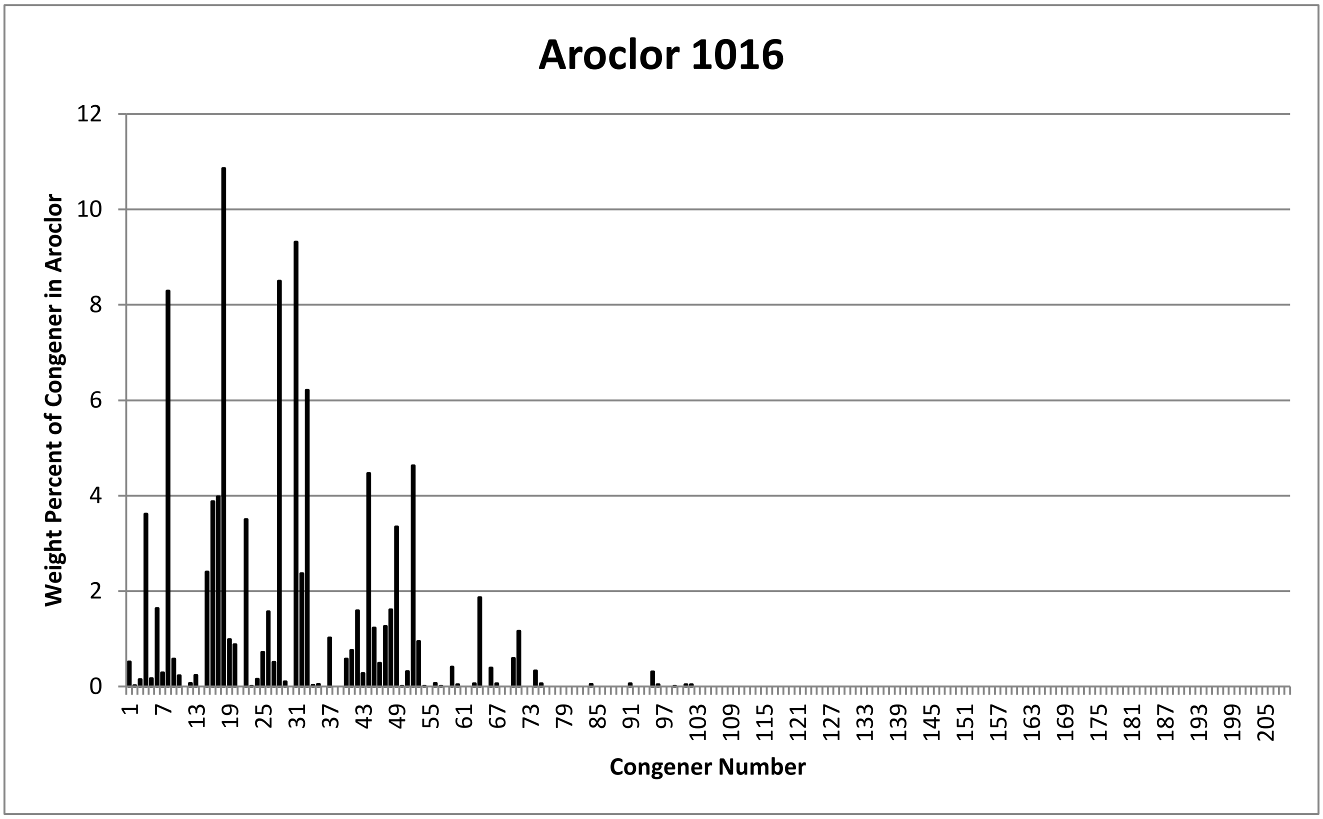
Adapted from ASTDR, 2000.

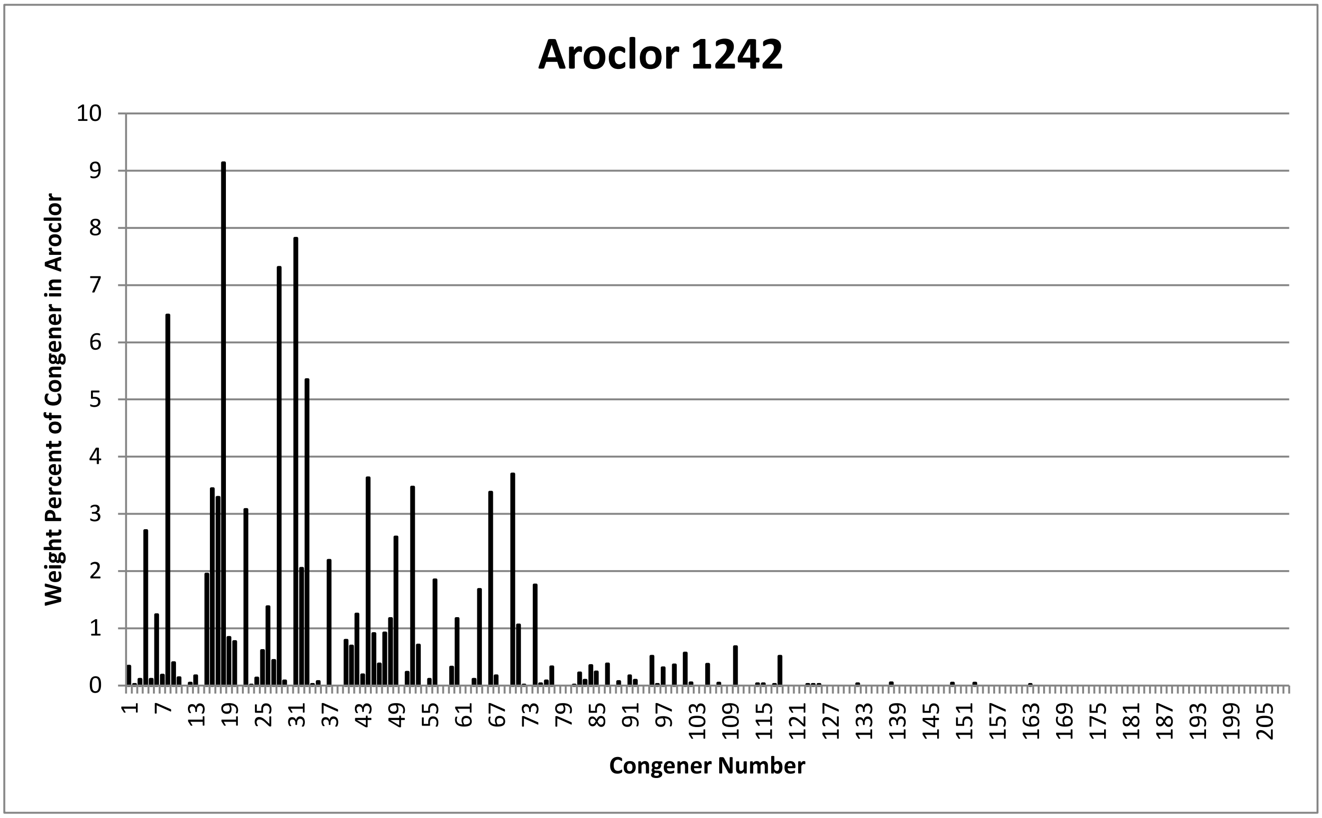
Weight Percent of Congeners in Aroclors



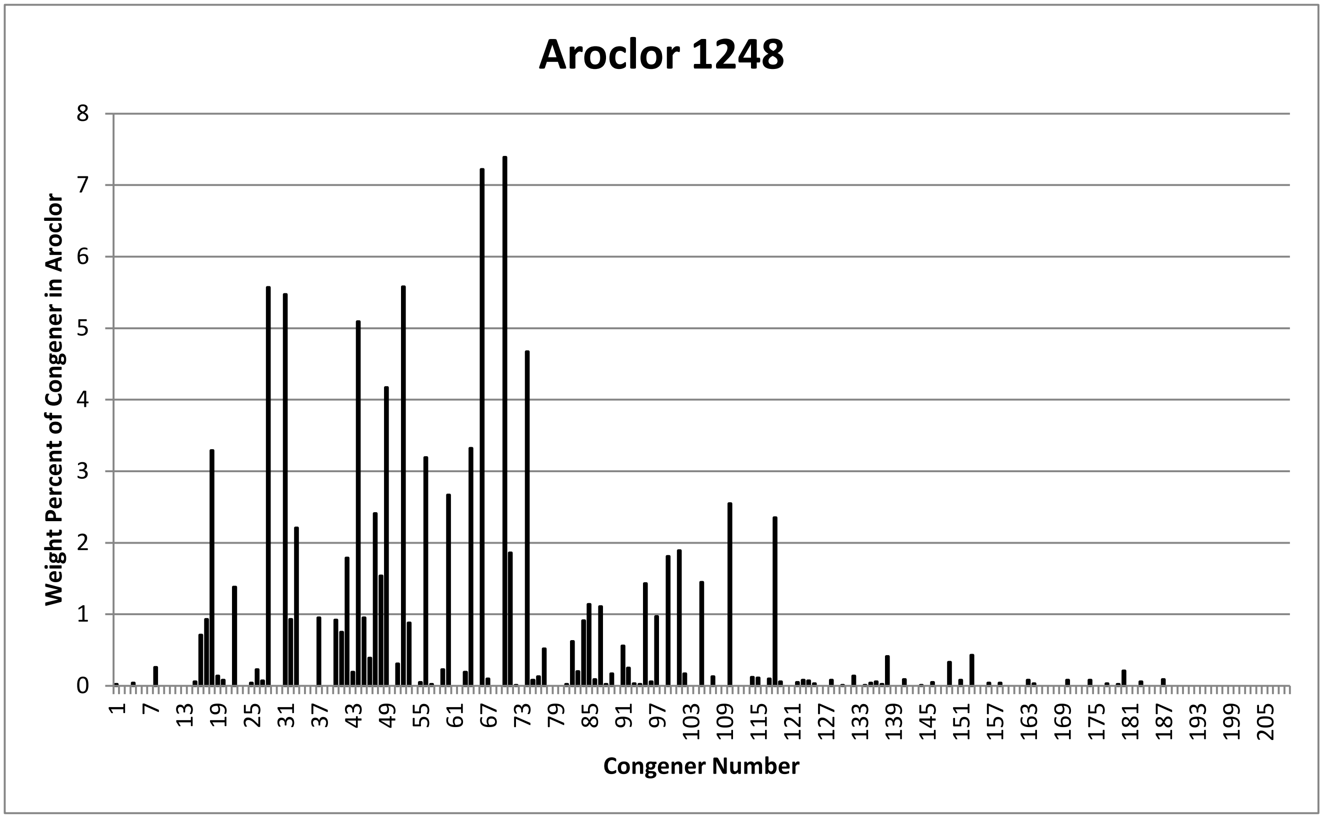


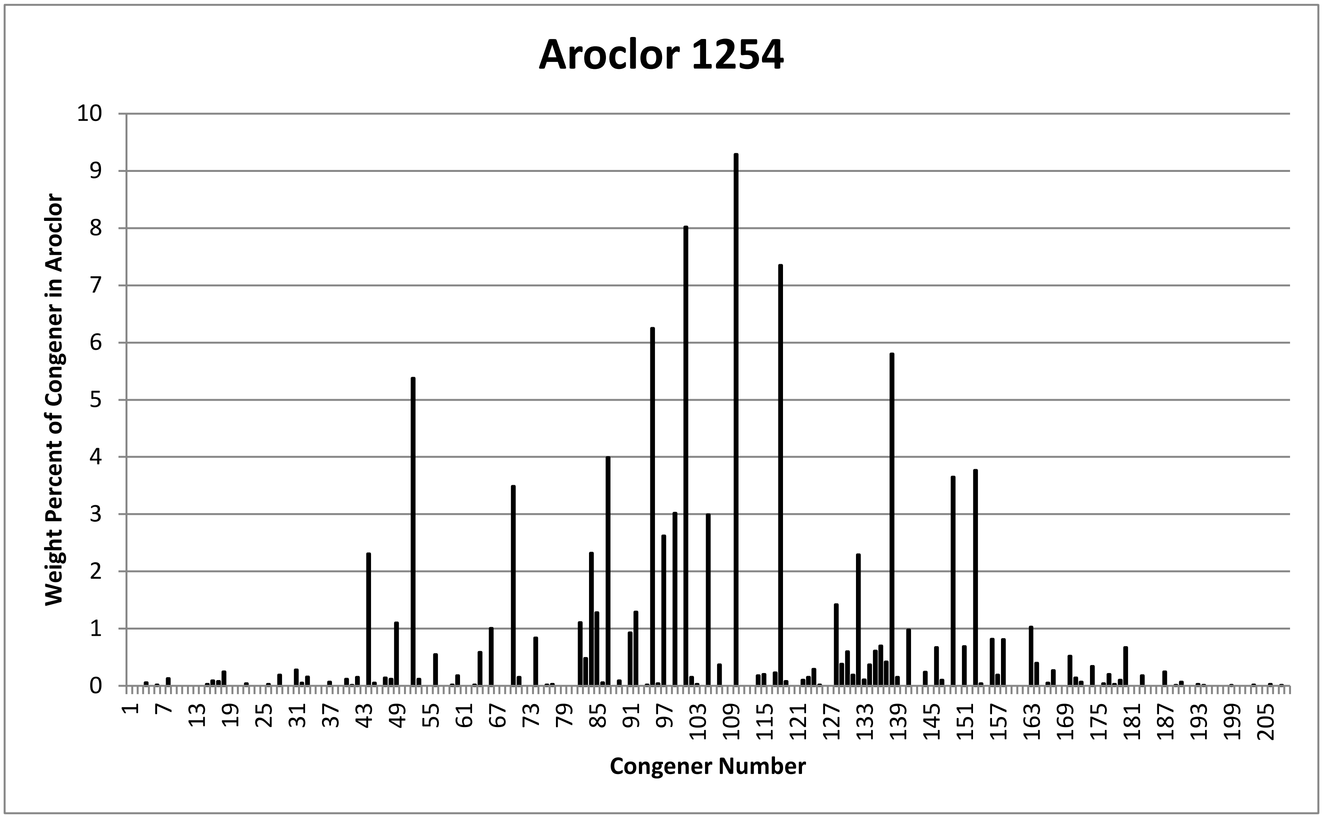
(Adapted from Frame et. al, 1996)



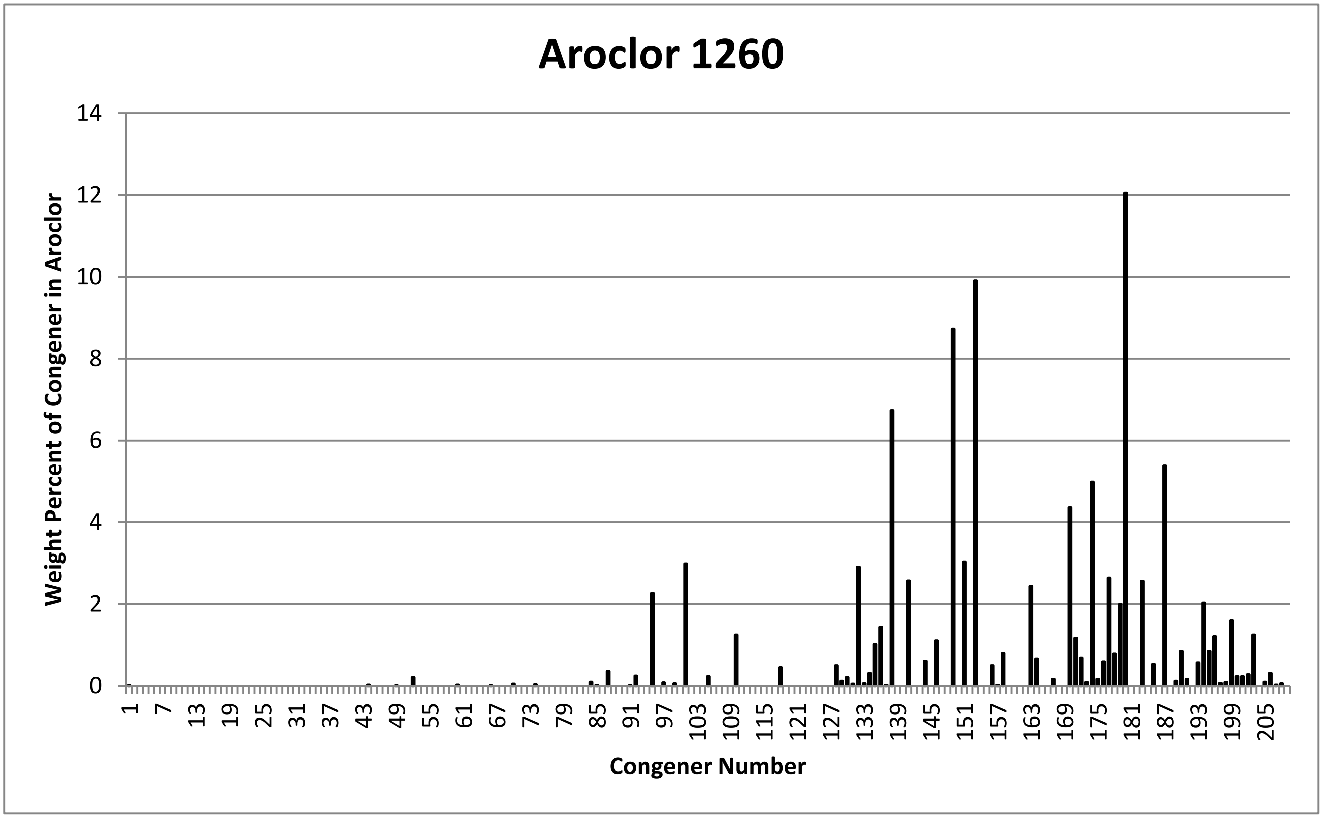


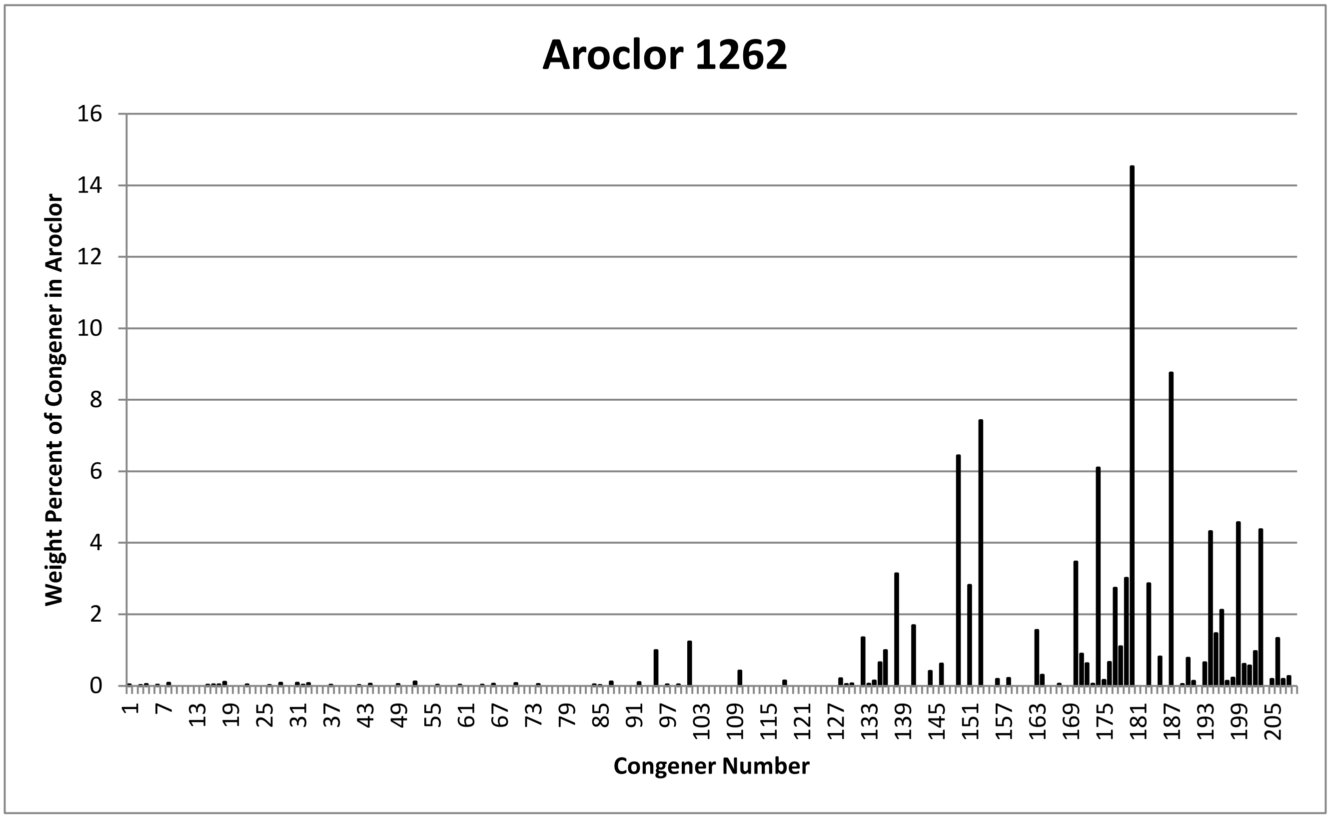
(Adapted from Frame et. al, 1996)





(Adapted from Frame et. al, 1996)





(Adapted from Frame et. al, 1996)

Appendix B

SUMMARY OF RESULTS

Table B-1

Summary of PCB Product Sampling Results

Product Type	Media	Product ID	Total PCB (ug/kg or ppb)	Field Replicate (ppb)	Lab Duplicate (ppb)	Brand
Yellow road paint	Liquid	001	0.732	2.686		Ennis standard #2 - Product # 983712
Yellow road paint	Liquid	002	64.880			Sherwin Williams Promar TM 5713
White road paint	Liquid	003	0.414	0.396		Ennis standard #2 - Product # 983711
White road paint	Liquid	004	0.281		0.220	Sherwin Williams Promar TM 5712
Hydrant Paint	Liquid/Spray	005	0.003		0.010	Rustoleum Pro HP Enamel - Aluminum
Utility Locate Paint	Liquid/Spray	006	21.527			Rustoleum Industrial Choice, Solvent-based - green
Class B Firefighting Foam	Liquid	007	0.029			Alcoseal 3-3 (AR-FFFP)
Deicer	Liquid	008	1.332	1.952		MgCl Freezegard
Deicer	Liquid	009	0.038			Enhanced salt brine with SB Boost
Vehicle wash soap	Liquid	010	0.003		0.068	SuperXL, Hotsy
Vehicle wash soap	Liquid	011	0.068			Simple Green
Pesticide/Herbicide	Liquid	012	<0.0001		<0.0001	2-4D: Nufarm Weedar 64
Pesticide/Herbicide	Liquid	013	6.890			Portfolio 4F, Wilbur-Ellis
Pesticide/Herbicide	Liquid	014	0.012			Roundup Pro Max, Monsanto
Pesticide/Herbicide	Liquid	015	0.316			Crosshair, Wilbur-Ellis
Motor oil	Liquid	016	0.856		0.826	SAE 15W-40 Firebird Heavy Duty EC (bulk), Connell Oil
Motor oil	Liquid	017	0.969			Valvoline Full Synthetic 5W-30
Used motor oil	Liquid	018	0.502	2.375		SAE 15W-40 Firebird Heavy Duty EC, Connell Oil
Diesel	Liquid	019	<0.019			#2 Diesel, dyed
Gasoline	Liquid	020	0.935		0.811	Regular unleaded
Dirt road dust suppressant	Liquid	021	0.091			Asphalt emulsions- EADA
Dirt road dust suppressant	Liquid	022	0.086			Lignosulfonate- Ligno Road Binder (natural polymer in wood)
Dirt road dust suppressant	Liquid	023	3.574			Dustguard Liquid MgCl (different concentration than deicer)
Lubricant	Liquid	024	0.623			MP Gear Lube SAE 85W-140, Phillips 66 Company
Asphalt tack	Liquid	025	0.085			SSR1 asphalt tack
Crack sealer	Solid	026	7.975			Special Asphalt SA Premier (3405- midrange crack sealer)
Asphalt release agent	Liquid	027	0.558		0.443	Soy What, TechniChem Corp.
Hydroseed	Solid	028	2,509.088			Natures Own Hydroseeding Mulch, Hamilton Mfg Inc
PVC pipe	Solid	029	1.999			ASTM 3034 8", Diamond PVC
CIPP liner	Solid	030	1.110			Cast in place pipe liner, installed by SAK
Shortliner	Solid	031	17.780			Infrastructure Repair Systems Inc
Yellow road paint, dried	Solid	032	0.565			Ennis standard #2 - Product # 983712
White road paint, dried	Solid	033	0.379		0.335	Ennis standard #2 - Product # 983711

Product Type	Media	Product ID	Total PCB (ug/kg or ppb)	Field Replicate (ppb)	Lab Duplicate (ppb)	Brand
Thermoplastic tape road striping	Solid	034	10.776			Ennis-Flint Pre-Mark
Antifreeze	Liquid	035	0.018			Kool Green Extended Life (recycled)
Thermoplastic tape road striping	Solid	036	3.325			Ennis-Flint Pre-Mark

Personal Care Products

Product Type	Media	Product ID	Total PCB (ug/kg or ppb)	Field Replicate (ppb)	Lab Duplicate (ppb)	Brand
Hand soap	Liquid	101	0.037			Dial Antibacterial, pomegranate and tangerine
Laundry soap	Liquid	102	0.174			Tide original liquid
Dish soap	Liquid	103	0.083			Dawn Ultra antibacterial
Shampoo	Liquid	104	0.058			Suave naturals
Toothpaste	Liquid	105	0.032			Aquafresh Extreme Clean Whitening

Notes:

Total PCB values have been blank corrected: congeners < 3 times the associated blank value not included in total.

ug/kg = micrograms per kilogram

ppb = parts per billion

CHAPTER IV

The Role of Hatcheries in North American Wild Salmon Production

Key Points

✔ A significant share of the salmon caught by North American commercial fishermen are released from hatcheries. In recent years, hatchery fish have accounted for about 38 percent of total Alaska "wild" salmon catches, including about 40 percent of Alaska pink salmon catches and 69 percent of Alaska chum salmon catches. Most Alaska hatchery production is concentrated in Southeast Alaska and Prince William Sound. The importance is highlighted by ADF&G: "The ocean ranching program provides hundreds of Alaskans with seasonal jobs. It is now considered the largest agricultural industry in Alaska" (Farrington 2004 p. 2).

✔ The Alaska hatchery program faces significant economic and political challenges, including:

- Lower economic net return due to lower prices
- Declining state financial support for hatcheries
- Declining direct benefits to fishermen from hatcheries as the share of catches needed to cover costs of hatchery operations increases
- Opposition from fishermen dependent on natural wild salmon catches who argue that large-scale hatchery catches has depressed ex-vessel prices they receive
- Lack of markets for "dark" hatchery fish (fish that have physiologically changed as they move back to fresh water) in some years, leading to discarding of fish carcasses after extraction of salmon roe
- Concerns about potential adverse effects of hatchery releases on Alaska natural wild salmon runs.

✔ There are also significant hatchery programs in British Columbia, the U.S. Pacific Northwest and California, which account for significant shares of the commercial and recreational fisheries.

✔ Hatcheries add another dimension of complexity and ambiguity to the discussion over environmental, economic and social issues related to wild and farmed salmon. Some of the environmental and economic issues associated with salmon farming are also associated with commercial hatchery production.

Introduction[1]

It is common to think of salmon as either "wild" or "farmed." However, not all "wild" salmon are equally wild. A large share of the salmon returning to North American streams, and a large share of the salmon caught by North American commercial fishermen, are released from hatcheries and are considered 'ranched' salmon. However, most discussion is framed in a 'wild' salmon context which includes both 'natural wild' and 'ranched.'

In some ways, hatchery salmon are more like farmed salmon than natural wild salmon.[2]

- Like farmed salmon, hatchery salmon spend the first part of their lives in hatchery incubation systems and/or rearing containers, eating similar kinds of feeds.
- Like those farmed salmon which escape into the natural environment, hatchery salmon may potentially affect the genetic diversity of natural wild salmon stocks. This is particularly a concern in Washington, Oregon and California.
- Like farmed salmon, hatchery salmon compete in world markets with natural wild salmon.
- Like farmed salmon, there are significant costs in producing hatchery salmon, and the extent to which hatcheries are economically viable depends upon market conditions.

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[1] A good deal of the discussion of this chapter, in particular the portion on Alaska's hatchery programs, is drawn from Knapp (1999).

[2] See footnote 2 in Chapter II.

Unlike farmed salmon, hatchery fish compete with natural wild fish for food. For these reasons, hatcheries add another dimension of complexity and ambiguity to the discussion over environmental, economic and social issues related to wild and farmed salmon.

Once thought of as a way to restore and enhance natural wild salmon runs, hatchery salmon are now recognized as potentially harmful to natural wild salmon runs because of genetic interactions and competition for food and habitat in freshwater and marine environments. There is an active debate among scientists, commercial fishermen and the public as to the appropriate role and scale of salmon hatcheries. This is particularly true in the U.S. Pacific Northwest.

In this chapter we review the role of hatchery salmon in North American commercial wild salmon fisheries, and the economic issues associated with hatchery salmon.

Overview of North American Hatchery Programs

Salmon hatcheries have been established in North America for many purposes including:

- Introducing salmon fisheries where none previously existed.
- Replacing or enhancing natural salmon runs which were extinct or diminished.
- Increasing abundance of salmon for sports fisheries
- Increasing abundance of salmon for commercial fisheries.

Hatcheries were first established in North America in the second half of the nineteenth century, motivated by the recognition that natural stocks of salmonids were in decline and the desire to introduce salmon and trout outside their native ranges (Thorpe 1980). The first hatchery propagation of Pacific salmon (*Oncorhynchus* spp.) took place in Canada in 1857 (Bardach et al. 1972). Soon after, salmon hatchery techniques were adopted in the United States. The first U.S. hatchery was opened in 1864 in New York State to raise brook trout (Calabi 1990). However, hatchery-based enhancement programs were introduced at a significant scale only after the 1950s. Hatcheries were introduced to Japan in 1877.

More than two billion Pacific salmon were released in 2000 by North American salmon hatcheries (Table IV-1). Alaska accounted for 69 percent of total releases, while Canada and the U.S. Pacific Northwest each accounted for about 16 percent (Table IV-2).

Alaska releases were mostly pink and chum salmon, western Canadian releases (mostly British Columbia) were mostly sockeye, chum and chinook salmon and U.S. Pacific Northwest releases were mostly chinook and coho salmon. Alaska accounted for the largest share of pink and chum salmon releases; Canada accounted for the largest share of sockeye releases, and the U.S. Pacific Northwest accounted for the largest share of chinook and coho releases (Table IV-2).

Table IV-1 **Salmon Fry Releases by Species, Region, and Area, 2000 (millions of fish)**

		Chinook	Sockeye	Coho	Pink	Chum	Total
Alaska		9.2	59.8	19.3	879.7	507.7	1479.7
Canada	Yukon	0.2	0.0	0.0	0.0	0.0	0.2
	Queen Charlotte	0.2	0.0	1.3	0.0	22.2	23.7
	North Coast	4.3	90.5	1.6	0.2	12.7	109.3
	West Coast Vancouver Island	17.5	0.0	2.7	0.0	31.8	51.9
	South Coast	29.2	39.3	14.8	16.9	30.6	130.7
	Interior B.C.	2.2	19.2	0.7	0.0	0.0	22.1
	Canada Total	53.5	148.9	21.1	17.0	97.3	337.9
Pacific Northwest	Washington	117.4	16.9	43.9	1.6	38.8	229.5
	Oregon	32.3	0.0	8.7	0.0	0.0	46.8
	California	43.8	0.0	0.6	0.0	0.0	46.8
	Idaho	6.8	0.1	0.5	0.0	0.0	15.3
	Pacific Northwest Total	200.3	17.0	53.7	1.6	38.8	338.4
TOTAL		**263.0**	**225.7**	**94.2**	**898.4**	**643.8**	**2156.0**

Source: North Pacific Anadromous Fish Commission, NPAFC Hatchery Release Data.

Note: Includes all juvenile salmon releases.

Table IV-2 **Share of Salmon Fry Releases, by Region and Species, 2000**

	Chinook	Sockeye	Coho	Pink	Chum	Total
Alaska	3%	26%	21%	98%	79%	69%
Canada	20%	66%	22%	2%	15%	16%
Pacific Northwest	76%	8%	57%	0%	6%	16%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: NPAFC Hatchery Release Data

Table IV-3 **Number of Fry Released per Kilogram of Commercial Catches, 1997-2001**

	Chinook	Sockeye	Coho	Pink	Chum	Total
Alaska	2.3	0.7	1.5	5.5	6.3	4.3
Canada	53.4	18.3	115.6	2.3	15.3	14.2
Pacific Northwest	52.1	15.8	42.1	1.8	16.2	34.9

Note: Calculated by dividing average fry releases for the period 1997-2001 (thousands of fish) by average commercial catches for the period 1997-2001 (thousands of kilograms). For the Pacific Northwest, average fry releases for the period 1997-2000 were used becauses 2001 data were not available.

Table IV-3 provides a general indicator of the relative scale of hatchery releases in comparison to commercial harvests. For chinook, sockeye and coho salmon, hatchery releases per kilogram of commercial catches were much higher in Canada and the U.S. Pacific Northwest than in Alaska—suggesting that commercial fisheries for these species are relatively more dependent on hatcheries in Canada and the U.S. Pacific Northwest than Alaska. For pink and chum salmon, hatchery releases per kilogram of commercial catches were much more comparable among the three regions.

The Hatchery Process

The production of salmon in hatcheries recreates the early portion of the life cycle of the species in a protected environment (Willoughby 1999). Salmon hatcheries consist of both a freshwater and a marine phase. The freshwater phase encompasses the spawning cycle, egg production, hatching and first-feeding stages. As the fry develop, they turn into fingerlings (or parr as the Europeans tend to call them), and finally grow to become smolts. At this point the fish have become physiologically adapted to seawater conditions.

- Broodstock management: Broodstock are the fish from which the eggs and milt (sperm) are taken. Selection of the broodstock from adults returning to the hatchery has changed significantly over time. Until recently, little concern was given to such things as managing to maintain the genetic integrity of a river's native salmon. In recent years, scientists have determined that these needs must be addressed and have prescribed methods to choose broodstock in a more careful manner (National Research Council 1996).
- The hatchery: The hatchery phase is probably the most technically demanding, requiring a high degree of organization and planning. The objective of this portion of the cycle is to fertilize and hatch the eggs then raise the fry until release to open water. After hatching, the young fish feed on the contents of their yolk sac for several weeks and are called yolk-sac fry or alevins. A short time after hatching the yolk sac has been almost totally consumed and the alevins are generally developed enough to start feeding. Starter diets formulated with feed ingredients, such as fishmeals and fish oils, give rapid growth.
- Fry and fingerling development: When the alevins begin to feed they are known as fry. During this phase, growth is rapid. As they develop, fry become more accustomed to solid feed and increase their activity. When the fry are sufficiently developed, they are transferred into larger tanks. Once the fry reach an average weight of about 5 g, they are known as *fingerlings*.
- Smolt production: Once the larger fingerlings are sufficiently developed, they will undergo major physical and physiological changes to become smolts. These changes mark the transformation from a freshwater fingerling to a seawater fish (Fitzgerald et al. 2002). The smoltification process involves changes in most organ systems, morphological (silvery color), physiological (ATPase activity) and behavioral (swimming with the current), which will allow the fish to survive, grow and develop normally in the marine environment.

Hatcheries managed for stock enhancement of the commercial and sport fisheries, generally release fish to the open water at either the fry, fingerling or smolt stage depending on species and management objectives. Pink and chum salmon are generally released at the fry stage with a large number of fry released. In British Columbia, the U.S. Pacific Northwest, where the purpose of the hatcheries are generally to ensure the survival of the stock, species such as chinook, coho and sockeye are released as smolts to increase the probability of survival in the wild.

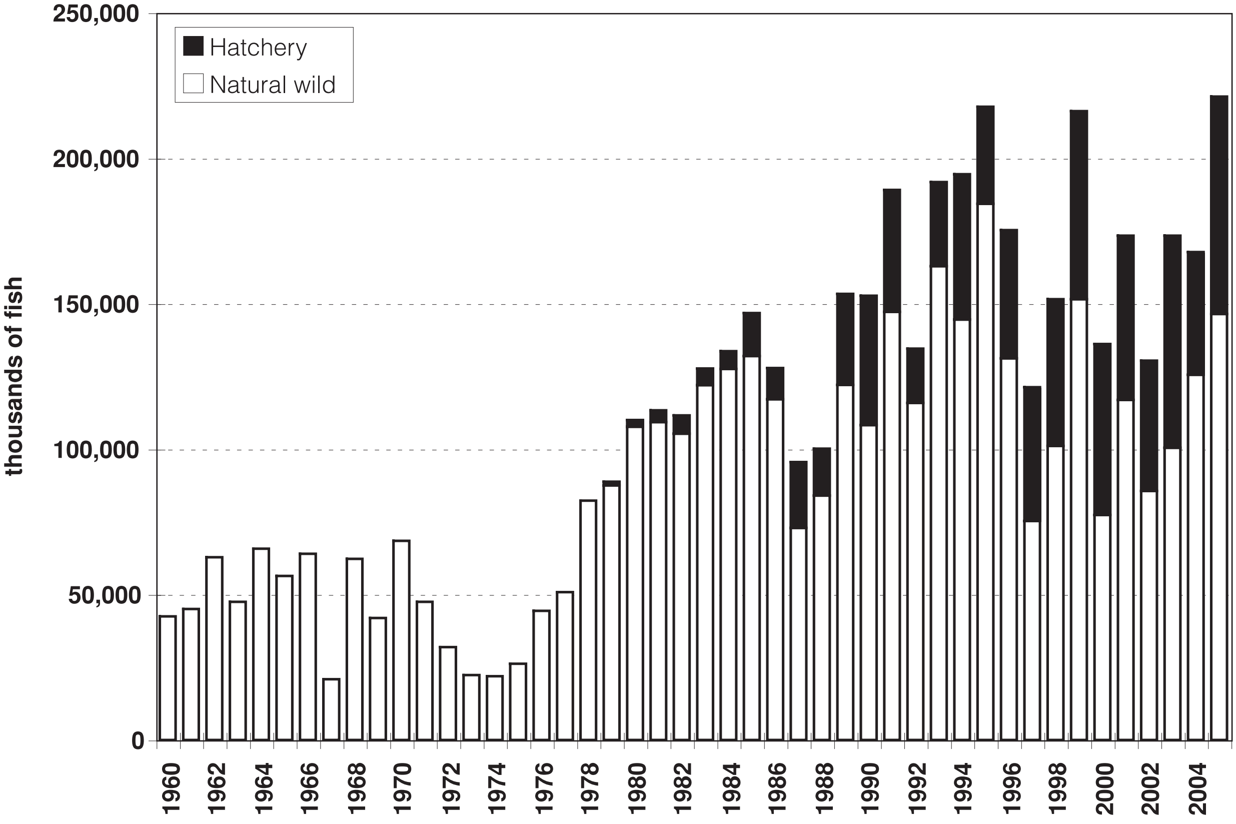
The Alaska Salmon Enhancement Program

Beginning in the 1970s, the State of Alaska supported the development of numerous salmon hatcheries, with the goal of increasing and stabilizing Alaska salmon returns.[3] State support of the Alaska salmon enhancement program was linked to the rapid rise in Alaska oil revenues following the discovery and development of oil on Alaska's North Slope. The State supported hatchery development by loaning money to private non-profit organizations for hatchery construction and operation, as well as by building and operating State-owned hatcheries which were later transferred to private non-profit regional aquaculture associations.

Beginning in the 1980s catches of both hatchery salmon and natural wild salmon increased rapidly. In 2002, the total catch of hatchery fish was 45 million salmon, about one-third of the total Alaska salmon catch (Figure IV-1).[4]

The relative importance of hatcheries varies between different Alaska salmon species. During the period 2000-2002, hatchery fish accounted for 69 percent of Alaska chum salmon catches, 40 percent of pink salmon catches and 12 percent of catches of other species (Table IV-2). Hatchery fish accounted for about

Figure IV-1 **Alaska Commercial Salmon Catches Since 1960: Natural Wild Salmon and Hatchery Salmon**



Source: Data for 1960-1978: ADFG Catch Data 1878-1981; Data for 1979-2005: ADFG Hatchery Data

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[3] The Alaska Department of Fish and Game's annual reports on the Alaska Salmon Enhancement Program, available at www.cf.adfg.state.ak.us/geninfo/enhance/enhance.php, provide detailed information about the program.

[4] Hatchery fish are identified in several ways, including coded wire tags, fin clips and otolith marking (a process by which an identifiable microscopic colored ring sequence in fish ear bones is created by exposing fish to a series of planned temperature changes).

28 percent of the total ex-vessel value of Alaska catches. The importance is highlighted by ADF&G: "The ocean ranching program provides hundreds of Alaskans with seasonal jobs. It is now considered the largest agricultural industry in Alaska" (Farrington, C., ADF&G,. 2004 p. 2).

The relative importance of hatcheries also varies between different areas of Alaska. In 2002, Southeast Alaska and Prince William Sound accounted for about 80 percent of hatchery catches (Table IV-4).

Certain Alaska fisheries are overwhelmingly dependent on hatchery salmon, including the Southeast Alaska chum salmon fishery, the Prince William Sound chum salmon fishery and the Prince William Sound pink salmon fishery. In other major fisheries, such as western Alaska sockeye salmon fisheries and the southeast Alaska pink salmon fishery, hatchery fish account for only a small share of total catches. Note that the two highest value species, chinook and sockeye, are less dependent on hatcheries. Part of the explanation is the health of the natural sockeye stocks in Alaska, and the relatively high cost and time it takes to raise chinook smolts.

Although hatcheries have clearly increased Alaska salmon catches, they have not stabilized catches. Salmon catches by region and in the state as a whole still vary greatly from year to year, even with hatchery programs, because hatchery fish are subject to the same ocean conditions as wild salmon. This is illustrated in Figure IV-2. During the period 1990-2005, Alaska hatchery releases of pink salmon were relatively stable, ranging between 800 million and 1 billion fish. During the same period, returns of Alaska hatchery pink salmon ranged from 15 million to 69 million fish. The percentage of fish returning varied from 1.7 percent to 7.2 percent.

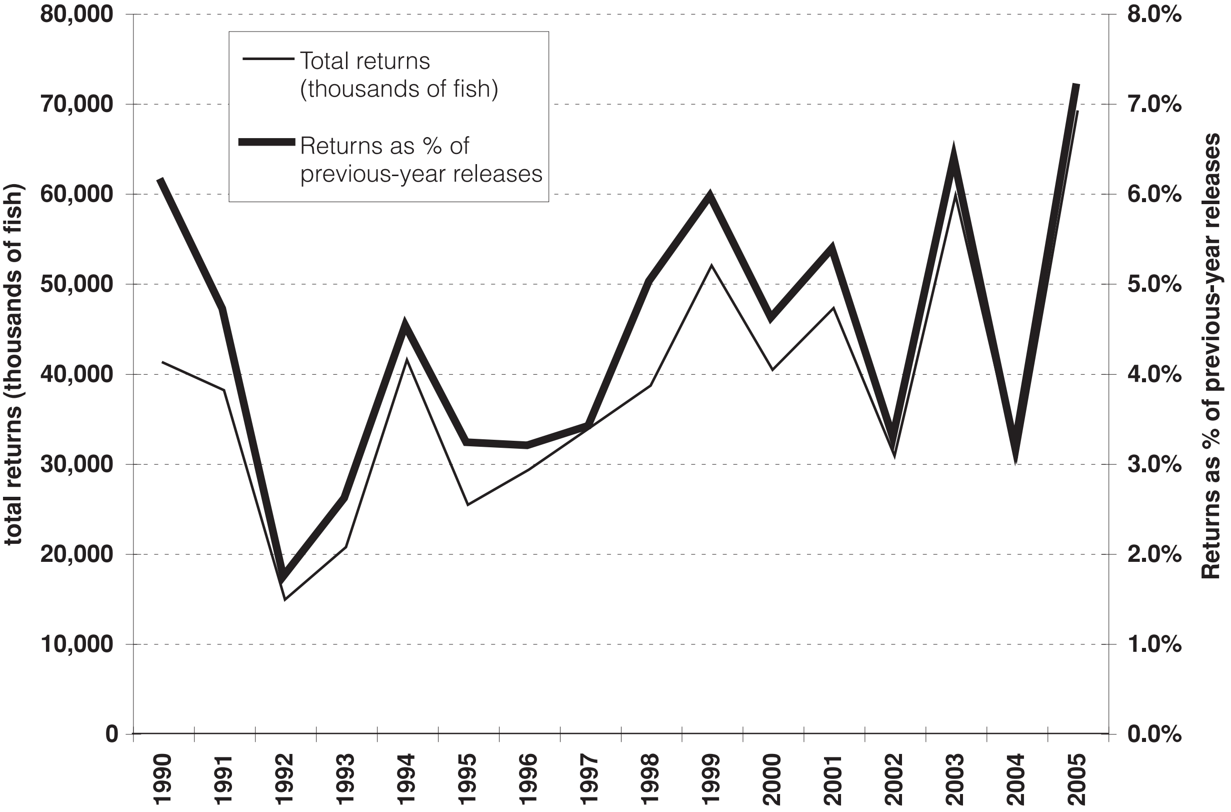
Large numbers of hatchery fish are caught by commercial fishermen prior to their return to the hatcheries. Near hatchery sites, boats hired by the hatchery catch additional large numbers of fish in the so-called 'cost recovery' fishery. All the proceeds from this fishery go to the hatchery. Any remaining hatchery fish are left to mill around the hatchery and die. They are not 'programmed' with a stream in mind to return to. Although some may stray may find a stream and spawn in it, this is neither intended nor desired.

Table IV-4 Alaska Salmon Catches by Species and Region, Hatchery & Total, 2002

	Area	Chinook	Sockeye	Coho	Pink	Chum	Total
Commercial catches of hatchery fish (000 fish)	Southeast	87	120	1,425	1,924	5,617	9,173
	Prince William Sound	0	1,164	36	18,772	6,112	26,084
	All other areas	1	1,466	217	7,747	88	9,519
	Alaska total	**88**	**2,750**	**1,678**	**28,443**	**11,817**	**44,776**
Share of total hatchery catches, by species	Southeast	1%	1%	16%	21%	61%	100%
	Prince William Sound	0%	4%	0%	72%	23%	100%
	All other areas	0%	15%	2%	81%	1%	100%
	Alaska total	**0%**	**6%**	**4%**	**64%**	**26%**	**100%**
Share of total hatchery catches, by area	Southeast	99%	4%	85%	7%	48%	20%
	Prince William Sound	0%	42%	2%	66%	52%	58%
	All other areas	1%	53%	13%	27%	1%	21%
	Alaska total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Total commercial catches (000 fish)	Southeast	372	787	2,986	45,612	6,294	56,051
	Prince William Sound	40	2,262	650	18,950	6,373	28,275
	All other areas	128	19,438	1,135	23,000	2,357	46,058
	Alaska total	**540**	**22,487**	**4,771**	**87,562**	**15,024**	**130,384**
Hatchery share of commercial catches	Southeast	23%	15%	48%	4%	89%	16%
	Prince William Sound	0%	51%	6%	99%	96%	92%
	All other areas	1%	8%	19%	34%	4%	21%
	Alaska total	**16%**	**12%**	**35%**	**32%**	**79%**	**34%**

Source: ADFG Hatchery Data.

Figure IV-2 **Estimated Returns of Alaska Hatchery Pink Salmon, 1990-2005**



Source: ADFG Hatchery Data.

Challenges for the Alaska Salmon Enhancement Program

The Alaska Salmon Enhancement Program consists of a variety of public and private sector salmon rehabilitation and enhancement projects. In 2002, these included 29 non-profit corporation hatcheries (by far the most significant component of the program), two state-operated hatcheries, two Federal or Bureau of Indian Affairs hatcheries and several streamside incubation and restoration projects (Farrington 2003).

The Alaska Salmon Enhancement Program has clearly succeeded in increasing total salmon catches, particularly in Southeast Alaska and Prince William Sound. However, the program faces a number of challenges which could affect the future scale of hatchery releases and thus total Alaska salmon catches, particularly of pink and chum salmon. Below, we briefly review these challenges.

Lower Prices

A fundamental problem for the Alaska Salmon Enhancement Program is that real (inflation-adjusted) prices have declined significantly since the start of the program, in particular for chum and pink salmon (Figure IV-3). As a result, investing in raising and releasing young salmon results in less of an increase in future catch value, for any given rate of ocean survival.

In theory, we might expect that as prices decline the net economic benefits of hatcheries would decline, and at some point total hatchery releases would begin to decline. However, this has not yet happened to any significant extent. Hatchery releases of pink and chum salmon stopped growing in the mid-1990s, but have not shown any significant decline (Figure IV-4).

In order to understand the relationship between salmon prices and hatchery releases, we must review the structure of hatchery operations and how they are financed. Most salmon hatcheries in Alaska are now operated by private non-profit (PNP) organizations, most of which received initial funding from state grants and capital and operating loans, to be repaid from hatchery revenues. There are two categories of PNP organizations: independent PNPs and regional aquaculture associations.

Hatcheries may earn revenues to cover operating expenses and repay state loans in two ways. First, hatcheries are authorized to catch a percentage of the adult salmon returning to terminal “special harvest areas” for sale. These are referred to as “cost-recovery” catches.” Typically cost-recovery fish are caught by just a few boats, catching very large volumes, working under contract to the hatcheries in the special harvest areas. All other returning hatchery salmon are caught in “common-property fisheries” by commercial, sport and subsistence fishermen.

Second, in management areas with regional aquaculture associations, fishermen may vote to assess an “enhancement tax” on the ex-vessel value of their salmon landings. These enhancement tax funds also support hatchery operations. Enhancement tax rates are presently 3 percent in southeast Alaska and 2 percent in Prince William Sound, Cook Inlet and Kodiak. No enhancement taxes are assessed in other areas.

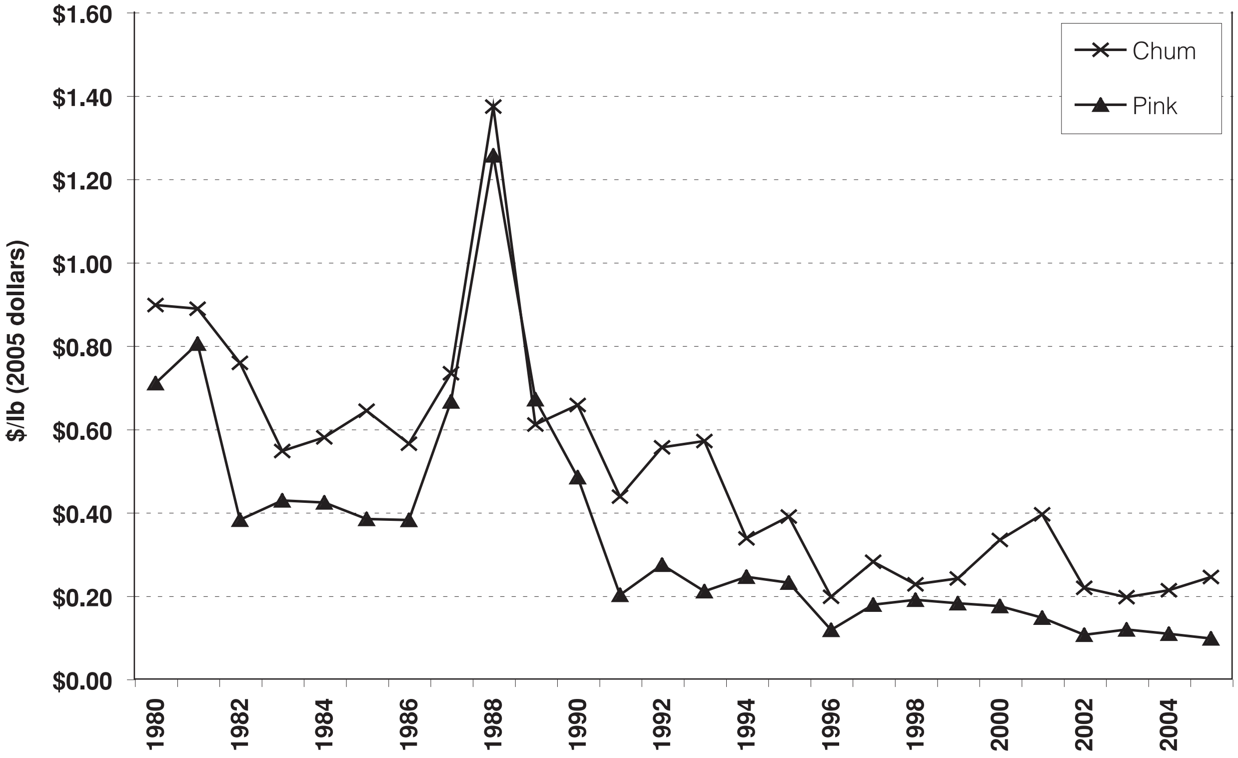
As ex-vessel prices have declined, enhancement tax collections have declined, so that the hatcheries have had to rely on cost-recovery catches for a greater share of their revenues. In addition, because prices are lower, hatcheries need to catch more fish in the cost-recovery fisheries to meet any given revenue target. As a result, as prices decline an increasing share of the hatchery returns have been caught in cost-recovery fisheries rather than by commercial fishermen in the common property fisheries. This trend is particularly evident for chum salmon, for which the cost-recovery share of catches increased from less than 30 percent in the early 1990s to more than 51 percent in 2003 (Figure IV-5).

As the cost-recovery share of hatchery catches increases, the share of the benefits captured by commercial fishermen (other than those few who participate in the cost-recovery fishing) declines. Put differently, an increasing share of the fish goes to support the hatcheries, rather than the original concept of increasing the total volume of fish available to all fishermen.

Increasing the share of hatchery fish going to cost-recovery harvests has allowed the hatcheries to continue to operate despite lower salmon prices. However, over time, this may create a political problem for the hatcheries, which depend upon enhancement taxes paid by fishermen on all catches—not just catches of hatchery fish—and which also depend upon the political support of commercial fishermen to address other issues which they face (discussed below).

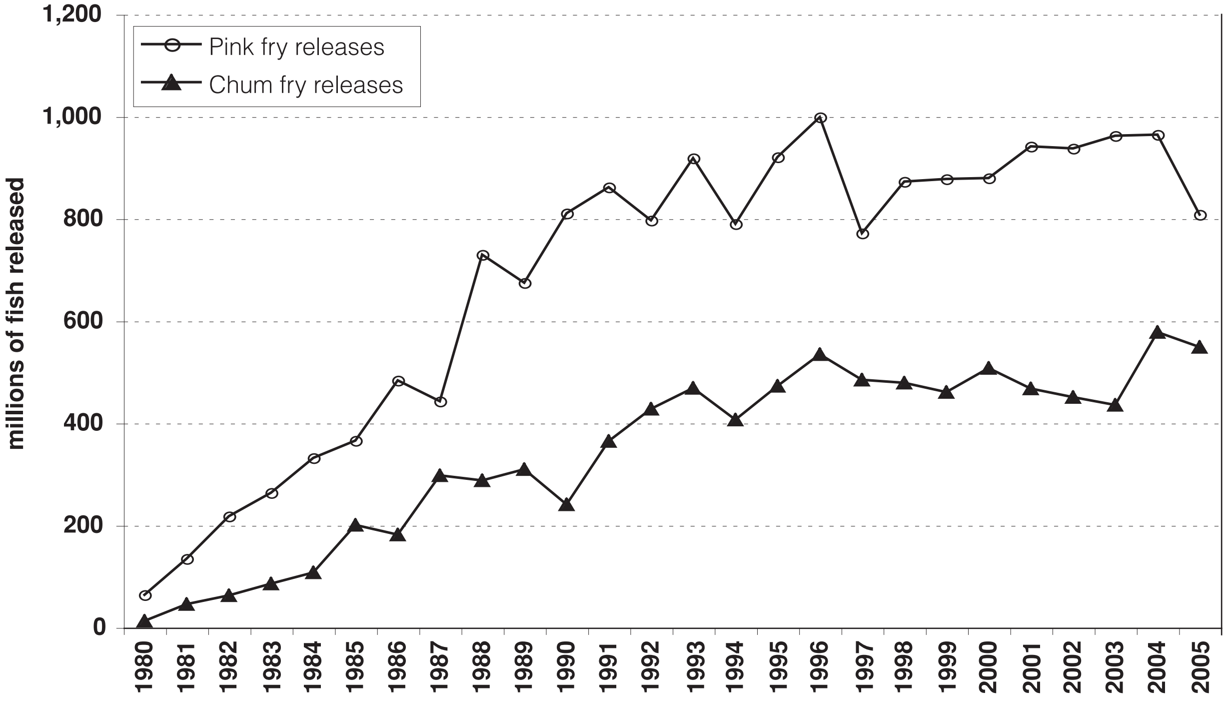
In addition to covering their operating costs, hatcheries also need to make payments on the loans they have received from the State of Alaska’s Fisheries Enhancement Revolving Loan Fund. During the early 1990s, as ex-vessel prices declined, many hatcheries requested and received permission to reschedule loan repayments. As Alaska’s oil revenues have declined, the State is less likely to extend this kind of assistance should hatcheries face financial difficulties in the future.

Figure IV-3 **Average Real Ex-Vessel Prices for Alaska Chum and Pink Salmon, 1980-2005**



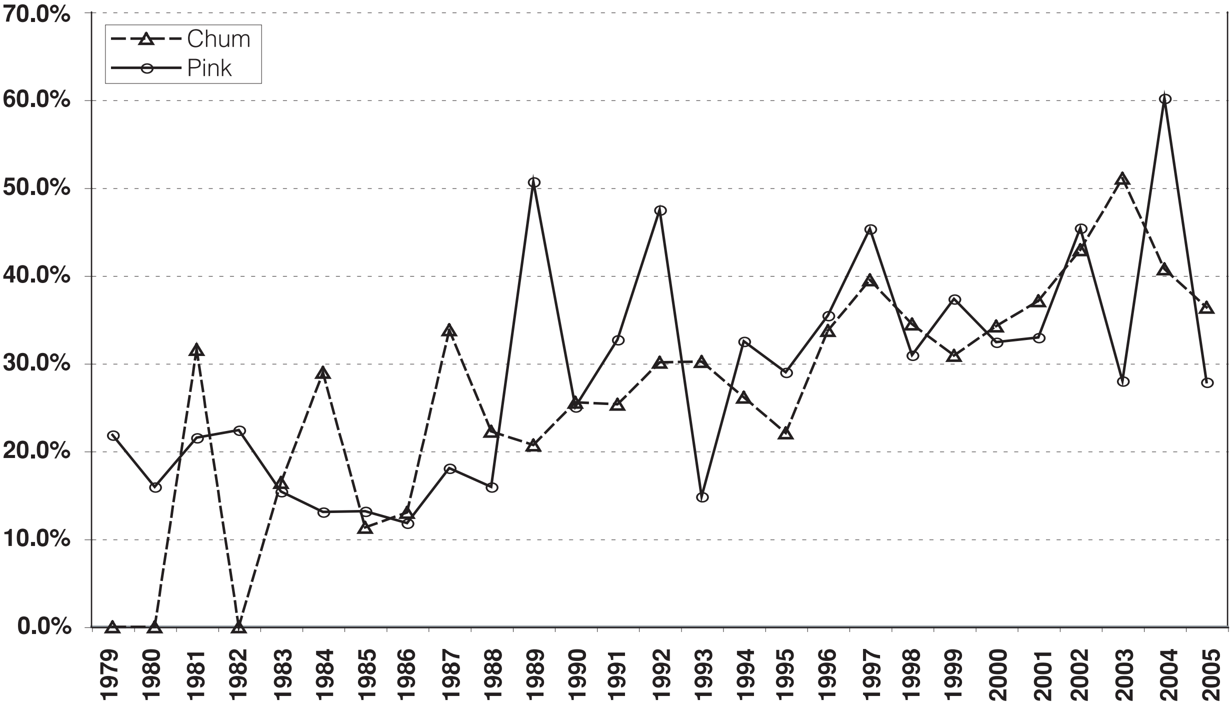
Source: ADFG Catch data. Adjusted for inflation based on Anchorage CPI.

Figure IV-4 **Alaska Hatchery Releases of Pink and Chum Salmon Fry, 1980-2005**



Source: ADFG Hatchery Data.

Figure IV-5 **Hatchery Cost-Recovery Share of Alaska Hatchery Salmon Catches**



Source: ADFG Hatchery Data.

Market Effects of Hatchery Production

As we discuss in future chapters, salmon prices are sensitive to total salmon supply.

During the 1990s, fishermen in regions of Alaska without hatchery production—in particular areas of interior and western Alaska dependent on chum salmon—argued that increased hatchery catches were responsible for the disastrous decline in prices which they had experienced. More generally, the question began to be raised whether Alaska salmon hatcheries were actually increasing the total value of Alaska salmon catches, or whether the value of the increased harvests was being offset by corresponding negative effects on prices.

How much Alaska hatchery catches may have depressed Alaska salmon prices, or whether or not hatcheries have actually increased the total ex-vessel value of Alaska salmon catches (not to mention net economic value after subtracting costs of hatchery operations) is not an easy question to answer. As we discuss in subsequent chapters, salmon markets are complex and are affected by many factors. In addition, they are subject to structural change, so that the effects of a given volume of hatchery catches on prices may have changed over time.[5]

In the short-term, higher catches in a given region in any given year tend to lower ex-vessel prices in that year. Over the longer term, prices are driven by world supply and demand rather than supply and demand from any particular region. If, as with hatchery production, other regions have the ability to respond to higher prices by increasing production, then higher or lower production by a particular region will not necessarily affect long-term world prices.

In general, it seems likely that Alaska hatchery production has had some negative effects on ex-vessel prices of chum and pink salmon, but that hatcheries are not the only factor contributing to lower prices. Clearly, hatcheries have benefited fishermen and processors in some areas (primarily Prince William Sound and Southeast Alaska) by greatly increasing catches. At the same time, hatcheries have not benefited, and may well have harmed, fishermen and processors in other areas without hatchery production. Thus, the Alaska salmon hatchery program has at times been an issue between different regions of Alaska.[6]

Roe "Stripping" or "Salvaging"

A particularly contentious issue associated with the Alaska salmon hatchery program has arisen as a result of declining prices for fresh, frozen and canned salmon while prices for salmon roe have remained strong. In some years the value of fresh, frozen and canned products have fallen below the costs of processing, particularly for lower-quality "dark" salmon caught in hatchery terminal areas after they have begun to undergo physiological changes associated with return to fresh water, and when unexpectedly large returns exceed local processing capacity. For these fish, the most economically profitable utilization is to extract the salmon roe but to dispose of the salmon carcass.

Normally, it is illegal to dispose of salmon harvested in Alaska without utilizing the fish, under a State law which bans the "waste" of commercially harvested fish. However, in some years hatcheries and processors have applied for exemptions from this law and have received permission to grind up and dispose of salmon carcasses at sea, after first removing valuable salmon roe. This practice is commonly referred to as "roe-stripping" or "roe-salvaging" depending on one's perspective on it.

This "dumping" of salmon has been strongly criticized by some segments of the Alaska salmon industry and the public who have argued that it is immoral to waste fish and that the "stripped" or "salvaged" roe competes unfairly with other roe production. Others have responded that utilizing the valuable salmon roe is better than the alternative of not harvesting the fish at all, in particular since returning hatchery fish provide no ecological benefit and large volumes of dead fish in hatchery terminal areas would pollute these areas.

One example of this issue occurred during the 2003 pink salmon season in Prince William Sound, when 49 million pink salmon were caught after a preseason harvest projection of 27 million fish. More than 4 million pink salmon (about 8 percent of the Prince William Sound pink salmon catch and about 3 percent of the total Alaska pink salmon catch) were ground and "recycled" after the eggs were removed (Tkacz 2003).

When low prices or lack of processing capacity lead to the disposal of hatchery fish after roe extraction, it usually contributes to adverse publicity for the salmon hatchery program and questioning whether the hatchery production is needed—adding to the other political issues faced by hatcheries.[7]

Effects of Hatcheries on Alaska Natural Wild Salmon

To minimize potential adverse effects of hatchery releases on natural wild runs, the State has established an extensive regional planning process for salmon enhancement and set strict conditions for egg collection, fish transport and release and management

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[5] Market effects of the Alaska hatchery program were addressed by Boyce et al. (1993) and Herrmann (1993). These analyses were critiqued by Wilen (1993).

[6] A different market-related issue is whether hatchery sales of cost-recovery catches may depress prices paid to local fishermen for both hatchery and natural wild fish caught in common-property fisheries.

[7] In an *Anchorage Daily News* article, a Prince William Sound fisherman who is a former chairman of the Alaska Seafood Marketing Institute was quoted as commenting: "It's just disappointing. . . We've got the mother of all runs, and we can't sell all of the fish. I'm worried. I'm worried that some fishermen and legislators in other areas might think it's a mistake to be generating these pink salmon, but we're pretty grateful for them around here for all the opportunity they create. Nobody anticipated this kind of return. We should not do anything knee-jerk about occasionally having overproduction." (Loy 2003).

of enhanced stocks. Hatcheries may only use eggs collected originally from local wild salmon stocks.[8]

However, as in other areas, some critics still question whether the Alaska salmon hatchery program may adversely affect Alaska's natural wild salmon runs. One concern relates to the potential for competition for food between hatchery salmon and natural wild salmon, both for juvenile fish in near-shore waters as well as in the open ocean.

Another set of issues relate to the management of commercial fisheries in which fishermen are catching mixed stocks of hatchery and natural wild salmon. If large returns of hatchery fish are mixed with depleted runs of natural wild fish, there is the potential for over-harvests of natural wild fish runs.

Another concern relates to the "straying" of returning hatchery fish into streams with natural runs of wild salmon, with the potential for genetic change in the natural wild salmon populations. For all of these concerns, the scientific complexity of the issues, together with lack of data and research, makes it difficult to determine how serious the potential problems associated with the hatchery program may or may not be.[9]

"Wild" Image of Alaska Salmon

An issue which may grow in importance over time is the effect of Alaska's salmon hatchery program on the "wild" image of Alaska salmon fisheries. The salmon farming industry has been subject to growing criticism over alleged adverse environmental effects as well as market effects on wild salmon fisheries. As we discuss in later chapters, the argument has been made that because of these alleged adverse effects of farmed salmon, consumers should favor wild salmon over farmed salmon. Over time, some salmon farmers may respond to these criticisms by pointing out problems associated with wild salmon. One response is likely to be that not all Alaska salmon are fully "wild," and that there are environmental and market issues associated with hatchery salmon as well as farmed salmon.[10] If this caused Alaska's hatchery program to become a concern for some consumers in the future, it could possibly reduce political support within Alaska for the hatchery program.

It should be noted that Alaska chum salmon, which account for by far the largest share of United States consumption of fresh and frozen Alaska wild salmon, is also the species most dependent on the Alaska hatchery program.

The Future of the Alaska Salmon Enhancement Program

The issues discussed above are the subject of an intense and long-running political debate about the Alaska salmon hatchery program, between supporters of the program and those who argue for substantially scaling back hatchery releases. The debate is not widely understood outside of Alaska or the salmon industry.

A series of special studies and task forces and special studies have examined the issues related to hatcheries, and at various times proposals to limit hatchery production have been debated before the Board of Fisheries. In 1991, a committee of the Alaska Senate undertook a special review of fisheries enhancement in Alaska, in order to "assemble and analyze information about the program and the global context in which it operates," and to "serve as the first step in ensuring that current and future enhancement efforts will be economically and biologically sound, while fulfilling the goals for which the program was established" (Alaska State Senate 1992). In 1996, a "Hatchery Policy Group" was appointed to review and make recommendations on state-wide hatchery production policy and hatchery loan policy (Gardiner 1996). In 2002, the Alaska legislature established a Joint Legislative Salmon Industry Task Force to review issues facing the salmon industry and make recommendations to the legislature. The Task Force formed a number of subcommittees, including a 'Hatchery Subcommittee' which was charged with examining Alaska hatchery policy issues.[11]

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[8] See McGee (1995) for a useful review of the planning process and state policies related to the hatchery program and protection of wild salmon.

[9] These concerns were summarized in Environment and Natural Resources Institute (2001): "Alaska's ocean-ranching salmon hatcheries operate amidst considerable uncertainty. Perhaps the most striking feature uncovered by this review was the many gaps in the scientific data from which one could fairly draw conclusions of the effects hatcheries may or may not have on wild salmon. Alaska has been successful in augmenting salmon harvest with hatchery-produced fish, but whether or not salmon biodiversity has been adequately protected in the process is unanswered. . . . With respect to fish-culture practices, Alaska's hatcheries are among the best in North America. . . . Given the late date at which Alaska's ocean-ranching program was established, the state was able to benefit from mistakes made elsewhere. The program started on better footing by having genetic oversight of operations through fish transport permits, hatchery siting, egg takes, broodstock development, etc." Nevertheless, the report concluded that, as a result of mixed-stock management issues, competition for resources between hatchery and wild salmon stocks, and potential effects on genetic diversity of wild salmon populations, "industrial-scale hatchery salmon production . . . could be jeopardizing Alaska's wild salmon."

[10] Dodd (2003) suggested that "the fish which the hatcheries produce for commercial fishermen undoubtedly eat sizeable quantities of prey species as they move up the feed chain towards harvest time, prey that would otherwise be available to truly 'wild' fish." Another example is provided by an article posted on the website of the Washington Fish Growers Association (www.wfga.net): "Salmon farming vs. salmon ranching is another interesting issue that likely doesn't make its way into the 'wild is good, farmed is bad' marketing campaign. In order to help maintain its commercial fishery, and enhance wild fish stocks, Alaska decided to forego the salmon farming route and do salmon ranching instead. Salmon ranching is a lot like salmon farming. Fish are raised in ocean-based pens, fed a steady diet of processed food (purchased in British Columbia, interestingly enough, and consumed at nearly six times the rate used in British Columbia fish-farm operations), fed some dyes important to their health and colour, also antibiotics. When they're big enough, they let them go. Alaska releases more than 1.5 billion "ranched" fish into the waters every year, and they happily swim away, competing for food with their natural-born cousins, and eventually get caught (along with the wild fish) in the commercial fishery. . ."

[11] Information about the activities of the Task Force, including proposed legislation developed by the task force, was posted on the website of the United Fishermen of Alaska, at www.ufa-fish.org/taskforce/.

Earlier task forces and studies have not resulted in major changes to the Alaska's hatchery program policies or the scale of hatchery releases. However, the underlying political issues remain and the debate over the program continues, even expanding into new fora. With the Marine Stewardship Council's (MSC) certification of the Alaska salmon fishery as a sustainable fishery (see Chapter XVI for a more thorough discussion), one of the concerns brought up in the certification process in 2000-2001 was the hatchery program. In particular, the assessment team was concerned about the lack of research on the potential effects of salmon hatcheries on the wild stock gene pool and reproductive fitness (Scientific Certification Systems 2000). This concern remained in 2005 as the Alaska salmon fishery entered its new five-year assessment for re-certification under the MSC program.

It is possible that Alaska hatchery salmon releases and catches could decline significantly in the future due to lower economic return of hatcheries and/or changing political circumstances. It is difficult to predict whether such a decline will in fact occur or when it might occur. It could be that hatchery salmon—as opposed to natural wild salmon—would be most affected by changing economic circumstances in wild fisheries.

The British Columbia Salmonid Enhancement Program

In 1977, in response to declining British Columbia salmon runs, the Canadian federal Department of Fisheries and Oceans (DFO) launched a Salmonid Enhancement Program (SEP). The program included both the construction of hatchery facilities as well as a variety of other habitat enhancement projects such as spawning channels, incubation boxes and lake enrichment.

DFO estimates that about 10-20 percent of the British Columbia sport and commercial salmon catch originates from SEP projects, and about a dozen terminal fisheries are dependent on enhanced stocks (DFO 2000a). A terminal fishery is one that occurs at the place where the hatchery salmon were released into fresh water.

In a 2000 review of the Salmonid Enhancement Program, the Pacific Fisheries Resource Conservation Council (PFRCC 2000; DFO 2000b) concluded that:

> *In hindsight, it is difficult to say whether the Salmonid Enhancement Program and its predecessors, which have accounted for close to a half-billion dollars in public investments over the years, have produced any net return on investment, if measured by a net gain of salmon. There is evidence to suggest a net loss of wild salmon abundance, directly and indirectly because of enhancement initiatives. . .*
>
> *The Council's review of the Salmonid Enhancement Program leads inevitably to the conclusion that some facilities created by it have resulted in the displacement of wild salmon by hatchery-produced fish. This has occurred when hatchery salmon have attracted fishing effort that unavoidably produced unsustainably high rates of harvest on co-migrating wild salmon. It has also occurred because juvenile fish from wild populations have been subjected to competition from hatchery fish in rearing areas, and in the ocean phase of the salmon life cycle.*
>
> *Declines in numerous wild-salmon populations, concurrent with increases in production from a few large hatcheries, tend to create a situation in which salmon abundance is attributable to ever-fewer stocks. This places the salmon resource at an increasingly greater risk of random, catastrophic disruption.*

History of Salmon Hatcheries in the U.S. Pacific Northwest

Hatchery techniques for the artificial propagation of Pacific salmon were developed for the first time in Canada around 1857 and soon spread to the United States (Bardach et al. 1972).

The construction and operation of the first hatcheries for Pacific salmon in the United States began on the McCloud River in northern California in 1872 and in 1877 and 1878 on the Clackamas and Rogue Rivers in Oregon (Atkinson 1988). In 1883, the first Canadian hatchery for Pacific salmon was built at Bon Accord (near New Westminster, British Columbia) on the Fraser River (PCSF 2004). The first hatchery in Washington State was built on the Kalama River in 1895 (WDFW 2004). Four years later, the Washington Department of Fish and Wildlife began the construction of salmon hatcheries in the mid-Columbia River region, on the Wenatchee and Methow Rivers (Wahle and Pearson 1984).

Hatcheries were originally built to reverse the trend of declining populations of wild salmon and to compensate for land use decisions that permanently altered large areas of fish habitat (WDFG 2004). Emphasis was initially placed on chinook and coho salmon despite an incomplete understanding of the complex life history of these species. Hatcheries propagated and stocked salmon for many years without concrete evidence of the success and long-term implications of their efforts.

Large-scale construction of salmon hatcheries began in 1938, when Congress passed the Mitchell Act to provide federal money for construction of hatcheries as a way of replacing the thousands of acres of salmon spawning grounds that were blocked or flooded behind dams. Subsequently, more than 80 hatcheries were built in the Columbia River basin (Novak 1998).

Currently, the State of Washington has one of the largest artificial propagation systems in the world, with a hatchery program that operates 24 complexes with 91 rearing facilities. Together they raise and release more than 201 million Pacific salmon, 8.5 million steelhead (salmon) trout and 22.6 million trout and warm-water fish (Maynard and Flagg 2001). Hatchery-bred fish help support the State's $850 million per year sportfishing industry (*The Wave News Network* 2004).

A group called the Hatchery Review Group unveiled a new blueprint for the State of Washington's hatchery programs on April 23, 2004 (*The Wave News Network* 2004). The blueprint cost $28 million to write and has more than 1,000 recommendations for improving the large salmon hatchery system. Examples include closing some hatcheries that are especially detrimental to wild stocks, and limiting the number of hatchery fish released so that they do not overrun wild stocks protected under the Endangered Species Act.

In addition, the state has 12 federal hatcheries and 35 tribal rearing facilities which produce another 50 million salmonids for release. In Oregon, the Department of Fish and Wildlife operates 34 hatcheries and 15 other rearing facilities, which release about 43 million Pacific salmon, 5.7 million steelhead (salmon) trout and 8.3 million trout. California has eight salmon and steelhead (salmon trout) hatcheries.

Depending on species and area, the salmon enhancement programs in the U.S. Pacific Northwest produce as much as 70 to 90% of salmon harvested in the commercial and recreational fisheries.

The potential for hatchery salmon to affect wild stocks went unrecognized for many years. Between the mid-1950s and early 1970s, scientists found increasing evidence that hatchery salmon was harming the remaining wild salmon runs. It seems clear now that hatcheries have had demographic, ecological and genetic impacts on wild salmon populations.

These effects include the reduction of genetic diversity within and between salmon populations, creation of mixed-population fisheries, altered behavior of fish, ecological imbalances due to the elimination of the nutritive contribution of carcasses of spawning salmon from streams, and the displacement of the remnants of wild runs (NRC 1996). As Hilborn (1992) notes:

> *Large-scale hatchery programs for salmonids in the Pacific Northwest have largely failed to provide the anticipated benefits; rather than benefiting the salmon populations, these programs may pose the greatest single threat to the long-term maintenance of salmonids… I argue that hatchery programs that attempt to add additional fish to existing healthy wild stocks are ill advised and highly dangerous.*

As a result, academic, environmental and salmon advocate groups have proposed a redesign of the traditional objectives of hatchery management, which needs to shift away from producing more fish for harvest towards providing a means for the recovery and conservation of wild salmon populations (LLTK 2004; NRC 1996).

It is worth noting that there have been a few attempts at private salmon ranching, such as Ore Aqua Foods, a subsidiary of Weyerhaeuser and Anadromous Inc., a subsidiary of British Petroleum, both operating in Oregon during the late 1970s and 1980s. Private salmon ranching is based on the premise that smolts released from the private hatchery will return and will be captured by the "owner" of the fish. These have been unsuccessful primarily because ocean mortality is high and uncertain, and property rights related to salmon released to the ocean are poorly defined. In addition to these problems, salmon enhancement (public or private) may undermine the management of wild stocks through direct and indirect competition.

The 2005 *Atlas of Pacific Salmon* summarized the breadth and complexity of the issues related to salmon hatcheries in the U.S. Pacific Northwest and elsewhere.

> *The benefits of hatcheries are compelling: they may offset losses in abundance in naturally spawning stocks and reduce harvest pressure on wild populations; they help stabilize commercial harvest; and they serve as laboratories for the study and preservation of biodiversity. Hatcheries also provide a solid economic base for salmon-dependent communities, including native peoples.*
>
> *Yet these benefits are counterbalanced with significant scientific uncertainty regarding freshwater and ocean carrying capacity, particularly within a trans-Pacific context . . . Interbreeding and brood stock transfer among rivers can challenge wild population viability and genetic integrity. Hatchery production can mask ecological problems at the heart of declines in wild populations. Artificial propagation can deprive rivers of marine-derived nutrients . . . essential to functioning freshwater ecosystems. Unfortunately, isolating impacts of hatchery fish on wild populations is extremely difficult, and so efforts to determine hatchery success or failure remain inconclusive.*
>
> *Two legislative debates—whether to count hatchery fish under endangered species legislation . . . and whether to allow surplus hatchery fish to spawn in the wild—have fulminated in recent years, underscoring the fact that hatchery management is among the most controversial issues in fisheries today.*

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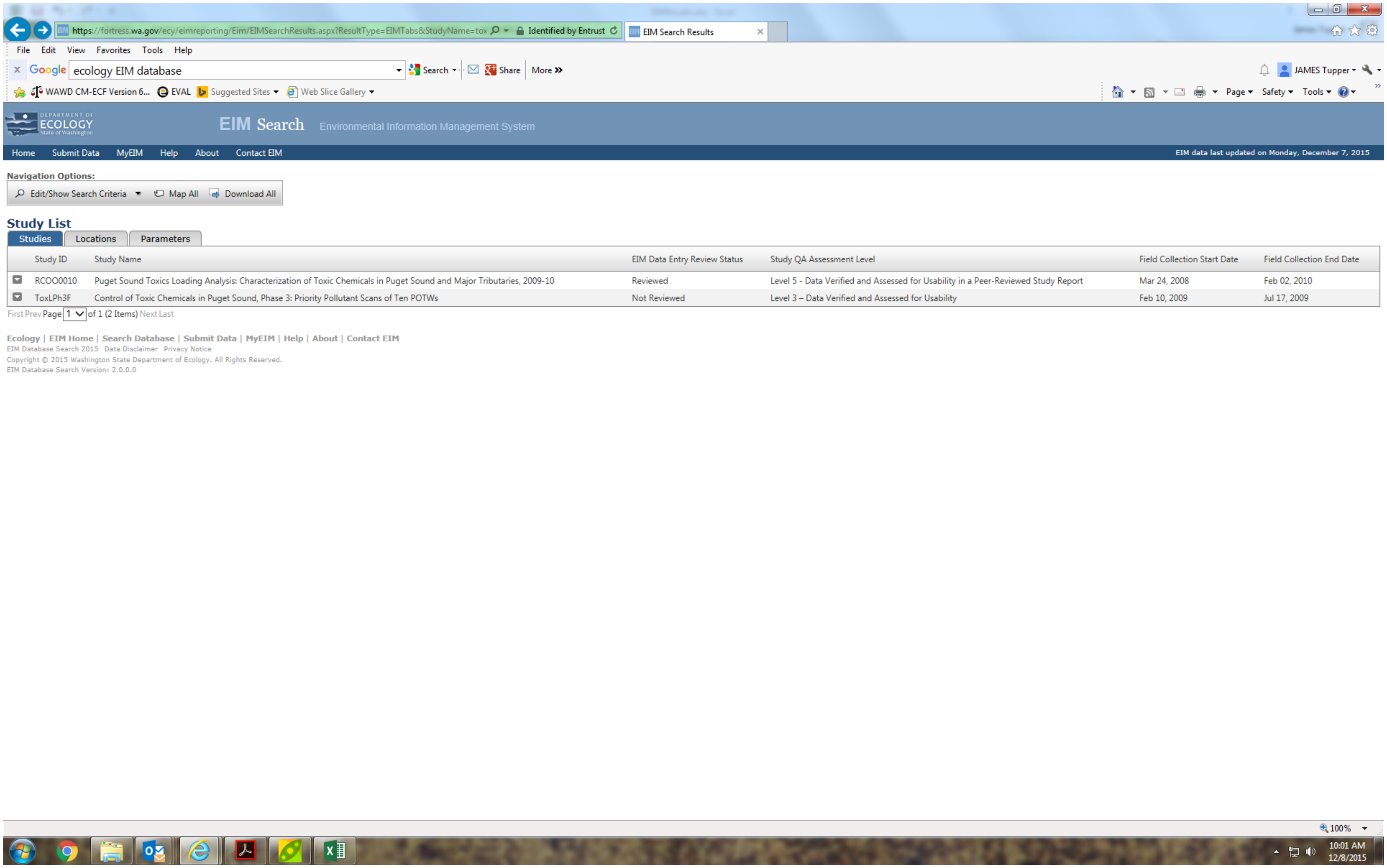

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
WATER

JUN 25 2004

Ms. Maxine I. Lipeles, J.D.
Director, Interdisciplinary Environmental Clinic
Washington University in St. Louis
1 Brookings Drive #1120
St. Louis, MO 63130

Dear Ms. Lipeles:

Thank you for your letter of February 25, 2003, to Administrator Whitman transmitting a petition on behalf of the Ozark Chapter of the Sierra Club requesting that the U.S. Environmental Protection Agency (EPA) set consistent and adequate water quality standards for defined portions of the Mississippi and Missouri rivers. EPA has carefully considered your petition and our formal response is enclosed.

In summary, EPA agrees with the Sierra Club that the Mississippi and Missouri Rivers are valuable resources that must be protected. After evaluating the currently approved water quality standards applicable to the petition area waters, the existing scientific knowledge for each pollutant at issue, and whether the affected states are working to establish or revise water quality standards in a manner that would address potential concerns, EPA is denying the Sierra Club's specific request but committing to further action.

In our discussions with you and the Sierra Club, you specified that two of your highest priority issues are numeric criteria for nutrients and bacteria. You also indicated that if federal promulgation of numeric nutrient criteria was not an option, you would like to see more federal leadership on nutrient issues in the petition area. In response to the petitioners' request to promulgate numeric nutrient criteria, we do not believe it is appropriate to promulgate numeric criteria for these specific waters until the science and the development of numeric nutrient criteria in the big rivers are better understood. However, in response to your request for more federal leadership, in addition to the ongoing work to address hypoxia in the Gulf of Mexico, EPA is committing to convene a multi-day national workshop to bring together states and others to discuss the development and adoption of appropriate ambient water quality criteria for nutrients for the Mississippi and Missouri Rivers to protect the rivers as well as the Gulf of Mexico. Following the workshop, EPA will publish a report that will summarize the results of the workshop, identify next steps, and establish a roadmap for how EPA would work with its partners to address nutrients in the Mississippi and Missouri Rivers. EPA has identified the necessary funds and will begin planning the workshop immediately with the intent to hold the

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workshop in 2005. EPA hopes that the Sierra Club and other stakeholders will actively participate in this effort to help ensure success. In the interim, EPA will continue to assist the states and invest additional resources in the development and adoption of nutrient criteria for the rivers' tributaries, with the expectation that state adoption and implementation of nutrient criteria for tributaries of the Mississippi and Missouri Rivers will lead to an overall reduction of nutrient loadings entering the petition area and thus flowing to the Gulf of Mexico.

With regard to the petitioners' request to promulgate bacteria criteria in the petition area, we are pleased to inform you that both Illinois and Missouri have sent EPA formal letters committing to adopt *E. coli* criteria for the petition area (among other waters) within their states. Missouri has committed to adopt *E.coli* criteria (as well as appropriate recreation uses) by July of 2005. Illinois has committed to initiate its rulemaking process to adopt *E. coli* criteria by September 30, 2004. The remaining six states have either adopted *E. coli* criteria or have proposed *E. coli* criteria in their state rulemaking process and are moving forward to adopt it into state regulation. If any state does not follow through on its commitment, EPA will, if necessary, promulgate water quality standards for the petition area within these states.

The Agency expects states to protect their waters consistent with the requirements of the Clean Water Act and the federal regulations. While EPA is not promulgating water quality standards for the petition area in response to the petition at this time, EPA is committed to continue to work with states and others to ensure these valuable waters are adequately protected.

We understand the Sierra Club's concern regarding the consistency, adequacy, and effective monitoring of water quality standards for the Mississippi and Missouri Rivers. I want to assure you EPA carefully considered the petition and the additional information you provided in our decision making process. If you would like to discuss your concerns further, please feel free to contact me at (202) 564-5700 or Geoffrey Grubbs, Director of the Office of Science and Technology at (202) 566-0430.

Sincerely,

[Signed by Ben Grumbles, June 25, 2004]

Benjamin H. Grumbles
Acting Assistant Administrator

Enclosure

cc. J. I. Palmer, Jr, Regional Administrator, Region 4
Bharat Mathur, Acting Regional Administrator, Region 5
Richard Greene, Regional Administrator, Region 6
James B. Gulliford, Regional Administrator, Region 7

DECISION ON PETITION FOR RULEMAKING TO PUBLISH WATER QUALITY STANDARDS FOR THE MISSISSIPPI AND MISSOURI RIVERS WITHIN ARKANSAS, ILLINOIS, IOWA, KANSAS, KENTUCKY, MISSOURI, NEBRASKA AND TENNESSEE

On February 26, 2003, the Ozark Chapter of the Sierra Club (hereafter Sierra Club or petitioner) submitted a petition to the United States Environmental Protection Agency (hereafter "EPA" or Agency) requesting that EPA publish water quality standards for the Mississippi and Missouri Rivers within the petition area. As described below, EPA has given careful consideration to the issues raised in the petition and its request but is HEREBY DENYING the petition for the reasons set forth below.

Petition for Rulemaking

On February 26, 2003, the Ozark Chapter of the Sierra Club submitted a petition requesting that EPA set consistent and adequate water quality standards for defined portions of the Mississippi and Missouri Rivers ("petition area"). The petition area includes portions of the Mississippi and Missouri Rivers in Arkansas, Illinois, Iowa, Kansas, Kentucky, Missouri, Nebraska, and Tennessee ("the petition states"). The Sierra Club submitted this petition pursuant to Paragraph 9 in the Settlement Agreement in American Canoe Ass'n v. Browner, 98-1195-CV-W and 98-482-CV-W (W.D. Mo.) (Effective date 2-27-01).

The petitioner summarizes its request as follows:

> Pursuant to the Settlement Agreement[1], the Ozark Chapter requests that, within one year of receipt of this petition, the EPA publish water quality standards for the Mississippi and Missouri Rivers within the petition area states. Such standards should be:
>
> 1) Consistent among the states on each river, such that no state impairs the ability of any other affected state (whether across-stream or downstream) to achieve its water quality standards; and
> 2) Adequate:
>   a) Including numeric criteria for chlordane, atrazine, polychlorinated biphenyls, *E. coli*, enterococci, conventionals (including dissolved oxygen and ammonia), nutrients, sediments, and an index of biological integrity for the aquatic community ("the petition pollutants"), among other criteria; and
>   b) Reflecting criteria sufficient to achieve and maintain fishable/swimmable water quality criteria.
> *3)* In addition, such standards should include monitoring requirements sufficient to support a uniform, statistically based method for determining whether the rivers are meeting their water quality standards. Petition at 2 – 3.

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[1] Settlement Agreement. American Canoe Ass'n v. Browner, 98-1195-CV-W and 98-482-CV-W (W.D.M.o). Effective date 2-27-01. The Settlement Agreement provides that EPA will "grant or deny" the petition within a year of its receipt. On February 26, 2004, the parties to the settlement agreed to extend the date by which EPA would respond to the petition to June 25, 2004.

Statutory and Regulatory Background

The Clean Water Act (CWA) establishes a comprehensive program "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." CWA section 101(a). The interim goal of the CWA is to attain water quality that provides for the protection and propagation of fish, shellfish, and wildlife. CWA section 101(a)(2).

The CWA section 303 requires states to adopt (subject to federal approval) water quality standards. The principle components of states' water quality standards are: (a) designated uses for waters, such as water supply, recreation, fish propagation, agriculture, and navigation; (b) water quality criteria, which define the amounts of pollutants the waters may contain without impairing their designated uses; and (c) antidegradation requirements, which protect existing uses and otherwise limit degradation of waters. CWA section 303(c)(2)(A) and 303(c)(2)(B), and 40 C.F.R. §§131.3(b), 131.3(f), 131.3(i), 131.6, 131.10-.11 (uses and criteria); and 40 C.F.R. §131.12 (antidegradation).

Designated Uses

Pursuant to CWA section 303(c)(2)(A) and 40 C.F.R. §131.10(a), states must designate appropriate water uses to be achieved and protected taking into consideration the use and value of water for public water supplies, protection and propagation of fish, shellfish, and wildlife, recreation in and on the water, agricultural, industrial, and other purposes including navigation. Where existing water quality standards specify designated uses less than those that are presently being attained, the state shall revise its standards to reflect the uses actually being attained. 40 C.F.R. §131.10(i). A state must conduct a use attainability analysis (UAA) where a state designates or has designated uses that do not include uses specified in section 101(a)(2) (sometimes referred to as "fishable/swimmable"), or where the state wishes to remove designated uses specified in section 101(a)(2), or to adopt subcategories of uses specified in section 101(a)(2) which require less stringent criteria. 40 C.F.R. §131.10(j).

Water Quality Criteria

The CWA section 304(a)(1) provides that EPA shall develop (and from time to time thereafter, revise) recommended water quality criteria based on current data and scientific judgment regarding the relationship between pollutant concentrations and environmental and human health effects. EPA's recommended section 304(a) criteria serve as guidance for states to use in deriving criteria to protect states' adopted designated uses.

EPA currently derives its section 304(a) water quality criteria for the protection of aquatic life using EPA's *Guidelines for the Derivation of Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* ("Guidelines") (Stephan et al. 1986. NTIS: PB85-227049). The Guidelines provide that each criterion is derived from the evaluation of toxicological data from a representative universe of species, allows for the inclusion of site-specific considerations, and results in a chemical concentration expected to be protective of aquatic life and their uses.

EPA currently derives its section 304(a) water quality criteria for the protection of human health using the *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)* ("Methodology") (EPA-822-B-00-004, www.epa.gov/waterscience/humanhealth/method). The Methodology details the necessary components of the risk assessment: hazard (cancer and non-cancer effects), exposure (from drinking water and fish consumption rates), and bioaccumulation (from measured or calculated bioaccumulation factors). The exposure component of criteria is based on consumption of contaminated aquatic organisms and drinking water. Many of the hazard identification and dose response assessments can be found in EPA's Integrated Risk Information System (IRIS)[2], a database that summarizes available toxicity data and contains EPA's assessment of the data. EPA establishes criteria at a recommended risk level for carcinogens; however, selection of a specific risk level is a risk management decision and EPA believes adoption of either a 10^{-6} or a 10^{-5} risk level represents an acceptable range of discretion for states and tribes[3].

The scientific efforts that lead to the publication of a final ambient water quality criterion for protection of either aquatic life or human health typically need 18 months or more to complete. EPA follows the procedures described in EPA's *Guidelines for the Derivation of Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* and the *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000)*, as well as Agency policy and procedures governing the development of scientific data and documents. This process includes an extensive search of peer reviewed literature, data quality evaluation, criterion and supporting documentation derivation, public scientific input, and peer review. Both the derivation process and the public and peer participation are critical to ensuring that the final section 304(a) criteria meet the clarity, transparency, and scientific rigor standards of the Agency. These steps ensure that the final criteria are scientifically defensible and that risk management decisions based on the criteria are legally defensible.

Ultimately, water quality criteria provide a basis for controlling discharges or releases of pollutants into surface waters. In establishing criteria, EPA's regulations require states to adopt water quality criteria to protect designated uses by adopting EPA's section 304(a) criteria recommendations, modifying EPA's section 304(a) criteria recommendation to reflect site-specific conditions, or deriving and adopting criteria based on other scientifically defensible methods. 40 C.F.R.§131.11. In addition, states may establish narrative criteria where numeric criteria cannot be established or to supplement numeric criteria.

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[2] U.S. Environmental Protection Agency. Integrated Risk Information System. < http://www.epa.gov/iriswebp/iris/index.html>

[3] U.S. Environmental Protection Agency. *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000).* Office of Water, Washington D.C., EPA-822-B-00-004. October 2000.

Under the regulations[4], narrative criteria have the same force and effect as numeric criteria. The National Pollutant Discharge Elimination System (NPDES) regulations require that the permitting authority establish water quality-based effluent limits for any parameters in the discharge of a point source that the permitting authority determines are or may be discharged at a level which will cause, have reasonable potential to cause, or contribute to an excursion above any applicable state water quality standards, including narrative criteria. 40 C.F.R. §122.44(d)(1)(i). EPA regulations specify three options for deriving a numeric effluent limitation for a particular parameter designed to implement a narrative criterion: (1) use a calculated numeric water quality criterion; (2) use EPA's section 304(a) water quality criteria on a case-by-case basis, supplemented by other relevant information; or (3) use an indicator parameter (see 40 C.F.R. §122.44(d)(1)(vi)). CWA section 303(d) requires states to identify water quality limited segments (i.e. impaired waters) that do not meet applicable water quality standards. For those water quality limited segments identified under 40 C.F.R. § 130.7, the CWA and EPA's regulations require states to develop Total Maximum Daily Loads (TMDLs) which specify the maximum pollution loads the water body can assimilate and still meet water quality standards. TMDLs also allocate these loads among the various pollution sources. For the purposes of CWA section 303(d), "applicable water quality standards refers to water quality standards established under CWA section 303 "…including numeric criteria, narrative criteria, [and] water body uses…" 40 C.F.R. §130.7(b)(3).

Protection of Downstream Uses

The federal regulations state, "In designating uses of a water body and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters." 40 C.F.R. §131.10(b). The regulations do not compel states to adopt the same criteria and uses, nor do they suggest that this is the only way a state can meet these requirements. The water quality program is structured to provide states with flexibility to determine the best way to meet their obligations under § 131.10(b).

Under the NPDES permitting regulations, no permit may be issued "when the imposition of conditions cannot ensure compliance with applicable water quality requirements of all affected States[.]" 40 C.F.R. §122.4(d). To obtain approval of a state NPDES program, the CWA requires the state to have the authority to notify other affected states of applications for permits and provide an opportunity for a hearing. CWA section 402(b)(3). Further, the state must allow any state whose waters may be affected by the discharge to submit recommendations. If the permitting state rejects the recommendations, it must notify the affected state and EPA Administrator. CWA section 402(b)(5). Where EPA determines the permitting state rejected the recommendations for inadequate reasons, EPA may exercise its discretionary authority to object to the permit. If the objection is not resolved, EPA may issue a federal permit. 40 C.F.R. §123.44 (c)(2).

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[4] 40 C.F.R. §122 and 40 C.F.R. §130

EPA's Authority and Role

Whenever a state adopts new or revised water quality standards, the state is required under the CWA section 303(c) to submit such standards to EPA for review and approval or disapproval. EPA reviews and approves or disapproves the water quality standards based on whether the standards meet the requirements of the CWA and federal regulations as discussed above.

If EPA determines that a new or revised water quality standard submitted for its review is consistent with the CWA's requirements, the standards "shall thereafter be the water quality standard for the applicable waters" of the state. If EPA determines that a new or revised water quality standard is inconsistent with the CWA's requirements, EPA is to notify the state of the relevant shortcomings (i.e. EPA will "disapprove" the state's water quality standards) and specify the changes needed to meet the CWA's requirements. The state then has ninety days to adopt the changes specified. CWA Section 303(c)(3). If such changes are not adopted, EPA is then required to promulgate a federal standard. In doing so, EPA shall "promptly prepare and publish proposed regulations setting forth a revised or new water quality standard for the navigable waters involved" and promulgate ninety days thereafter if the state still has not adopted water quality standards in accordance with the CWA. CWA Section 303(c)(4).

In addition to EPA's authority to review and approve new and revised water quality standards, EPA also has a separate, discretionary authority to promulgate federal water quality standards for a state if the Administrator determines that new or revised water quality standards are necessary to meet the requirements of the CWA. CWA Section 303(c)(4)(B), 40 C.F.R. §§131.5(b), 131.22(b). In its petition to EPA, the Sierra Club asks that the EPA Administrator exercise his discretionary authority under the Clean Water Act to correct the perceived deficiencies identified by the Sierra Club in its petition. Therefore, in deciding if promulgation of water quality standards is "necessary to meet the requirements of the CWA," EPA has evaluated whether the minimum requirements of the Act and the federal regulations (i.e., designated uses consistent with sections 101(a)(2) and 303(c)(2)(A) and criteria protective of those uses), are satisfied by the existing state water quality standards. Below, each of the specific issues raised by the Sierra Club are reviewed against this standard.

The structure of the Water Quality Standards program, as described, reflects Congress' intent to "recognize, preserve, and protect the primary responsibilities and rights of states to prevent, reduce, and eliminate pollution [and] to plan the development and use (including restoration, preservation and enhancement) of … water resources[.]" CWA Section 101(b). Accordingly, the CWA confers to the states primary authority for setting water quality standards. EPA's role is largely one of oversight, in which it reviews a state's new or revised water quality standards as they are adopted by the states and submitted to EPA. CWA Section 303(c). EPA exercises its discretionary authority under CWA section 303(c)(4)(B) only when the Administrator has determined that the existing state water quality standards are insufficient to meet the requirements of the CWA.

EPA's approach to evaluating the petition, state standards, and the need for Federally promulgated water quality standards

In determining how to respond to the petition, EPA considered the following:

(1) What are the currently approved water quality standards that apply to the petition area and what are the apparent differences in state water quality standards that the petitioner identifies?

EPA reviewed the petition and the addenda in the petition, which contain multiple tables comparing uses and criteria within the petition area. After reviewing this information, EPA conducted its own independent analysis of the currently approved state water quality standards.[5], [6]

(2) Are the water quality standards of the petition states inconsistent with the CWA? Do any differences in water quality standards among the petition states indicate the standards are inconsistent with the CWA?

As discussed earlier, the federal regulations do not compel states to adopt the same criteria and uses to meet the requirements of the Act. Therefore, differing water quality standards do not necessarily indicate that the water quality standards are inconsistent with the CWA. Where differences in water quality standards were confirmed in EPA's analysis, EPA examined whether the various state water quality standards nonetheless provided protection for the petition area waters. Such protection could be afforded in a number of ways. EPA looked to see if a state applies ambient water quality criteria, either as part of general standards that apply to all waters or criteria to protect another designated use that would protect the designated uses applicable to the petition area. EPA looked to see if a state might have implementation procedures outside of EPA approved water quality standards (e.g., procedures to derive numeric criteria) that would further describe how the state implements its water quality standards and whether this information would resolve any apparent inconsistencies/inadequacies. EPA also reexamined the state water quality standards to determine why the differences might exist. To do so, EPA compared state water quality criteria to EPA's previous section 304(a) criteria recommendations and looked at the assumptions/policy decisions that states used to determine if the criteria were derived using scientifically defensible methods.

(3) Are the differences in water quality standards a basis for environmental concern?

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[5] See Attachment A

[6] See Attachment B

Where EPA confirmed states have different designated uses and/or criteria for the petition area, EPA evaluated the degree of environmental concern linked to those specific differences. EPA evaluated the petition data to determine whether the petitioner identified any specific information to indicate where the differences were causing an environmental problem of concern. EPA then reviewed states' section 303(d) impaired waters lists for 2002 to see whether the states themselves identified segments within the petition area to be impaired by the petition pollutants. If a state identified the pollutant on the section 303(d) list, EPA then investigated whether any documented evidence exists to show that water from an upstream state or across stream state was the leading cause of the impairment even if that water body was meeting the upstream or across stream states' water quality standards.

(4) Is the current level of scientific knowledge sufficient to determine the criteria appropriate to adequately protect designated uses?

EPA investigated the current status of scientific knowledge for each pollutant identified by the petitioner. EPA first identified its most current section 304(a) criteria recommendation. EPA then considered where it is in the process to either revise its section 304(a) criteria recommendations or to derive a section 304(a) criteria recommendation for pollutants where one does not exist. EPA also evaluated the scientific understanding of these pollutants to determine whether the science is sufficient at this time to support federal or state development of numeric ambient water quality criteria for the petition area.

(5) Are the states working to revise their water quality standards in a way that would address the concerns of this petition?

Development and implementation of water quality standards to protect state waters are primarily the state's responsibilities. CWA section 101(b). EPA identified the instances where adjacent states adopted different ambient water quality criteria for pollutants that EPA has provided section 304(a) criteria recommendations and determined if these differences have the potential to cause adverse effects. In these cases, EPA evaluated whether the states are making a good faith effort to revise their water quality standards to address these concerns and incorporate the latest scientific knowledge.

Issues Identified by Petitioner and EPA's Response

1) Designated Uses

Petitioner's Position - The Sierra Club claims that while variations in designated uses are acceptable in some circumstances, states have designated uses throughout the petition area that vary inappropriately. The petitioner maintains that as a result of these inconsistencies, "when downstream states designate these interstate rivers for uses such as drinking water, fishing, and contact recreation, but upstream states do not protect for those uses, downstream states may be unable to achieve their water quality standards." Petition at 12. In the petition, the Sierra Club specifically identifies that, unlike their surrounding states, Kentucky does not designate the Mississippi River for drinking water, Iowa does not designate the Mississippi or Missouri Rivers for a fishing use, and Missouri does not designate the Mississippi or Missouri Rivers for primary contact recreation. The Sierra Club also claims that Iowa designates one portion of the Missouri River for non-contact recreation whereas stretches above and below that portion of the river are classified for primary contact recreation. Petition at 10 – 11. The petitioner requests that EPA use its authority under the CWA section 303(c)(4) to promulgate water quality standards applicable to the Mississippi and Missouri Rivers in the eight state region around the rivers' confluence. Such standards should be consistent among the states on each river, such that no state impairs the ability of any other affected state (whether across-stream or downstream) to achieve its water quality standards. Petition at 1 and 3.

EPA Response – For the reasons provided below, EPA concludes that it is unnecessary to federally promulgate, at this time, any designated uses for the petition area to meet the requirements of the CWA section 303(c) or the federal water quality standards regulations at 40 C.F.R. Part 131.

a) Aquatic life Use

In the petition, the Sierra Club did not discuss any specific concerns regarding the designated aquatic life uses within the petition area. However, tables contained in the petition's addenda (see addenda 6 and 7), showed that some petition states designate aquatic life uses for the petition area differently from their neighboring states.

The Sierra Club's addenda show that all states within the petition area designate an aquatic life use to these waters but label the uses differently. To understand the significance of these differences, EPA evaluated the currently approved state water quality standards to determine whether the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of aquatic life uses is necessary. EPA found that while the specific terms used by each state may differ (e.g., Significant Resource Warm Water (IA), Warm Water Aquatic Habitat (KY), Perennial Delta Fishery (AR))[7], each state designates uses to protect aquatic life consistent with the CWA and federal regulations. Based on this information, EPA determined that each state designates a use to provide for the protection and propagation of fish, shellfish, and wildlife. Therefore, EPA does not believe it is necessary to federally promulgate, at this time, aquatic life uses for the petition area to meet the requirements of the CWA under CWA section 303(c)(4)(B).

b) Drinking water supply

The Sierra Club points out in the designated use section of the petition that Kentucky does not designate the Mississippi River for drinking water uses whereas surrounding states have

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[7] See Attachment B

made such a designation. Petition at 10. Addendum 6 of the petition also indicates that Tennessee does not designate a drinking water use for the segment of Mississippi River from the upstream end of the Loosahatchie Bar to the Mississippi/Tennessee state line. The petitioner did not provide any specific evidence of adverse impacts on drinking water uses resulting from these differences. EPA evaluated the information contained in the petition and the currently approved state water quality standards to determine if the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of drinking water uses is necessary. To assess the potential for human health impacts, EPA also identified the drinking water intake locations and assessed whether there is any evidence that the drinking water use at these intakes is impaired as a result of different water quality standards within the petition area.

EPA found that where segments of the Mississippi and Missouri Rivers in the petition area are used for drinking water (i.e., drinking water intakes exist) states have designated those segments for a drinking water use. Kentucky does not designate its portion of the Mississippi River for drinking water supply because the state does not use the Mississippi River as a source of drinking water. Tennessee does not designate the segment of the Mississippi River from the upstream end of Loosahatchie Bar to the Mississippi/Tennessee state line as drinking water because they do not use this segment for drinking water. This Tennessee segment, however, while identified in addendum 6, is not within this petition area as defined in the petition. Therefore, EPA will not address this segment further in its response.

Since Kentucky does not designate the Mississippi River for a drinking water source, EPA evaluated whether an across stream or downstream state's drinking water uses are impaired by Kentucky's lack of designated drinking water use. While it is true that Missouri and Tennessee designate the Mississippi River located within the petition area for a drinking water use, EPA confirmed that Missouri does not have any drinking water intakes along the Mississippi River located across from Kentucky (Cape Girardeau south to Kentucky/Tennessee border) and Tennessee (which is downstream of Kentucky) does not have any drinking water intakes at all along the Mississippi River. In addition, neither Missouri nor Tennessee lists the drinking water uses on the Mississippi River within their jurisdiction as impaired. Therefore, EPA concludes that Kentucky's lack of a drinking water use is not preventing a downstream or across stream state from attaining and maintaining a drinking water use since there are no drinking water intakes or drinking water use impairments downstream or across stream from Kentucky. Therefore, Kentucky's lack of a public water supply designated use is consistent with the CWA and federal regulations at 40 C.F.R. §131.10(b). EPA concludes it is unnecessary to federally promulgate, at this time, drinking water uses for Kentucky within the petition area to meet the requirements of the CWA under CWA section 303(c)(4)(B).

c) Fish Consumption

The Sierra Club asserts that Iowa does not designate the Mississippi and Missouri Rivers for fish consumption although its waters are adjacent to Illinois, which the Sierra Club indicates has designated a fish consumption use. Petition at 10 – 11. Addenda 6 and 7, however, show that Illinois does not designate the Mississippi River for fishing. EPA evaluated this information and the currently approved state water quality standards to determine if the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of fish consumption uses is necessary.[8] EPA first looked to see which states explicitly designate fish consumption as a use applicable to the petition area. For those states that do not, EPA evaluated the states' water quality standards to determine whether the criteria applicable to the petition area protect fish consumption uses in the petition area.

Missouri's aquatic life use is labeled Warm Water and Human Health Fish Consumption. Kansas designates the Missouri River for Food Procurement which is defined as "the use of surface waters other than stream segments for obtaining edible forms of aquatic or semiaquatic life for human consumption"[9], thus protecting human health for fish consumption. The remaining six states (Kentucky, Tennessee, Iowa, Nebraska, Illinois and Arkansas) do not explicitly designate fish consumption as a use within the petition area; however, all six of these states apply ambient water quality criteria to the petition area applicable to all surface waters or to protect another designated use that were derived to protect humans from possible risks posed by fish consumption. For example, Kentucky's minimum criteria applicable to all surface waters includes water quality criteria for the protection of human health from the consumption of fish tissue (See 401 KAR 5:031 Surface Water Standards, Section 2 Minimum Criteria Applicable to Surface Waters, Table 1 Water Quality Criteria for the Protection of Human Health from the Consumption of Fish Tissue).[10]

With regard to the Sierra Club's specific concern that Iowa lacks a fish consumption use, Iowa's Class B (WW) or Warm Water Aquatic Life use, which applies to both the Mississippi and Missouri Rivers within the petition area, includes a narrative provision (see Iowa State Standards at 567 IAC 61.3(1)(b)(4)) to prohibit the contamination of fish tissue which would present a hazard to human health as well as numeric water quality criteria for specific pollutants intended to protect human health from possible risks posed by fish consumption (See Iowa State Standards, 567 IAC 61.3(3) Table 1).

EPA concludes that while all the petition states do not specifically designate the petition area for fish consumption, all petition states apply human health criteria to protect humans from possible risks posed by fish consumption and therefore effectively protect fish consumption uses consistent with the CWA and federal regulations at 40 C.F.R. Part 131. Therefore, it is unnecessary for EPA to federally promulgate, at this time, a fish consumption use for any state within the petition area to meet the requirements of the CWA under CWA section 303(c)(4)(B).

d) Recreation

The Sierra Club points out that Missouri designates the Mississippi and Missouri Rivers for secondary contact recreation use while surrounding states designate the waters for primary contact recreation use. The petition further states that one portion of the Missouri River in Iowa's jurisdiction is designated for non-contact recreation instead of primary contact recreation

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[8] See Attachment B

[9] See Attachment A

[10] See Attachment A

uses. Petition at 10 – 11. Addenda 6 and 7 reiterate this information. EPA evaluated this information and the currently approved state water quality standards to determine if the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of recreation uses is necessary.[11] EPA first reviewed each state's water quality standards to determine what recreation uses and associated criteria apply to protect these uses. Where EPA found a primary contact recreation use and/or the associated ambient water quality criteria absent, EPA discussed its findings with the state to determine whether the state intended to revise its water quality standards in the near future, and if that revision would resolve the issue identified in this petition.

EPA's analysis shows that Illinois, Kentucky, Tennessee, Arkansas, Nebraska, Kansas, and Iowa have all adopted primary contact recreation uses and the water quality criteria to protect a primary contact recreation use for all segments of the Mississippi and/or Missouri Rivers within the petition area. While the petitioner identifies Iowa as not applying a primary contact use to one segment along the Missouri River, EPA's analysis showed that Iowa has designated all portions of the Missouri River within the petition area for primary contact recreation. The stretch of the Missouri River within Iowa's jurisdiction flows from the confluence with the Big Sioux River to the Iowa/Missouri state line. Iowa's water quality standards specifically state that the Missouri River from the Iowa/Missouri state line to the confluence with the Big Sioux River is designated for Class A (waters "to be protected for primary contact recreation"), among other uses (See Iowa State Standards, 567 IAC 61.3(5)(e)).

On October 14, 2003, the Missouri Coalition for the Environment filed a lawsuit against EPA alleging that EPA has a duty to promulgate water quality standards for Missouri. One of the issues raised in the lawsuit is Missouri's lack of primary contact recreation uses. The state of Missouri has provided EPA a letter committing to adopt a primary contact use (labeled "whole body contact" by the state of Missouri) for the waters within the petition area (among others in the state). Missouri has committed to completing its rulemaking process to adopt such uses by July of 2005.

To summarize, seven of the eight petition states have adopted primary contact recreation uses for the petition area consistent with the CWA and federal regulations at 40 C.F.R. Part 131 and Missouri has initiated a rulemaking process to adopt primary contact uses for the petition area by January 2005, for the petition area. For this reason, EPA concludes that it is unnecessary for EPA to federally promulgate, at this time, a primary contact use for Missouri or Iowa within the petition area to meet the requirements of the CWA under CWA section 303(c)(4)(B) in response to this petition.

e) *Agriculture, Aesthetics, Irrigation, Livestock & Wildlife watering, Navigation, Industrial uses*

In the petition, the Sierra Club did not identify any specific instances where states designated agriculture, aesthetic, irrigation, livestock and watering, navigation or industrial uses to the petition area differently. However, tables contained in the petition's

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[11] See Attachment B

addenda (see addenda 6 and 7), showed some differences in how petition states designate these uses for the petition area.

The addenda show differences among the states' designations for agriculture, aesthetics, irrigation, livestock and wildlife watering, navigation, and industrial uses. For example, while Iowa, Illinois, Arkansas and Tennessee designate the Mississippi River within the petition area for agricultural uses, Missouri does not. To understand the significance of these differences, EPA evaluated the currently approved state water quality standards to determine whether the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of any of these uses is necessary. Based on a review of the petition states' approved water quality standards[12], the criteria adopted to protect aquatic life uses are more stringent than the criteria that are or would be applied to protect agriculture, aesthetics, irrigation, livestock and wildlife watering, navigation, or industrial uses within the petition area. Therefore, EPA concludes that the most stringent criteria that the states apply to the petition area to protect aquatic life will also protect agriculture, aesthetics, irrigation, livestock and wildlife watering, navigation and industrial uses wherever they have been designated in the petition area. Accordingly, it is not necessary for EPA to promulgate, at this time, any of these uses for the petition area to meet the requirements of the CWA under CWA section 303(c)(4)(B).

2) Water Quality Criteria

Petitioner's Position – In addition to the concerns regarding designated uses, the Sierra Club asserts that the problems in the petition area are compounded by states applying different criteria or no criteria to protect designated uses even in the situations where the underlying designated uses are equivalent. The Sierra Club specifically identifies the following pollutants at issue: chlordane, atrazine, polychlorinated biphenyls, *E. coli*, enterococci, dissolved oxygen, ammonia, nutrients, and sediments. They also identify the need for an index of biological integrity for the aquatic community. Petition at 3. The petitioner requests that EPA exercise its authority under section 303(c)(4) of the CWA to promulgate water quality standards applicable to the Mississippi and Missouri Rivers in an eight state region around the rivers' confluence. EPA should set standards that are adequate to achieve the CWA's fishable/swimmable requirements.

EPA's Response – EPA evaluated the currently approved water quality criteria within the petition area for chlordane, atrazine, polychlorinated biphenyls, *E. coli*, enterococci, dissolved oxygen, ammonia, nutrients, sediments, and an index of biological integrity for the aquatic community to determine if the criteria are consistent with the requirements of the CWA section 303(c) and the federal water quality standards regulations at 40 C.F.R. Part 131. These criteria were identified in Paragraph 9 of the Settlement Agreement in American Canoe Ass'n v. Browner, 98-1195-CV-W (W.D. Mo.) (effective date 2-27-01), as well as in the Sierra Club's petition. EPA finds that the petitioner has not demonstrated that a federal promulgation of new or revised water quality criteria for the

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[12] See Attachment A

petition area is needed to meet the requirements of the CWA and the federal regulations. Therefore, EPA denies the petitioner's request to promulgate any numeric water quality criteria, at this time, for the pollutants specifically identified by the petitioner, to apply to the petition area. EPA's detailed rationale for its conclusions regarding each of the pollutants is discussed in greater detail in the following paragraphs.

a) Atrazine

Aquatic Life Protection. The petition does not identify any specific concerns with the petition states' atrazine criteria for the protection of aquatic life. Addendum 8 of the petition describes the atrazine criteria that the states have adopted for the Mississippi River. It shows that none of the states along the Mississippi River have adopted numeric atrazine criteria to protect aquatic life uses (or any other use, except drinking water, as discussed below). Neither the petition nor the addenda contain any information or discussion of atrazine criteria to protect aquatic life uses on the Missouri River.

EPA evaluated this information as well as the currently approved state water quality standards to determine if the state water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of numeric atrazine criteria for the protection of aquatic life is necessary for the petition area. EPA first reviewed the states' currently adopted and approved water quality standards to validate the petitioner's findings. Specifically, EPA looked to see whether any states have adopted numeric or narrative atrazine criteria to protect aquatic life. EPA also reviewed the petition states' 2002 section 303(d) lists[13] to determine if any state identified atrazine as a pollutant responsible for impairing an aquatic life use. Finally, EPA evaluated the scientific understanding of atrazine to determine if the science is sufficient at this time to support EPA or state development of numeric ambient water quality criteria for the protection of aquatic life.

According to EPA's evaluation of the states' water quality standards, all eight of the petition states currently have narrative criteria related to toxic pollutants that may be used for establishing NPDES permits, listing waters as impaired by atrazine on section 303(d) lists and developing TMDLs, if necessary. As discussed earlier in the "Statutory and Regulatory Background" section, narrative criteria may form the regulatory basis for these purposes. While the petition's addendum 8 indicates that no state has adopted numeric atrazine criteria, EPA found that three states, Illinois, Nebraska and Kansas, have numeric aquatic life criteria for atrazine.[14] Illinois has an EPA approved procedure for implementing their narrative criteria at Title 35, Subtitle C, Chapter 1, Section 302.210 in Illinois' water quality standards. This procedure derives numeric values to be used as ambient water quality criteria for toxic pollutants, including atrazine.[15] Nebraska

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[13] See Attachment G

[14] See Attachment B

[15] Derived Water Quality Criteria, Illinois Environmental Protection Agency <http://www.epa.state.il.us/water/water-quality-standards/water-quality-criteria.html>

and Kansas have explicitly adopted ambient water quality criteria for atrazine.[16] However, these states adopted criteria at the state's own initiative without the benefit of a final EPA CWA section 304(a) criteria recommendation. These states exercised their discretion to adopt a numeric criterion for atrazine based on other scientifically defensible methods. None of the petition states identified (nor has EPA proposed to identify) atrazine as an impairing pollutant within the petition area on their 2002 section 303(d) impaired waters list.[17]

On November 7, 2003, EPA released and requested scientific views on a revised draft ambient water quality criteria document for atrazine to protect aquatic life. This document provides EPA's draft acute and chronic criteria recommendations for atrazine designed to protect aquatic life in both freshwater and saltwater. The revised draft criteria incorporate toxicity information for atrazine that had not been available at the time EPA published its 2001 draft recommendations (see EPA's website at http://www.epa.gov/waterscience/criteria/atrazine/). In addition to revising the 2001 draft criteria recommendations to reflect scientific views EPA received from the public during the comment period, the Office of Water has been closely coordinating with the Office of Pesticide Programs (OPP) to ensure that the draft ambient water quality criteria recommendation is consistent with OPP's ecological risk assessment. OPP used its ecological risk assessment for atrazine to ensure that its decision to reregister atrazine did not result in unreasonable adverse effects.

Since EPA is currently in the process of developing a final numeric atrazine water quality criterion to protect aquatic life and atrazine may be controlled, if necessary, in all petition states based on narrative criteria where numeric atrazine criteria to protect aquatic life uses do not exist, EPA concludes that it is not necessary for EPA to promulgate numeric atrazine criteria to protect aquatic life for the petition area, at this time, to meet the requirements of the CWA under CWA section 303(c)(4)(B). Once EPA's recommendations are finalized, it is EPA's policy to allow states an appropriate amount of time to incorporate EPA's newest recommendations into their water quality standards. When EPA's section 304(a) atrazine criterion to protect aquatic life is final and states have had appropriate time to incorporate the updated science into their water quality standards, EPA will evaluate the need for a federal promulgation where it is determined that atrazine criteria are necessary to protect designated uses in the petition area.

Human Health Protection. The Sierra Club's addendum 8 shows that Iowa, Missouri and Tennessee have adopted an ambient water quality criterion for atrazine of 3 µg/L to protect drinking water supplies along the Mississippi River while Arkansas, Illinois and Kentucky have not adopted numeric criteria for atrazine. In the petition's water quality criteria section, the Sierra Club specifically expresses a concern that Kentucky, the only state that does not designate the Mississippi River for a drinking water use, does not have a numeric criterion for atrazine to protect public health. The petition does not discuss atrazine criteria to protect human health on the Missouri River.

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[16] See Attachment B
[17] See Attachment G

EPA evaluated this information as well as the currently approved state water quality standards to determine if the state water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of numeric atrazine criteria for the protection of human health is necessary for the petition area. EPA first reviewed the states' currently adopted and approved water quality standards to validate the petitioner's findings. Specifically, EPA looked to see if any states have adopted numeric atrazine criteria to protect human health. EPA also reviewed the 2002 section 303(d) lists[18] to determine if any state identified atrazine as a pollutant responsible for impairing human health uses. Finally, EPA evaluated the scientific understanding of atrazine to determine if the science is sufficient at this time to support EPA or state development of numeric ambient water quality criteria to protect human health.

According to EPA's evaluation of the states' water quality standards, all of the petition area states along the Missouri River (Iowa, Nebraska, Missouri, and Kansas) apply 3 µg/l to protect public water supplies. Iowa, Missouri, and Tennessee have adopted 3 µg/l into their water quality standards to protect public water supplies on the Mississippi River. Kentucky, Illinois, and Arkansas have not adopted numeric water quality criteria for atrazine to protect human health. All eight of the petition states currently have narrative criteria related to toxic pollutants that may be used for establishing NPDES permits and TMDLs, if necessary. As discussed earlier in the "Statutory and Regulatory Background" section, narrative criteria can form the regulatory basis for these purposes. No state within the petition area has included atrazine as a pollutant on their section 303(d) impaired waters list nor did the petitioner raise any specific instances of concern in the petition.

The ambient water quality criterion of 3 µg/l that five of the eight petition area states have adopted to protect public water supplies is based on EPA's maximum contaminant level (MCL) published under § 1412(b)(4) of the Safe Drinking Water Act that applies to treated drinking water, not to ambient surface waters. EPA has not yet developed ambient water quality criteria recommendations for atrazine to protect human health under section 304(a) of the CWA because the science necessary to develop appropriate criteria for surface waters is not yet complete. Currently, the Agency is reassessing the available toxicity information on atrazine (OPP recently conducted a human health risk assessment for atrazine and concluded that there was a reasonable certainty of no harm from the reregistration of atrazine). Once this scientific evaluation is completed, EPA will consider developing ambient water quality criteria for atrazine. In the interim, states continue to have the discretion to adopt a numeric criterion for surface waters to protect human health based on other information, such as MCLs.[19]

In response to the petitioner's specific concern with respect to Kentucky, EPA concludes that since Kentucky does not use the Mississippi River as a drinking water

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[18] See Attachment G

[19] U.S. Environmental Protection Agency. 1994. *Water Quality Standards Handbook: Second Edition.* Office of Water, Washington, D.C. EPA-823-B-94-005a.

source, there are no drinking water intakes across or immediately downstream from Kentucky, and Kentucky could use narrative criteria to control atrazine if necessary, Kentucky's water quality standards are consistent with the CWA and federal regulations. Therefore, it is unnecessary for EPA to federally promulgate numeric atrazine criteria for Kentucky to protect human health uses, at this time, to meet the requirements of the CWA under CWA section 303(c)(4)(B).

With regard to Illinois and Arkansas, EPA concludes that a federal promulgation is unnecessary, at this time, to meet the requirements of the CWA CWA section 303(c)(4)(B). This conclusion is based on the following facts: The science is currently under review in preparation for criteria development; the states have not specifically identified atrazine as a pollutant impairing human health uses on their impaired waters list; the petitioner has not identified any specific concerns; and the petition states' current narrative criteria provide a basis for pollutant control in the absence of numeric criteria to protect local and downstream water quality standards (40 C.F.R. §131.10(b)), if necessary. However, once EPA issues section 304(a) criteria recommendations for atrazine for the protection of human health and EPA has provided states appropriate time to incorporate the latest science into water quality standards, EPA will reevaluate the need for a federal promulgation where it is determined that atrazine criteria are necessary to protect designated uses in the petition area.

b) PCBs

The Sierra Club identifies a specific concern regarding PCB criteria for two states, Iowa and Nebraska, both of which are upstream of Missouri on the Mississippi River and the Missouri River, respectively. The Sierra Club points out that Iowa's and Nebraska's PCB criteria are nearly ten times less stringent than Missouri's PCB criteria. Petition at 13 - 14. Addenda 10 and 11 of the petition provide tables describing the PCB criterion that each petition state applies to the petition area, as evaluated by the Sierra Club, and shows that the petition states have adopted varying criteria to protect their designated uses.

EPA evaluated the information provided by the petitioner as well as the currently approved state water quality standards for all petition states to determine if the PCB criteria in the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of numeric PCB criteria is necessary. EPA first reviewed the states' currently adopted and approved water quality standards to validate the petitioner's findings. Specifically, EPA identified exactly what numeric and/or narrative PCB criteria states have currently adopted to apply to the petition area.[20] EPA then investigated the basis for these criteria to determine if the states had adopted criteria based on EPA's recommendations or on other scientifically defensible methods. Finally, EPA looked for any documented evidence that may suggest the differences in criteria are preventing a downstream or across stream state from attaining and maintaining its water quality standards.

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[20] See Attachment B

Adverse human health effects are expected at much lower concentrations of PCBs than in aquatic life. As a result, EPA's CWA section 304(a) criteria recommendations for PCB to protect human health have generally been more stringent than those to protect aquatic life. In the case where states have adopted PCB criteria to protect both human health and aquatic life, the criteria to protect human health are more likely to drive regulatory decisions. Therefore, in its evaluation of currently approved PCB criteria, EPA focused on whether the states have adopted numeric criteria for PCBs to protect human health-related designated uses. EPA acknowledges there are variations in the numeric PCB criteria adopted by the petition states. There are four legitimate reasons why the numeric PCB criteria vary within the petition area:

(1) EPA published section 304(a) criteria recommendations several times over the past 20 years. EPA's revised section 304(a) criteria recommendations reflect the most current scientific knowledge but do not always result in more stringent criteria recommendations (e.g., EPA's 1999 section 304(a) recommendations for PCB were less stringent than its 1986 section 304(a) recommendations.)[21,22] States have adopted and revised PCB criteria at different points in time. The criteria the petition states adopted depended on the recommendations and information available at that time. For example, Kentucky and Kansas adopted human health criteria based on EPA's 1986 section 304(a) criteria recommendation while Nebraska (which evaluates the aquatic life and human health criteria and adopts whichever one is most stringent) adopted human health criteria based on EPA's 1992 National Toxics Rule (See 40 C.F.R. §131.36). These values were also published as section 304(a) criteria in 1999. On the Missouri River, even though Kansas' human health criterion for PCB is more stringent than Nebraska's (the upstream state), Nebraska's criterion is in fact based on more recent science. Therefore, comparing stringency of criteria is not an adequate method of determining whether states have appropriate criteria to protect the designated uses or whether they are providing for the attainment and maintenance of downstream water quality standards as required under 40 C.F.R. §131.10(b).

(2) While EPA did not publish revised section 304(a) criteria for PCBs between 1986 and 1999, EPA updated toxicity information for PCBs in EPA's IRIS[23] database in 1989. As a result, Iowa, Missouri, Arkansas, and Tennessee took EPA's 1986 section 304(a) criteria recommendations and incorporated the new toxicity information from IRIS to derive a revised ambient water quality criterion for PCBs. States have the discretion to derive criteria based on other scientifically defensible

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[21] U.S. Environmental Protection Agency. *Quality Criteria for Water*. Office of Water, Washington, D.C. < http://www.epa.gov/waterscience/criteria/goldbook.pdf > EPA 440/5-86-001. May 1986

[22] U.S. Environmental Protection Agency. *National Recommended Water Quality Criteria – Correction*. Office of Water, Washington, D.C. < http://www.epa.gov/waterscience/pc/1999table.pdf> EPA 822-Z-99-001. April 1999

[23] [23] U.S. Environmental Protection Agency . Integrated Risk Information System. < http://www.epa.gov/iriswebp/iris/index.html>

methods (40 C.F.R. §131.11). These states used EPA's method to derive criteria but used more recent toxicity information to ensure their criteria incorporated the latest scientific information at the time of adoption.

(3) As discussed in the "Statutory and Regulatory Background" section, EPA publishes section 304(a) criteria based on a 10^{-6} risk level for carcinogens; states may select a specific risk level based on their own risk management decisions. EPA believes that adoption of criteria within a risk level of 10^{-6} (one in a million incremental risk for cancer) or 10^{-5} (one in one hundred thousand incremental risk for cancer) represents an acceptable range of risk management discretion for states and tribes.[24] Within the petition states, each state adopts criteria to protect human health based on risk management decisions. Iowa, Arkansas, Tennessee, and Nebraska have adopted PCB criteria based on a 10^{-5} risk level; Illinois, Kentucky and Missouri have adopted PCB criteria based on a 10^{-6} risk level; and Kansas chose to adopt a PCB criterion to protect human health at a 10^{-7} risk level.

(4) EPA's regulations provide that states may adopt EPA's section 304(a) criteria recommendations, modify EPA's section 304(a) criteria to reflect site-specific conditions, or derive and adopt criteria based on other scientifically defensible methods. (40 C.F.R. §131.11 (b)). Illinois developed a procedure to translate its narrative criteria and derive numeric values for certain pollutants. EPA determined that this procedure is scientifically defensible and considers the numeric values derived using this procedure to be within the acceptable range to protect designated uses. Illinois uses this procedure to derive numeric values for PCBs that may be used to issue NPDES permits, to determine if a waterbody is impaired for PCBs and thus listed under CWA section 303(d) listings, and/or to develop a TMDL.

As discussed above, Iowa and Missouri adopted a numeric PCB criterion to protect human health based on the toxicity information available in IRIS that was updated in 1989. With regard to the Sierra Club's specific concern about Iowa's PCB criterion as compared to Missouri's criterion, EPA found that Iowa's criterion is an order of magnitude greater than Missouri's because Iowa has chosen to protect human health at a 10^{-5} risk level while Missouri protects human health at a 10^{-6} risk level. With regard to the Sierra Club's specific concern about Nebraska's PCB criterion as compared to Missouri, EPA found that Nebraska adopted a numeric PCB criterion to protect human health based on EPA's section 304(a) criteria recommendations published in 1999 (Missouri used the updated 1999 IRIS data), but chose a 10^{-5} risk level. As a result, Nebraska's PCB criterion is greater than Missouri's criterion.

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[24] U.S. Environmental Protection Agency. *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000).* Office of Water. Washington, D.C. EPA-822-B-00-004. <http://www.epa.gov/waterscience/humanhealth/method > October 2000.

As described in the "Statutory and Regulatory Background" section, the regulations do not compel states to adopt the same criteria and uses in order to provide for attainment and maintenance of downstream water quality standards (40 C.F.R. §131.10(b)), nor do the regulations suggest that this is the only way a state can meet the requirements under § 131.10(b). The water quality program is structured to provide states with flexibility to determine the best way to protect their designated uses and meet their obligations under § 131.10(b). The petitioner has not provided any specific instances where the differences in PCB criteria are preventing a downstream or across stream state from attaining its designated uses as required by 40 C.F.R. §131.10(b).

The PCB criteria adopted by the petition states vary due to any one or a combination of the above reasons. EPA found that the petition states adopted criteria based on an EPA section 304(a) criteria recommendation or another scientifically defensible method and these criteria are within the scientifically acceptable range to protect designated uses consistent with 40 C.F.R. §131.11. In addition, since the production of PCBs have been banned in the United States, EPA believes it is unlikely that any differences in criteria will lead to future increases in the discharge of PCBs. While the petition states do apply different numeric PCB criteria to the petition area and some states have listed certain segments of the petition area waters as impaired for PCBs, EPA is unaware of any evidence that indicates the impairments are a result of anything but local water quality or sediment quality issues. Therefore, EPA has no reason to believe that an upstream or across stream state is causing the impairments. For example, on the Missouri River, while Missouri lists the Missouri River as impaired at the Iowa/Missouri state line due to PCBs, Iowa does not. EPA has no reason to believe that the mere listing of the Missouri River for PCBs is due to the different PCB criterion in Iowa instead of water quality issues wholly within the state of Missouri. Since the petition states have adopted PCB criteria based on EPA recommendations or other scientifically defensible methods, states have mechanisms available to them to ensure downstream water quality standards are attained and maintained, if necessary, and because the petitioner has not provided any specific instances (nor has EPA identified) where the differences in PCB criteria are preventing a downstream or across stream state from attaining its designated uses (40 C.F.R. §131.10(b)), EPA concludes that it is unnecessary for EPA to federally promulgate numeric PCB criteria for the petition states at this time, to meet the requirements of the CWA under CWA section 303(c)(4)(B).

c) Chlordane

The Sierra Club identifies a specific concern regarding chlordane criteria for two states, Iowa and Nebraska. The Sierra Club specifically points out that Iowa's and Nebraska's chlordane criteria are nearly ten times less stringent than Missouri's chlordane criteria. Petition at 13 – 14. Addenda 12 and 13 of the petition provide tables describing the chlordane criteria that each petition state applies to the petition area, as evaluated by the Sierra Club, and shows that the petition states have adopted varying criteria to protect their designated uses.

EPA evaluated the information provided by the petitioner as well as the currently approved state water quality standards for all petition states to determine if any of the chlordane criteria in the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of numeric chlordane criteria is necessary. EPA first reviewed the states' currently adopted and approved water quality standards to validate the petitioner's findings. Specifically, EPA identified exactly what numeric and/or narrative chlordane criteria states have adopted to apply to the petition area.[25] Then EPA investigated the basis for these criteria to determine if states had adopted criteria based on EPA's recommendations or on other scientifically defensible methods. Finally, EPA looked for any documented evidence that may suggest the differences in criteria are preventing a downstream or across stream state from attaining and maintaining its water quality standards.

Adverse human health effects are expected at much lower concentrations of chlordane than in aquatic life. As a result, EPA's criteria recommendation for chlordane to protect human health is generally more stringent than those to protect aquatic life. In the case where states have adopted chlordane criteria to protect both human health and aquatic life, the criteria to protect human health are more likely to drive regulatory decisions. Therefore, in its evaluation of currently approved chlordane criteria, EPA focused on whether states have adopted numeric criteria for chlordane to protect human health-related designated uses. EPA acknowledges that there are variations in the numeric chlordane criteria adopted by the petition states. There are three legitimate reasons why the numeric chlordane criteria vary within the petition area:

(1) EPA published section 304(a) criteria recommendations several times over the past 20 years. EPA's revised section 304(a) criteria reflects the current scientific knowledge but does not always result in more stringent criteria recommendations (e.g., EPA's 1999 section 304(a) recommendations for chlordane were less stringent than its 1986 section 304(a) recommendations.)[26,27] States have adopted and revised chlordane criteria into their water quality standards at different points in time. The criteria the petition states adopted depended on the recommendations and information available at that time. For example, Missouri, Kansas, and Nebraska (Nebraska evaluates the aquatic life and human health criteria and adopt whichever one is most stringent) adopted human health criteria based on EPA's 1986 section 304(a) criteria recommendation while Iowa and Kentucky adopted human health criteria consistent with EPA's 1992 National Toxics Rule (see 40 C.F.R. §131.36). On the Mississippi River, even though Missouri's human health criterion for chlordane is more stringent than Kentucky's (the across stream state), Kentucky's criterion is, in fact, based on more recent science. Therefore, comparing stringency

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[25] See Attachment B

[26] U.S. Environmental Protection Agency. *Quality Criteria for Water*. Office of Water, Washington, D.C. < http://www.epa.gov/waterscience/criteria/goldbook.pdf > EPA 440/5-86-001. May 1986

[27] U.S. Environmental Protection Agency. *National Recommended Water Quality Criteria – Correction*. Office of Water, Washington, D.C. < http://www.epa.gov/waterscience/pc/1999table.pdf> EPA 822-Z-99-001. April 1999.

of criteria is not always an adequate method of determining whether states have appropriate criteria to protect the designated uses or whether they are providing for the attainment and maintenance of downstream water quality standards as required under 40 C.F.R. §131.10(b).

(2) As discussed in the "Statutory and Regulatory Background" section, EPA publishes section 304(a) criteria based on a 10^{-6} risk level for carcinogens; states may select a specific risk level based on their own risk management decisions. EPA believes that adoption of criteria within the risk level of 10^{-6} (one in a million incremental risk for cancer) or 10^{-5} (one in one hundred thousand incremental risk for cancer) represents an acceptable range of discretion for states and tribes.[28] Within the petition states, each state adopts criteria to protect human health based on different risk management decisions. Iowa, Arkansas, Tennessee, and Nebraska have adopted chlordane criteria based on a 10^{-5} risk level while Illinois, Kentucky, Kansas and Missouri have adopted chlordane criteria based on a 10^{-6} risk level.

(3) EPA's regulations provide that states may adopt EPA's section 304(a) criteria recommendations, modify EPA's section 304(a) criteria to reflect site-specific conditions, or derive and adopt criteria based on other scientifically defensible methods. (40 C.F.R. §131.11 (b)). Illinois developed a procedure to translate its narrative criteria and derive numeric values for certain pollutants. EPA determined that this procedure is scientifically defensible and considers the numeric values derived using this procedure to be within the acceptable range to protect designated uses. Illinois uses this procedure to derive numeric values for chlordane that may be used to issue NPDES permits, to determine if a waterbody is impaired for chlordane and thus listed under CWA section 303(d) listings, and/or to develop a TMDL.

With regard to the Sierra Club's specific concern about Iowa's chlordane criterion as compared to Missouri's criterion, EPA found that Missouri adopted a numeric chlordane criterion to protect human health based on EPA's 1986 section 304(a) criteria recommendation, while Iowa adopted human health criterion consistent with EPA's National Toxics Rule. Iowa's chlordane criterion is an order of magnitude greater than Missouri's because Iowa has chosen to protect human health at a 10^{-5} risk level while Missouri protects human health at a 10^{-6} risk level. With regard to the Sierra Club's specific concern about Nebraska's chlordane criterion as compared to Missouri's criterion, EPA found that both Missouri and Nebraska adopted chlordane criteria based on EPA's 1986 section 304(a) criteria, however, Nebraska's policy is to evaluate the aquatic life and human health criteria and to adopt whichever is most stringent to protect both aquatic life and human health. In 1986, EPA's section 304(a) criteria

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[28] U.S. Environmental Protection Agency. *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000).* Office of Water, Washington, D.C. EPA-822-B-00-004. <http://www.epa.gov/waterscience/humanhealth/method > October 2000.

recommendation to protect aquatic life was slightly more stringent than the 10^{-5} human health recommendations. Nebraska adopted one criterion to protect for both aquatic life and human health by adjusting EPA's recommended human health criterion for chlordane to protect human health at a 10^{-5} risk level. Therefore, the magnitude of Nebraska's chlordane criteria is close to an order of magnitude greater than Missouri's criterion because while Nebraska has chosen to protect human health at a 10^{-5} level, Missouri protects human health at a 10^{-6} risk level.

As discussed earlier, **t**he regulations do not compel states to adopt the same criteria and uses in order to provide for attainment and maintenance of downstream water quality standards (40 C.F.R. §131.10(b)), nor do the regulations suggest that this is the only way a state can meet the requirements under § 131.10(b). The water quality program is structured to provide states with flexibility to determine the best way to protect their designated uses and meet their obligations under § 131.10(b). The petitioner has not provided any specific instances where the differences in chlordane criteria are preventing a downstream or across stream state from attaining its designated uses (40 C.F.R. §131.10(b)).

The chlordane criteria adopted by the petition states vary due to any one or a combination of the above reasons. EPA found that the petition states adopted criteria based on an EPA section 304(a) criteria recommendation or another scientifically defensible method and these criteria are within the scientifically acceptable range to protect designated uses consistent with 40 C.F.R. §131.11. In addition, since the use of chlordane has been banned in the United States, EPA believes it is unlikely that any differences in states' criteria will lead to a future increase in discharge of the pollutants. While the petition states do apply different numeric chlordane criteria to the petition area and some states have listed certain segments of the petition area waters as impaired for chlordane, EPA is unaware of any evidence that indicates the impairments are a result of anything but local water quality or sediment quality issues. Therefore, EPA has no reason to believe that an upstream or across stream state is causing the impairments. For example, on the Missouri River, while Missouri lists the Missouri River as impaired at the Iowa/Missouri state line due to chlordane, Iowa does not. EPA has no reason to believe that the mere listing of the Missouri River for chlordane is due to the different chlordane criterion in Iowa instead of water quality issues wholly within the state of Missouri. Since the petition states have adopted chlordane criteria based on EPA recommendations or other scientifically defensible methods, states have mechanisms available to them ensure downstream water quality standards are attained and maintained, if necessary, and because the petitioner has not provided any specific instances (nor has EPA identified) where the differences in chlordane criteria are preventing a downstream or across stream state from attaining its designated uses (40 C.F.R. §131.10(b))**,** EPA concludes that it is unnecessary for EPA to federally promulgate numeric chlordane criteria for the petition states, at this time, to meet the requirements of the CWA under CWA section 303(c)(4)(B).

d) *E. coli*/enterococci

The Sierra Club requests that EPA ensure water quality standards are adequate in the petition area by publishing water quality standards that include numeric criteria for *E. coli* and enterococci. Further, the Sierra Club illustrates its assertion that states protect their designated uses inconsistently by pointing out that Missouri's narrative criteria (i.e. lack of numeric criteria) for fecal coliform may be less protective than the numeric fecal coliform criteria that Nebraska and Kansas apply to the Missouri River. (See also discussion in "Recreation" section.) The Sierra Club concludes that this apparent inconsistency causes Nebraska and Kansas to violate water quality standards where they share a border with Missouri. Petition at 14. Addendum 14 of the petition describes which states have adopted fecal coliform criteria for the Missouri River and shows that Missouri is the only state along the Missouri River within the petition area that has not adopted a fecal coliform criterion of 200 organisms per 100 milliliters. The petition's addendum also shows that no state along the Missouri River in the petition area has adopted *E. coli* or enterococci criteria. Neither the petition nor its addenda include any information regarding the applicability of fecal coliform, *E. coli*, or enterococci criteria for the Mississippi River.

EPA evaluated the information submitted by the petitioner as well as the currently approved state water quality standards to determine if the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of numeric bacteria criteria is necessary. EPA first reviewed the states' currently adopted and approved water quality standards to validate the petitioner's findings. Specifically, EPA evaluated state adopted numeric bacteria criteria to protect recreational uses and whether these are consistent with EPA's latest scientific recommendation.[29] EPA then sought to understand where various states were in their water quality standards review process to determine if any state is in the process of revising its bacteria criteria or is planning to in the near future.

EPA published its latest recommendation for bacteria criteria in 1986.[30] This 1986 criterion recommended that states adopt *E. coli* or enterococci as indicators for gastrointestinal illness in fresh recreation waters instead of fecal coliform, as previously recommended. Of the eight states in the petition area, Kansas, Nebraska, Iowa and Tennessee have adopted and EPA has approved *E. coli* criteria to protect a primary contact recreation use in the Mississippi and/or Missouri Rivers. Arkansas has adopted *E. coli* criteria and EPA expects Arkansas to submit revised water quality standards to EPA in June 2004. Kentucky has proposed adopting *E. coli* in its state rulemaking process and EPA expects Kentucky to submit revised water quality standards to EPA in the fall of 2004. On November 7, 2003, Missouri sent EPA a formal letter committing to adopt *E. coli* criteria for the petition area by July 2005. On March 23, 2004, Illinois sent EPA a formal letter committing to initiate adoption of *E. coli* criteria into water quality standards by September 30, 2004.

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[29] See Attachment B

[30] U.S. Environmental Protection Agency. *Ambient Water Quality Criteria for Bacteria – 1986*. Office of Water, Washington, D.C. EPA 440/5-84-002. < http://www.epa.gov/waterscience/beaches/1986crit.pdf> January 1986.

In its 1986 guidance, EPA recommended that states adopt *E. coli* or enterococci criteria in order to protect contact recreation uses in freshwaters, including those within the petition area, and enterococci in marine waters. Congress endorsed EPA's recommendation in 2000 with respect to coastal waters when it amended the CWA by enacting the Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act). The newly added CWA section 303(i) requires, by April 2004, that states "…adopt and submit to the Administrator water quality criteria and standards for the coastal recreation waters of the state for those pathogens and pathogen indicators for which the Administrator has published criteria under section 304(a)." (Coastal waters are defined in section 502(21) to include waters of the Great Lakes and marine coastal waters designated for use for swimming, boating, surfing, and similar water contact activities.) Further, section 303(i) directs EPA to propose and promulgate standards as protective as the 1986 criteria recommendations for states that fail to comply with section 303(i).

Based on the current scientific knowledge, EPA continues to recommend that states adopt *E. coli* or enterococci criteria to protect recreation waters. As described earlier, the CWA provides EPA the discretionary authority to set a new or revised standard for a state if the Administrator determines that new or revised water quality standards are necessary to meet the requirements of the CWA. However, with regard to the petition area, EPA concludes that it is unnecessary to initiate a rulemaking to promulgate federal *E. coli* or enterococci criteria for the petition area at this time to meet the requirements of the CWA under CWA section 303(c)(4)(B) since all eight states have either adopted *E. coli* or enterococci criteria, proposed adoption, or have committed to adopting such criteria to protect recreation uses in the petition area within a reasonable timeframe. EPA's decision is consistent with Congress' intent to "recognize, preserve, and protect the primary responsibilities and rights of states to prevent, reduce, and eliminate pollution…of … water resources." CWA Section 101(b).

Further, EPA believes the BEACH Act expresses Congress's intent for EPA to address the nation's coastal recreation waters as a first priority to ensure appropriate bacteria criteria are in place to protect beachgoers. As a result, EPA is focusing its efforts to assist states in adopting bacteria criteria consistent with the requirements under CWA section 303(i) and intends to promulgate bacteria criteria for coastal recreation waters, where necessary. If, however, Kentucky, Arkansas, Missouri or Illinois fail to follow through on their commitment to adopt appropriate bacteria criteria for the petition area, EPA will, if necessary, initiate a federal rulemaking to establish *E. coli* or enterococci criteria for the petition area within these states.

e) Dissolved Oxygen

While listed as one of the pollutants at issue, neither the petition nor the addenda to the petition discuss any specific issues/concerns related to numeric dissolved oxygen criteria in the petition area. Nonetheless, in the absence of any information from the petitioner, EPA analyzed currently approved state water quality standards, in conjunction with implementation procedures that further describe how the state implements its water quality standards, and found that all of the petition states apply a dissolved oxygen criterion of 5 mg/l to protect aquatic life consistent with the CWA.[31] Therefore, it is unnecessary for EPA to federally promulgate numeric dissolved oxygen criteria for the petition area, at this time, to meet the requirements of the CWA under CWA section 303(c)(4)(B

f) Ammonia

While listed as one of the pollutants at issue, neither the petition nor the addenda to the petition discuss any specific issues/concerns related to numeric ammonia criteria in the petition area. Nonetheless, in the absence of any information from the petitioner, EPA evaluated the petition states' currently approved water quality standards to determine if the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of numeric ammonia criteria is necessary. EPA first reviewed the states' currently adopted and approved water quality standards to validate the petitioner's findings. Specifically, EPA looked to see whether any states have adopted numeric and/or narrative ammonia criteria to protect aquatic life consistent with EPA's recommendations.[32] If the criteria varied state to state, EPA looked to see why the criteria varied and whether the variation was within the states' scientific discretion and whether the resulting criteria were protective of the designated use. Finally, EPA looked at the petition states' 2002 section 303(d) impaired waters lists[33] to determine if any petition state identified ammonia as an impairing pollutant responsible for impairing aquatic life uses.

All eight of the petition states have adopted numeric ammonia criteria applicable to the portions of the Mississippi and Missouri Rivers within their jurisdiction. Kansas, Iowa, Nebraska and Tennessee adopted numeric ammonia criteria identical to EPA's most recent section 304(a) criteria recommendation published in 1999. Missouri, Illinois, and Kentucky have adopted criteria based on EPA's section 304(a) recommendations published before 1999. Arkansas adopted numeric ammonia criteria on April 23, 2004 and is expected to submit their revised water quality standards for EPA review and approval in June 2004. In the interim, Arkansas's narrative criterion may be used to control ammonia levels, if necessary, through water quality-based NPDES limits or TMDLs.[34] In EPA's review of the petition states' section 303(d) lists[35], no state within the petition area included (nor did EPA propose to include) ammonia as a pollutant impairing designated uses.

In developing its 304(a) criteria recommendations, EPA took into account the fact that ammonia is a complex pollutant with its effect on aquatic life dependent on several

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[31] See Attachment B
[32] See Attachment B
[33] See Attachment G
[34] See Attachment A
[35] See Attachment G

factors, including temperature and pH. EPA's most recent recommended criteria reflect these complexities by providing numeric calculation approaches that consider these two variables. Further, states may modify EPA's section 304(a) criteria recommendations based on their own analysis of the available toxicity data taking into account local characteristics. In addition, EPA has not recommended a specific method to determine the appropriate temperature and pH to use when deriving numeric ammonia criteria. As a result, states may use temperature and pH differently leading to variations in the derived state numeric ammonia criteria. EPA evaluated these states' currently adopted and approved numeric ammonia criteria taking into account these variations and determined that all of the numeric ammonia criteria values applied by the petition states to the petition area are within the scientifically reasonable range and are expected to protect the designated uses consistent with the federal regulations at 40 C.F.R. §131.11. EPA continues to work with all states to ensure the latest scientific knowledge regarding ammonia is incorporated into state water quality standards.

Since ammonia criteria will generally vary with pH and temperature, any comparison of stringency among the state criteria depends on the pH and temperature used for the comparison. Scientifically, it is unclear what the most relevant pH and temperature conditions would be for making such comparisons. Therefore, it is not possible to rank, with confidence, state ammonia criteria by stringency. As mentioned earlier, the petition did not identify any specific instances of concern related to numeric ammonia criteria in the petition states nor do any of the petition states identify ammonia as an impairing pollutant on their section 303(d) list. Taking this into consideration as well as the fact that seven of the eight states' currently approved ammonia criteria are within the scientifically reasonable range and are expected to protect the designated uses consistent with the federal regulations at 40 C.F.R. §131.11 and the remaining state (Arkansas) has adopted a numeric ammonia criterion, EPA concludes it is unnecessary to federally promulgate numeric ammonia criteria for the petition area, at this time, to meet the requirements of the CWA under CWA section 303(c)(4)(B).

g) Nutrients

The Sierra Club raises several concerns regarding nutrients in the petition. They assert that states inconsistently apply numeric criteria for nitrogen and phosphorus to the Mississippi and Missouri and that inadequate nutrient criteria in the petition area contributes to the hypoxic zone in the Gulf of Mexico. Petition at 17. Regarding the petitioner's concern of inconsistent nutrient criteria, the Sierra Club specifically indicates that Kentucky has a narrative criterion while neighboring Missouri has a numeric nitrogen criterion and that Arkansas is the only state in the petition area to apply a numeric phosphorus criterion to the Mississippi River. Petition at 13 – 14. Addenda 9 and 15 appear to support these examples of inconsistent criterion on the Mississippi River and offer additional information, but only describe the criteria applicable to the Mississippi River and not the Missouri River within the petition area.

To support their request that EPA publish numeric criteria for nutrients in the petition area, the Sierra Club referred to a recent General Accounting Office (GAO) report that stated "sediments, nutrients and pathogens (including *E. coli* and enterococci) - account for fifty percent [sic] of the impaired waters nationwide." The petitioner goes on to state that despite this statistic, EPA has not developed recommendations for numeric water quality criteria for nutrients. Petition at 15 – 16. The GAO report indicates that EPA is in the process of developing numeric criteria for nutrients.[36]

EPA evaluated the petition information as well as the currently approved state water quality standards to determine if the petition states' water quality standards are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of numeric nutrient criteria is necessary. EPA first looked to see which states have adopted numeric nitrogen or phosphorus criteria to protect designated uses. Second, EPA looked to see if the petition states have adopted narrative criteria for nutrients and whether there are accompanying procedures to derive numeric criteria. Third, EPA identified the current state efforts and where the petition states are in their process to adopt numeric criteria based on the latest scientific information. Finally, EPA collected information regarding the scientific understanding of nutrients and designated uses (in local waters and the effect on the Gulf of Mexico) to determine if the science is sufficient, at this time, to support EPA or state development of numeric ambient water quality criteria for the Mississippi and Missouri Rivers.

Based on its evaluation, EPA found that Tennessee recently adopted, and EPA approved, narrative criteria for nutrients along with a procedure to derive numeric nutrient criteria applicable to free flowing streams to protect designated uses from the effects of excessive algal growth. Kansas applies numeric criterion for elemental phosphorus for the petition area. Iowa, Illinois, Missouri, Nebraska, and Kansas apply a numeric criterion for nitrates and/or nitrites to the petition area to protect human health. Arkansas has recently adopted narrative criteria for nutrients in place of previous numeric phosphorus guidelines (which is not considered to be a criterion). However, through its implementation procedures approved by EPA, Arkansas does establish point source discharge limits for nitrate-nitrogen to protect drinking water uses in surface waters.[37] EPA is currently working with these states to determine if additional criteria or procedures are necessary for nitrogen and phosphorus to protect surface waters from adverse effects due to nutrient overenrichment. All eight petition states have narrative criteria applicable to nutrients that may be used for establishing NPDES permits, listing waters as impaired by nutrients on section 303(d) lists and developing TMDLs, if necessary.

As indicated earlier, the petitioner further expresses its concern regarding nutrients in the Mississippi and Missouri Rivers by referencing the hypoxic zone in the

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[36] General Accounting Office. *Water Quality: Improved EPA Guidance and Support Can Help States Develop Standards that Better Target Cleanup Efforts*. GAO-03-308 < http://www.gao.gov/new.items/d03308.pdf> (January 2003). p 37.

[37] Arkansas Department of Environmental Quality. *Arkansas Water Quality Planning and Management: State Continuing Planning Process*. Little Rock, Arkansas. 1999.

northern Gulf of Mexico as “a graphic demonstration of the inadequacy of current water quality standards in the vicinity of the petition area.” Petition at 16. While the Sierra Club specifically quotes the discussion contained in The Mississippi River/Gulf of Mexico Watershed Nutrient Task Force’s *Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico* regarding the significant impact of nutrients carried to the Gulf (from the Mississippi River basin) on the Hypoxic zone, the *Action Plan* also states that “There are no simple solutions that will reduce hypoxia in the Gulf. An optimal approach would take advantage of the full range of possible actions to reduce nutrient loads and increase nitrogen retention and denitrification.”[38]

According to the *Action Plan*, 56% of the nitrate load enters the Mississippi River above the Ohio River and the Ohio River basin itself adds 34% of the nitrate load. About 90% of the total nitrate load to the Gulf comes from nonpoint sources. Modeling by Alexander et al (2000)[39] indicates that more than 90% of the nitrate reaching the Mississippi River will be transported downstream to the Gulf of Mexico. This implies that the Mississippi River primarily transports nutrients downstream with little or no processing or removal of nitrogen occurring.[40,41] Battaglin et al (2001) believe that the ability of the Mississippi River to process nitrate normally is being overwhelmed by the nitrate loads from upstream sources. As a result, the Mississippi River is unable to achieve the net decrease in nitrate amounts that normally would occur. USGS studies show that denitrification could be optimized in the Upper Mississippi River (source of Mississippi River to confluence with Illinois River) by diverting water from the river to off-channel “backwater” areas that have conditions to promote nitrogen removal during non-flooding periods. However, even optimal denitrification in the Upper Mississippi River would only result in 5-10% reduction in load to the Gulf of Mexico.[42] The ability to use this method to achieve optimal denitrification in the middle and lower Mississippi Rivers is very small since the River is essentially disconnected from the carbon-rich floodplain ecosystem that could help process nitrogen, by flood control levees.[43] In other words, even if the Mississippi River could optimally process nitrogen like many other waters, the amount of nitrogen being loaded into the river prevents the river from reducing total nitrogen loadings into the Gulf more than 10%. These studies emphasize how complex the nutrients problem is in the Mississippi River basin and the need for states to control nutrients at the source.

In 2001, EPA began providing states with waterbody specific technical guidance manuals and numeric nutrient criteria recommendations for states to use as starting points

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[38] Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. *Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico.* http://www.epa.gov/msbasin/actionplan.htm. January 2001.

[39] Alexander, R.B., Smith, R.A., and Schwarz, G.E. 2000. *Effect of stream channel size on the delivery of nitrogen to the Gulf of Mexico*. Nature 403: 758-761.

[40] Richardson, W.B., Strauss, E.A., Bartsch, L.A., Monroe, E.M., Cavanaugh, J.C., Vingum, L., and Soballe, D.M. *Denitrification in the Upper Mississippi River: rates, controls, and contribution to the nitrate flux.* (in press).

[41] Battaglin, W.A., Kendall, C., Chang, C.C.Y., Silva, S.R., and Campbell, D.H. 2001. Chemical and isotopic evidence of nitrogen transformation in the Mississippi River, 1997-1998. Hydrol. Process. 15: 1285-1300.

[42] Richardson, W.B., Strauss, E.A., Bartsch, L.A., Monroe, E.M., Cavanaugh, J.C., Vingum, L., and Soballe, D.M. *Denitrification in the Upper Mississippi River: rates, controls, and contribution to the nitrate flux.* (in press).

[43] U.S. Geological Survey. *Nutrients in the Upper Mississippi River: Scientific Information to Support Management Decision, The Upper Mississippi River – Values and Vulnerability*. USGS Fact Sheet 105-03. July 2003.

to protect aquatic life from eutrophication resulting from excessive nutrients, not just toxic effects. EPA has provided nutrient criteria recommendations for most of the freshwater in the nation, excluding wetlands (see http://www.epa.gov/ost/standards/nutrient.html).

States throughout the United States have been working with EPA to develop appropriate nutrient criteria plans to quantitatively address nutrients in their waters. EPA expects these plans to be developed collaboratively with EPA and to include descriptions of the approach the state will use to develop criteria, the relative priorities of waterbodies or waterbody type, data collection plans, and a schedule describing the major milestones for developing and adopting nutrient criteria. EPA's policy was described to the states in a November 14, 2001, memo available at http://www.epa.gov/waterscience/criteria/nutrientswqsmemo.pdf. Since data are more readily available and the science is better understood for lakes, reservoirs and tributaries to the Mississippi and Missouri Rivers, states have generally indicated in their plans that they are focusing on developing nutrient criteria for these waters prior to adopting quantitative nutrient criteria specifically for the Mississippi and Missouri Rivers.

EPA believes that it is important that states establish quantitative nutrient criteria, where necessary to protect designated uses, for all waters where criteria can be developed based on sound science. The studies discussed above support EPA's position that state adoption and implementation of nutrient criteria for tributaries of the Mississippi and Missouri Rivers will lead to an overall reduction of nutrient loadings in the Mississippi and Missouri River basin. These reductions will improve water quality and help protect the designated uses of these rivers as well as the Gulf of Mexico, in the near term. Therefore, while states are not currently focused on adopting quantitative nutrient criteria specifically for the Mississippi and Missouri Rivers, EPA believes that the states in the petition area are appropriately focusing attention and resources on the smaller waterbodies that flow into these rivers before addressing these two large rivers themselves. EPA intends to work with the states to establish quantitative nutrient criteria for these waters. As a result, EPA also expects, as the *Action Plan* states, that "…. actions taken to address local water quality problems in the basin will frequently also contribute to reductions in nitrogen loadings to the Gulf."[44]

EPA will work closely in the petition area with the five states that have not yet provided EPA with draft nutrient criteria plans to ensure that an appropriate approach and timeframe to develop nutrient criteria is established consistent with its November 2001 policy memo. EPA will work with the other states in the petition area that have developed nutrient criteria plans to ensure successful implementation. Whether a state has developed a nutrient criteria plan or not, EPA expects states to adopt nutrient criteria for the tributaries to the petition area in a timeframe consistent with EPA's guidance in the November 2001 policy memo and will evaluate the need to promulgate federal nutrient criteria, as necessary, if a state fails to do so. In the interim, petition states'

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[44] Mississippi River/Gulf of Mexico Watershed Nutrient Task Force. *Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico.* http://www.epa.gov/msbasin/actionplan.htm. January 2001.

narrative criteria may serve as the basis for NPDES permits, section 303(d) listings and TMDLs, if necessary.

Although EPA has provided nutrient criteria recommendations for the ecoregions that encompass the Mississippi and Missouri Rivers, EPA's water quality criteria recommendations for nutrients are based on a reference condition approach (a reference condition reflects minimally impacted water quality conditions). In deriving the criteria recommendations, EPA incorporated data from the Mississippi and Missouri Rivers, however, since EPA's recommendations are based on reference conditions and are statistically derived to generally protect the designated uses of specific waterbody types in a specific ecoregion, it is not likely that EPA's approach which takes the 25th percentile of data from all flowing waterbodies in the ecoregions containing the Mississippi and Missouri Rivers will generate a reference condition value appropriate to base development of a nutrient criterion for these rivers. The Mississippi and Missouri Rivers have unique qualities (i.e., flow, depth, temperature and nutrient-algal response relationships) in their respective ecoregions, and EPA believes further consideration of historical data and water quality conditions are necessary before establishing nutrient criteria specifically for these rivers. Until more monitoring and research have been conducted to better understand how these large and complex rivers respond to nutrient enrichment, establishing numeric nutrient criteria for the petition area, today, would be less meaningful and effective than ensuring that quantitative nutrient criteria are adopted for waters where the linkage between nutrient concentrations and biological response are better understood and where the sources of nutrient loadings can be adequately controlled.

The *Action Plan* acknowledges the complex nature of nutrient cycling in the Mississippi and Atchafalya River basins as well as the Gulf of Mexico. As a result, it is "…difficult to predict specific improvements in water quality that will occur both in the Gulf as well as the entire Mississippi River basin for a given course of action….Further, …while the current understanding of the causes and consequences of Gulf of Mexico hypoxia is drawn from a massive amount of direct and indirect evidence collected and reported over many years of scientific inquiry, significant uncertainties remain. Further monitoring, modeling, and research are needed to reduce those uncertainties in future assessments and to aid decision making in an adaptive management framework." The Mississippi River/Gulf of Mexico Watershed Nutrient Federal, State, and Tribal Task Force (Nutrient Task Force) was chartered in 1998 to understand the causes and effects of eutrophication in the Gulf of Mexico and to coordinate activities to reduce the size, severity and duration of the Hypoxic zone and its effects. To combat the issues identified in the *Action Plan*, the Nutrient Task Force is developing the document *A Strategy for Monitoring, Modeling, and Research in Support of Managing Excess Nutrients in the Mississippi River Basin and Hypoxia in the Northern Gulf of Mexico*, that is intended to describe a framework for implementing monitoring, modeling, and research activities. This framework will provide a sound basis of scientific information to support implementation of a management plan to address nutrient over-enrichment in the Mississippi River basin and Hypoxia in the northern Gulf of Mexico. Scientific information will be provided in an adaptive-management framework through monitoring and periodic interpretation, model analysis, and continual improvement in knowledge and methods by supporting research. The Task Force is also investigating ways to track how existing federal, state, and local efforts are likely to decrease the size of the hypoxic zone.

Once the complex effects of nutrients unique to the Mississippi River basin and their affect on the hypoxic zone in the Gulf of Mexico are better understood, EPA will be able to confidently evaluate whether states have adopted nutrient criteria into water quality standards that adequately protect designated uses in the Mississippi and Missouri Rivers and the Gulf of Mexico, and ascertain whether federally promulgated nutrient criteria are needed. EPA has taken a strong leadership role in the Nutrient Task Force's efforts to establish a strategy to reduce the size of the hypoxic zone and is working with federal and state partners to investigate remaining scientific uncertainties. EPA agrees with the petitioner that it is important that states establish quantitative nutrient criteria for the Mississippi and Missouri Rivers to protect designated uses and serve as appropriate benchmarks for nutrient controls. Yet, EPA also believes that nutrient criteria must be based on sound science. Therefore, EPA intends to continue its leadership role on nutrients and facilitate federal and state collaborative efforts that will support the development and adoption of quantitative nutrient criteria into water quality standards that will not only protect against local effects of nutrients within the Mississippi River basin, but also help to reduce the size of the hypoxic zone in the Gulf of Mexico. EPA will work with key partners to determine the appropriate ambient water quality criteria for nutrients necessary to protect the unique ecosystems of the Mississippi and Missouri Rivers based on a sound scientific understanding of the relationship between nutrient concentrations and the biological response in these rivers.

EPA believes the most effective way to begin to address ambient water quality criteria for nutrients in the Mississippi and Missouri Rivers is to reach a consensus with the affected entities on a coordinated approach on addressing nutrients in the basin. Therefore, EPA will convene key partners at a multi-day national workshop to discuss the development and adoption of appropriate ambient water quality criteria for nutrients into water quality standards for the Mississippi and Missouri Rivers that will protect the rivers and the Gulf of Mexico. The workshop will include invitees from various federal agencies (e.g., U.S. EPA's Office of Water and Office of Research and Development, U.S. Geological Survey, and U.S. Department of Agriculture), states and other stakeholders with the objective of identifying the existing federal and state nutrients efforts along the Mississippi River, the Missouri River and the Gulf of Mexico; understanding the current state of the science and the barriers states are facing; determining additional research needs and priorities; and how federal and state agencies and stakeholders can work together to develop quantitative nutrient criteria for the Mississippi and Missouri Rivers. Following the workshop, EPA will publish a report to summarize the results of the workshop and identify next steps. This report will establish a roadmap for how EPA intends to work with its partners to address nutrients in the Mississippi and Missouri Rivers. This effort will also be closely linked with the Task Force to ensure that all related nutrient work is effectively coordinated. EPA has identified the needed funds and will begin planning the workshop immediately with the intent to hold the workshop in 2005. EPA agrees with the petitioner that the Mississippi and Missouri Rivers and the Gulf of Mexico are valuable resources and hopes that the Sierra Club and other stakeholders will actively participate in this effort to help ensure success.

Since EPA's current criteria recommendations may not be appropriate to promulgate for the Mississippi and Missouri Rivers, EPA intends to convene a national workshop that will initiate discussions on a collaborative approach to determining the appropriate ambient water quality nutrient criteria for the Mississippi and Missouri Rivers (taking into account the effects on the Gulf of Mexico). In order for EPA to promulgate nutrient criteria for the petition area based on sound science, EPA must first address the scientific uncertainties that remain regarding ambient water quality criteria for nutrients for the Mississippi and Missouri Rivers. In the interim, however, the states are actively working with EPA to develop and adopt quantitative nutrient criteria for tributaries to these rivers that will lead to an overall reduction of nutrients within the basin. Therefore, in the absence of scientifically sound criteria appropriate for these rivers, EPA concludes that it is unnecessary for EPA to federally promulgate numeric nutrient criteria for the petition area, at this time, to meet the requirements of the CWA under CWA section 303(c)(4)(B).

h) Sediments

In section IV of the petition titled "Existing water quality standards for the Mississippi and Missouri Rivers in the Petition area are inadequate", the Sierra Club discusses the January 2003 GAO report stating that EPA has not yet developed national numeric criteria for sedimentation despite the fact that "sediments, nutrients and pathogens (including *E. coli* and enterococci) - account for fifty percent [sic] of the impaired waters nationwide,". Neither the petition nor the addenda to the petition discuss any specific issues of concern related to numeric sedimentation criteria in the petition area. In the absence of any information from the petitioner, EPA evaluated the petition states' currently approved water quality standards to determine if they are inconsistent with the CWA and federal regulations at 40 C.F.R. Part 131 such that a federal promulgation of numeric sedimentation criteria is necessary. EPA first looked to see whether any states have adopted numeric and/or narrative criteria related to sedimentation to protect designated uses. Then EPA evaluated the scientific understanding about sedimentation and designated uses to determine if the science is sufficient at this time to support EPA or state development of ambient water quality criteria.

All eight of the petition states currently have narrative criteria related to sedimentation that may be used for establishing NPDES permit limits, listing waters as impaired by sediments on section 303(d) impaired waters lists, and developing TMDLs, if necessary. Arkansas applies a numeric criterion for turbidity to the petition area.

EPA has not yet published numeric criteria recommendations under section 304(a) of the CWA for sediments (suspended and bedded sediments (i.e. sediments accumulated on the bottom of a stream bed)) because the science is not yet fully understood regarding how to appropriately establish criteria for sedimentation in surface waters. As part of the Water Quality Standards and Criteria Strategy, finalized in August 2003 (see EPA's website at http://www.epa.gov/waterscience/standards/strategy/), EPA committed to developing a Suspended and Bedded Sediment Criteria Strategy after consulting with EPA's Science Advisory Board. This strategy will inform EPA's development of guidance on controlling excess sediments. The suspended and bedded sediment strategy is expected to identify methods for developing numeric suspended and bedded sediment criteria and lead to recommendations that states can use to adopt their own numeric criteria for suspended and bedded sediments. These recommendations will also provide a benchmark for EPA to evaluate the effectiveness of state water quality standards programs. Since the Agency is currently developing a Suspended and Bedded Sediment Criteria Strategy to inform EPA's criteria recommendations for suspended and bedded sediment criteria and all the petition states have narrative criteria to provide a basis for controlling suspended and bedded sediments in the interim, if necessary, EPA concludes that it is unnecessary for the Administrator to federally promulgate numeric sedimentation criteria for the petition states, at this time, to meet the requirements of the CWA under CWA section 303(c)(4)(B), at this time. However, once EPA has published section 304(a) criteria recommendations for suspended and bedded sediments and has provided states appropriate time to incorporate the latest science into water quality standards, EPA will reevaluate the need for the Administrator to determine that a federal promulgation of numeric suspended and bedded sediment criteria is necessary to meet the requirements of the CWA.

i) IBI

Neither the petition nor the addenda to the petition discuss any specific concerns related to an index of biological integrity (IBI) in the petition area beyond their request that EPA publish numeric criteria. An index of biological integrity adopted as a water quality criterion in water quality standards is known as "biocriteria". EPA does not require that states adopt biocriteria into water quality standards to protect designated uses, however EPA believes that biocriteria and bioassessments are desired elements of a robust water quality program, which help to achieve the objectives of the CWA under section 101(a).

The CWA section 304(a)(8) provides that EPA shall publish "…methods for establishing and measuring water quality criteria for toxic pollutants on other bases than pollutant-by-pollutant criteria, including biological monitoring and assessment methods." Since numeric biocriteria (response criteria based on water body condition) must be developed on a regional or water body-specific basis using bioassessment monitoring data gathered from those water bodies, EPA does not publish national recommended biocriteria. Instead, states use EPA's recommended methods to develop and adopt biocriteria to protect their designated uses, as needed.

EPA has published biocriteria methods for streams, small rivers, lakes, reservoirs, wetlands, and estuaries and continues to develop methods for all other water body types. (see http://www.epa.gov/waterscience/biocriteria/). EPA's 10 Regional Offices have developed biocriteria implementation strategies for their individual states and the Agency provides technical support through grants, contracts and training. As of 2001, all states and some Tribes and territories had bioassessment programs for streams and small rivers and most are in the process of developing quantitative biocriteria. In the petition area, Nebraska and Missouri have adopted narrative biocriteria into water quality standards. Arkansas, Kentucky, and Tennessee have adopted narrative biocriteria into water quality standards and have also developed a quantitative implementation procedure or translator to interpret this narrative for wadeable streams. Missouri is currently working to develop a procedure for wadeable streams to interpret their narrative, while Iowa is actively working to develop narrative and numeric biocriteria for wadeable streams.[45] Since EPA has not yet provided biocriteria methods for large rivers, it is unlikely that the procedures adopted by the petition states are applicable to the Mississippi and Missouri Rivers. However, it is clear the states are making substantial progress toward developing and adopting biocriteria for other water bodies, statewide. Further, CWA section 106(e)(1) includes biological monitoring in the description of a monitoring program necessary to receive a grant from the Administrator. Since 40 C.F.R. §130.7(b)(5) requires states to "assemble and evaluate all existing and readily available water quality-related data and information," any available biological information will continue to be a part of the state assessment process.

While EPA has not yet developed biocriteria methods for large rivers, EPA is developing large river indicators of biological and physical habitat condition to help states and tribes assess the water quality conditions and identify impairments in large rivers. Two guidance manuals have been produced to date. One of these manuals details the differences between the methods used by various agencies to assess small and large rivers in the U.S. (see http://www.epa.gov/nerleerd/MCD_nocover.pdf); the second manual is a logistical guide for conducting ecological assessments in large rivers (http://www.epa.gov/nerleerd/logistics_nocover.pdf). New methods specifically designed to adequately sample large rivers are being tested currently. The results from this research will provide additional information to enable states and tribes to make informed decisions about the selection of scientifically robust and efficient methods to assess the biological conditions of large rivers using various relevant endpoints.

EPA is promoting state collection of biological data in large rivers in several other ways. For example, two classes addressing large river bioassessment and monitoring were taught at the first National Biocriteria Workshop at Coeur d'Alene, Idaho in 2003. The workshop was very well attended by states, including those along the Mississippi and Missouri Rivers. In addition, EPA scientists are working with the Kentucky Department of Natural Resources (DNR) in their implementation of the large river monitoring component of a Conservation Reserve Enhancement Program (CREP). This work is serving as the first step in Kentucky DNR's effort to initiate a state-wide large river bioassessment and monitoring program, and it may serve as an

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[45] U.S. Environmental Protection Agency. *States and Tribes Embrace Bioassessment and Biocriteria for Protecting Streams and Small Rivers*. EPA - 822-F-03-005. June 2003.

example for other states to follow. Also, a team of scientists composed of national and regional large river experts is using the findings of completed research to develop a scientifically sound and logistically feasible large river bioassessment program for the Mississippi DNR.

For the reasons discussed above, EPA concludes that it is unnecessary for EPA to federally promulgate water quality standards that include an index of biological integrity for the petition area to meet the requirements of the CWA under CWA section 303(c)(4)(B). However, EPA believes that biocriteria and biomonitoring are important tools to support the state water quality programs and will continue to work with and encourage states to incorporate biological conditions/criteria into state water quality programs.

3) Monitoring

Petitioner's Position – The Sierra Club believes that limited and inconsistent water quality monitoring by states in the petition area is "a weak link in this system." Petition at 17. They assert that most of the states in the petition area do not routinely monitor water quality and that very little funding is devoted to ambient water quality monitoring. The Sierra Club also asserts that state monitoring approaches and methodologies lack consistency across the area leading to inconsistent and unreliable conclusions about waters meeting the applicable water quality standards, waters being listed as impaired under CWA section 303(d), and in identifying causes of impairment. The petitioner requests that EPA promulgate water quality standards that include monitoring provisions to support uniform, statistically based method for determining whether the rivers are actually meeting applicable water quality standards.

EPA's Response – EPA denies the petitioner's request that EPA promulgate monitoring requirements as part of state water quality standards for the petition area. The "Statutory and Regulatory Background" section of this response describes the requirements for state water quality standards programs. Neither the CWA nor the implementing regulations require that water quality standards include monitoring provisions. EPA agrees with the petitioner that addressing shortcomings in state monitoring programs is a priority but believes that EPA's non-regulatory approaches planned and underway will achieve the outcome of strengthened and more consistent monitoring and assessment activity in the petition states.

Background

CWA section 305(b) requires a comprehensive biennial report on water quality and CWA section 303(d) requires states to assess waters and develop lists of impaired waters that do not meet water quality standards, even after point sources of pollution have installed the required levels of pollution control technology. States have flexibility to devise various approaches to assess waters and determine which waters are impaired and should be listed under section 303(d). EPA does not approve or disapprove a state's assessment and listing methodology but does approve or disapprove a state's section 303(d) list and may raise any issues about the state assessment methodology during this process. When developing the list of impaired waters, the CWA and EPA's implementing regulations require that states "…assemble and evaluate all existing and readily available water quality-related data and information." 40 C.F.R. §130.7(b)(5).

The CWA and implementing regulations confer broad latitude on states and provide for state flexibility in assigning priorities and employing different assessment and water quality management methods. Assessment and listing of interstate waters can pose challenges because of differences among methodologies and priorities in state water quality management programs. As the petition demonstrates, different state approaches on shared waterbodies can also create public concern and confusion. Major contributors to uncertainty about the water quality status of many waters, including shared waters, are gaps in monitoring and assessment.

EPA Efforts to Improve State Monitoring and Assessment Overall

Improving the rigor and consistency of state monitoring and assessment programs is a top priority for EPA because the Agency recognizes these programs are an essential foundation for effective water quality management. EPA is devoting substantial resources and attention to this issue. In fiscal year (FY) 2004, EPA received $4 million to improve our ability to answer questions about water quality on a national basis. The President's FY 2005 Budget Request seeks $20 million to help states and tribes develop and implement statistically representative water quality monitoring programs. A key objective of this effort is greater consistency in monitoring across state programs.

In addition, EPA issued *The Consolidated Assessment and Listing Methodology (CALM) (July 2002)*[46]. CALM provides a framework for states to document how they collect and use water quality data and information for environmental decision-making, in particular for determining whether waters are attaining water quality standards, identifying waters that are impaired and need to be included in the section 303(d) lists, and identifying waters that are meeting standards so that they can be removed from the list.

In March 2003, EPA provided guidance to states on the elements needed to strengthen state monitoring and assessment programs, *Elements of a State Water Monitoring and Assessment Program.*[47] The guidance calls for states to develop or commit to develop a Comprehensive State Monitoring Strategy in FY04. This strategy should be a long-term implementation plan for improving monitoring and assessment and emphasize a comprehensive approach to assessing all waterbody types over time through the use of multiple tools.

In a related effort, EPA is encouraging states to adopt a consistent format for categorizing and reporting the status of waters according to whether they have met water quality standards, require more data, or require a Total Maximum Daily Load (TMDL). This "integrated reporting" guidance emphasizes the importance for states to clearly articulate their methodology

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[46] U.S. Environmental Protection Agency. Consolidated and Assessment Listing Methodology.: Toward a Compendium of Best Practices. 2002. <http://www.epa.gov/owow/monitoring/calm.html>

[47] U.S. Environmental Protection Agency. Elements of a State Water Monitoring and Assessment Program. 2003. < http://www.epa.gov/owow/monitoring/elements/elements03_14_03.pdf> EPA 841-B-03-003.

for assessing waters and provide the public an opportunity to comment on both the methodology and proposed list of impaired waters. See *EPA's Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, July 2003* (www.epa.gov/owow/tmdl/tmdl0103/index.html). The guidance also emphasizes that, where waters are shared among states, states should work together to collect, assemble, solicit, and assess all readily available data and information relevant to shared waters so that assessments are as consistent as possible. This coordination on shared waters is especially important for waters that are to be listed as impaired under CWA section 303(d) which then requires developing a TMDL.[48]

EPA expects that, through targeted funding and greater implementation of recent agency guidance, the quality and consistency of state monitoring and assessment programs will improve.

EPA and State Efforts to Improve Monitoring and Assessment in the Mississippi and Missouri Rivers

The challenge of improving water quality monitoring programs is even more daunting for large rivers such as the Mississippi and Missouri Rivers. The size and complexity of these rivers make representative data collection more difficult. Due to dilution in rivers of this size, localized water quality impairments may go undetected without intensive monitoring. Further, variability in river conditions means there is limited ability to extrapolate site-specific data where it does exist. To address the assessment challenges specific to large rivers, EPA's Office of Research and Development is preparing The Great Waters Initiative, a framework for state-based monitoring programs to assess the ecological condition of the Mississippi, Missouri and Ohio Rivers (see http://www.epa.gov/emap/greatriver/FactSheet.pdf). The framework is expected to include a probability-based design and indicators that could be used to assess the ecological condition of the three great rivers.

In the Upper Mississippi River basin, EPA Regions 5 and 7 are working directly with states to improve coordination on water quality management issues. The Upper Mississippi River Basin Association (UMRBA) is a regional interstate organization formed by the governors of Illinois, Iowa, Minnesota, Missouri, and Wisconsin to help coordinate the states' water quality issues related to the Mississippi River. UMRBA implemented a Water Quality Coordination Project that aimed to discern underlying reasons for state inconsistencies in assessment and listing and to initiate actions to address inconsistencies (www.umrba.org/wq/wq2002rpt.pdf). For example, one outcome of the project is a Memorandum of Understanding among the five UMRBA states to use a minimum number of common water reaches for purposes of characterizing water quality under CWA section 305(b) and identifying water quality impairments under section 303(d).

Over time, these efforts in the Upper Mississippi River basin should lead to improved consistency in state section 305(b) assessments and section 303(d) listings throughout Mississippi and Missouri basins. In addition to these ongoing efforts, EPA will work with the

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[48] U.S. Environmental Protection Agency. 2003. *EPA's Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, July 2003*. http://www.epa.gov/owow/monitoring/repguid.html).

petition states during the 2006 reporting and listing cycle (now underway) to resolve or explain, where possible, inconsistencies in the listing of impaired waters on the Mississippi and Missouri Rivers. Examples cited by the petitioner, including the fact that Arkansas and Kentucky did not include the Mississippi River on their 1998 section 303(d) list and that Kansas did not list the Missouri River in 1998, will be given particular consideration. EPA will continue through successive listing cycles to use any new sources of water quality data for the affected river segments, such as data generated through the Great Waters Initiative, to work with states in refining their impaired water lists. Therefore, EPA concludes it is unnecessary for EPA to federally promulgate monitoring requirements in water quality standards for the petition area to meet the requirements of the CWA under CWA section 303(c)(4)(B).

Conclusion

For the foregoing reasons, EPA denies the petition’s request for EPA to publish water quality standards for the petition area, at this time.

ATTACHMENT A – WATER QUALITY STANDARDS FOR PETITION STATES: LIST AND CITATIONS

State	State Regulation Information
Arkansas	Arkansas Pollution Control and Ecology Commission; Regulation 2 - Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas; (October 28, 2002); Effective under Clean Water Act - January 23, 2003. http://www.epa.gov/ost/standards/wqslibrary/ar/ar.html
Illinois	Title 35: Environmental Protection; Subtitle C: Water Pollution; Chapter 1: Pollution Control Board Parts 301 Introductions & Park 302 Water Quality Standards (August 26, 1999) http://www.epa.gov/ost/standards/wqslibrary/il/il.html
Iowa	567 Iowa Administrative Code Chapter 61 – Water Quality Standards Effective under Clean Water Act – June 16, 2004 http://www.epa.gov/ost/standards/wqslibrary/ia/ia.html
Kansas	Kansas Department of Health and Environment; Division of Environment; Bureau of Environmental Field Services Kansas Surface Water Register (December 15, 2003) Effective Under Clean Water Act–To be acted upon June 2004 Kansas Administrative Regulations Title 28, Article 16 – Surface Water Quality Standards (September 25, 2003) Effective Under the Clean Water Act – November 3, 2003 http://www.epa.gov/ost/standards/wqslibrary/ks/ks.html
Kentucky	Natural Resources and Environmental Protection Cabinet; Department for Environmental Protection; Division of Water Kentucky Administrative Regulations, Title 401, Chapter 5 Effective Under the Clean Water Act – December 8, 1999 http://www.epa.gov/ost/standards/wqslibrary/ky/ky.html
Missouri	Code of State Regulations Title 10 - Rules of Department of Natural Resources; Division 20 – Clean Water Commission; Chapter 7 – Water Quality 10 CSR 20-7 (10/31/99) http://www.epa.gov/ost/standards/wqslibrary/mo/mo.html
Nebraska	Nebraska Department of Environmental Quality Title 117 – Nebraska Surface Water Quality Standards (12/31/02) Effective Under the Clean Water Act – August 8, 2003 http://www.epa.gov/ost/standards/wqslibrary/ne/ne.html
Tennessee	Rules of the Tennessee Department of Environment and Conservation; Division of Water Pollution Control Chapter 1200-4-3 General Water Quality Criteria (October 1999) Effective Under the Clean Water Act – October 11, 1999 http://www.epa.gov/ost/standards/wqslibrary/tn/tn.html

Attachment B -- EPA analysis of State Water Quality Standards in the Petition Area
(Mississippi River)

NOTE: ***Spreadsheet reflects applicable numeric criteria only.***
Numeric criteria reflected are most stringent criteria applicable to segment.

STATE	DESIGNATED USE												NUMERIC WATER QUALITY CRITERIA									
EPA's most recent 304(a) recommendations next to pollutant label	**Outstanding State Resource Water**	**Primary Rec**	**Secondary Rec**	**Aquatic Life**	**Aesthetics**	**Fish Consumption**	**Drinking Water/Domestic Water Supply**	**Agriculture**	**Irrigation**	**Livestock & Wildlife watering**	**Naviagation**	**Industrial**	**chlordane (CCC = .0043 µg/l, water + organism = .00080 µg/l, organism only = .00081 µg/l) MCL=.002mg/L or 2 µg/l**	**atrazine 1500 µg/l freshwater, 760 µg/l saltwater, MCL = 3 ppb or 3 µg/l**	**Total PCBs (CCC = .014 µg/l, HH = .000064 µg/l updated) MCL = .5 ppb or .5 µg/l**	**e.coli (126 / 100 ml)**	**enterococci (33 per 100 ml)**	**DO (5 mg/l 1 day minimum)**	**Ammonia (1999 update, pH/temp. dependent)**	**Phosphorus (ecoregional based)**	**Nitrogen (ecoregional based)**	**Sediments (narrative, Sedimentation criteria in development)**
IA (effective 6/16/04)																						
Skunk River to Iowa River		X		Significant Resource Warm Water (Class B(WW))				X	X	X		X	C = .004 µg/l* A = 2.5 µg/l* HH (fish consumption) = .006 µg/l *		C = .014 µg/l * A = 2 µg/l * HH (fish consumption) = .0004 µg/l *	E. coli = 126/100 ml* (geometric) Mar 15 - Nov 15, 235/100 ml* (single sample max)		no less than 5 mg/l (at any time)				Turbidity shall not be increased by more than 25 NTU by any point source discharge
IA-MO state line to confluence w/ Skunk R.		X		Significant Resource Warm Water (Class B(WW))				X	X	X		X	C = .004 µg/l* A = 2.5 µg/l* HH (fish consumption) = .006 µg/l *		C = .014 µg/l * A = 2 µg/l * HH (fish consumption) = .0004 µg/l *	E. coli = 126/100 ml* (geometric) Mar 15 - Nov 15, 235/100 ml* (single sample max)		no less than 5 mg/l (at any time)				Turbidity shall not be increased by more than 25 NTU by any point source discharge
Burlington Water works							X	X	X	X		X	PWS = .021 µg/l *	PWS = 3 µg/l *	PWS = .0017 µg/l*						Nitrate as N = 10 mg/l Nitrate + Nitrite as N = 10 mg/l Nitrite as N = 1 mg/l	Turbidity shall not be increased by more than 25 NTU by any point source discharge
Koekuk Municipal Water Works Intake							X	X	X	X		X	PWS = .021 µg/l *	PWS = 3 µg/l *	PWS = .0017 µg/l*						Nitrate as N = 10 mg/l Nitrate + Nitrite as N = 10 mg/l Nitrite as N = 1 mg/l	Turbidity shall not be increased by more than 25 NTU by any point source discharge
Fort Madison Municipal Water Works Intake							X	X	X	X		X	PWS = .021 µg/l *	PWS = 3 µg/l *	PWS = .0017 µg/l*						Nitrate as N = 10 mg/l Nitrate + Nitrite as N = 10 mg/l Nitrite as N = 1 mg/l	Turbidity shall not be increased by more than 25 NTU by any point source discharge
IL(effective 8/26/99)	Designated General Use Water (protects for multiple uses)																					
Mississippi River		X^	X	X	X			X		X		X	Narrative w/Translator A = 2.4 µg/l C = .0043 µg/l noncancer = .72 ng/l	A = 280 µg/l ## C = 12 µg/l ##	HH = .015 ng/L	Fecal = 200 (geometric)* nor 400* in 10% of 30 day samples		no less than 5 mg/l (at any time) or less than 6 mg/l 16 of 24 hours		.05 mg/l* in reservoir/lake 8.1 hectares (or entering stream)		
Mississippi R. at Drinking Water/Food Processing Intakes		X^	X	X	X		Public and Food Processing Water Supply	X		X		X	.003 mg/l*	A = 280 µg/l ## C = 12 µg/l ##	HH = .015 ng/L (fish consumption only)	Fecal = 2000 (geometric)*		no less than 5 mg/l (at any time) or less than 6 mg/l 16 of 24 hours		.05 mg/l* in reservoir/lake 8.1 hectares (or entering stream)	Nitrate-Nitrogen = 10 mg/l*	
MO (effective 10/31/99)																						
State Line to Ohio R.			X	WW & HH fish consumption		X	X		X	X		X	HH (fish consumption) = .00048 µg/l* PWS = 2 µg/l*	PWS = 3 µg/l*	HH = .000045 µg/l*			5 mg/l (no less than)			PWS Nitrate-Nitrogen = 10 mg/L	
Ohio R. to Missouri R.			X	WW & HH fish consumption		X	X		X	X		X	HH (fish consumption) = .00048 µg/l* PWS = 2 µg/l*	PWS = 3 µg/l*	HH = .000045 µg/l*			5 mg/l (no less than)			PWS Nitrate-Nitrogen = 10 mg/L	
Missouri R. to Des Moines R.		X	X	WW & HH fish consumption		X	X			X		X	HH (fish consumption) = .00048 µg/l* PWS = 2 µg/l*	PWS = 3 µg/l*	HH = .000045 µg/l*	Fecal = 200*		5 mg/l (no less than)			PWS Nitrate-Nitrogen = 10 mg/L	
KY (12/8/99)																						
Mississippi R. - Confluence w/ Ohio R. to River Mile 947.0		X	X	Warm Water Aquatic Habitat									(Proposing to adopt 2002 EPA HH recommendations) C = .0043 µg/l* A = 2.4 µg/l* HH (fish consumption) = 0.0022 µg/l*		C = .0014µg/l* A = LC1* or 1/3 LC50* or .3 acute toxicity units* HH (fish consumption) = .000079 µg/l*	Fecal = 200 (geometric, not less than 5 samples/month)* nor <400* in more 20% or more of all samples in month		Daily average = 5.0 mg/l (no less than)** Minimum = 4.0 mg/l(no less than)*	un-ionized = 0.05 mg/l*			
Mississippi R. - River mile 947.0 to 945.0	X	X	X	Warm Water Aquatic Habitat									"		"	"	"	"	"			
Mississippi R. - River mile 945.0 to KY/TN state line		X	X	Warm Water Aquatic Habitat									"		"	"	"	"	"			

Attachment B -- EPA analysis of State Water Quality Standards in the Petition Area
(Mississippi River)

STATE		DESIGNATED USE											NUMERIC WATER QUALITY CRITERIA									
EPA's most recent 304(a) recommendations next to pollutant label	**Outstanding State Resource Water**	**Primary Rec**	**Secondary Rec**	**Aquatic Life**	**Aesthetics**	**Fish Consumption**	**Drinking Water/Domestic Water Supply**	**Agriculture**	**Irrigation**	**Livestock & Wildlife watering**	**Naviagation**	**Industrial**	**chlordane (CCC = .0043 µg/l, water + organism = .00080 µg/l, organism only = .00081 µg/l) MCL=.002mg/L or 2 µg/l**	**atrazine 1500 µg/l freshwater, 760 µg/l saltwater, MCL = 3 ppb or 3 µg/l**	**Total PCBs (CCC = .014 µg/l, HH = .000064 µg/l updated) MCL = .5 ppb or .5 µg/l**	**e.coli (126 / 100 ml)**	**enterococci (33 per 100 ml)**	**DO (5 mg/l 1 day minimum)**	**Ammonia (1999 update, pH/temp. dependent)**	**Phosphorus (ecoregional based)**	**Nitrogen (ecoregional based)**	**Sediments (narrative. Sedimentation criteria in development)**
AR (effective 1/23/03)																						
Mississippi River		X	X	Perrenial Delta Fishery			X		X			X	C = .0043 µg/l** A = 2.4 µg/l* HH = 5 ng/l		C = .0140 µg/l** HH = .4 ng/l	fecal = 200* (geometric) nor 400* in more than 10% of 30 day samples		5 mg/l (no less than)		TP = 100 µg/l***	10 mg/l effluent limit for dischargers near domestic water supply uses #	Turbidity = 50 NTU
TN (effective 10//11/99)																						
Mississippi R. Mile 741.0 to 820.0		X		X			X		X	X	X	X	(Adopted 2002 EPA HH recommendations, pending approval) C = .0043 µg/l A = 2.4 µg/l 2 µg/l* (PWS) water+organism = .0057 µg/l, organism only = .0059 µg/l	3 µg/l* (PWS)	C = .014 µg/l (each aroclor) 0.5 µg/l* (PWS) water+organism = .00044 µg/l total, organism only = .00045 µg/l total	Fecal = 200* , E.coli = 126 *(geometric based on 10 samples)		5 mg/l (no less than)				
Mississippi R. Mile 820.0 to TN/KY state line (Mile 905.0)		X		X			X		X	X	X	X	(Adopted 2002 EPA HH recommendations, pending approval) C = .0043 µg/l A = 2.4 µg/l 2 µg/l* (PWS) water+organism = .0057 µg/l, organism only = .0059 µg/l	3 µg/l* (PWS)	C = .014 µg/l (each aroclor) 0.5 µg/l* (PWS) water+organism = .00044 µg/l , organism only = .00045 µg/l	Fecal = 200* , E.coli = 126 *(geometric based on 10 samples)		5 mg/l (no less than)				

* Shall not exceed
** 24 hour average
*** As a guideline, shall not exceed
^Protects for Primary "for all General Use waters whose physical configuration permits
Based on Arkansas Water Quality Planning and Management: State Continuing Planning Process (1999)
Based on Narrative Procedure to derive Numeric Criteria

Attachment B -- EPA Analysis of State Water Quality Standards in the Petition Area
(Missouri River)

NOTE: ***Spreadsheet reflects applicable numeric criteria only.***
Numeric criteria reflected are most stringent criteria applicable to segment.

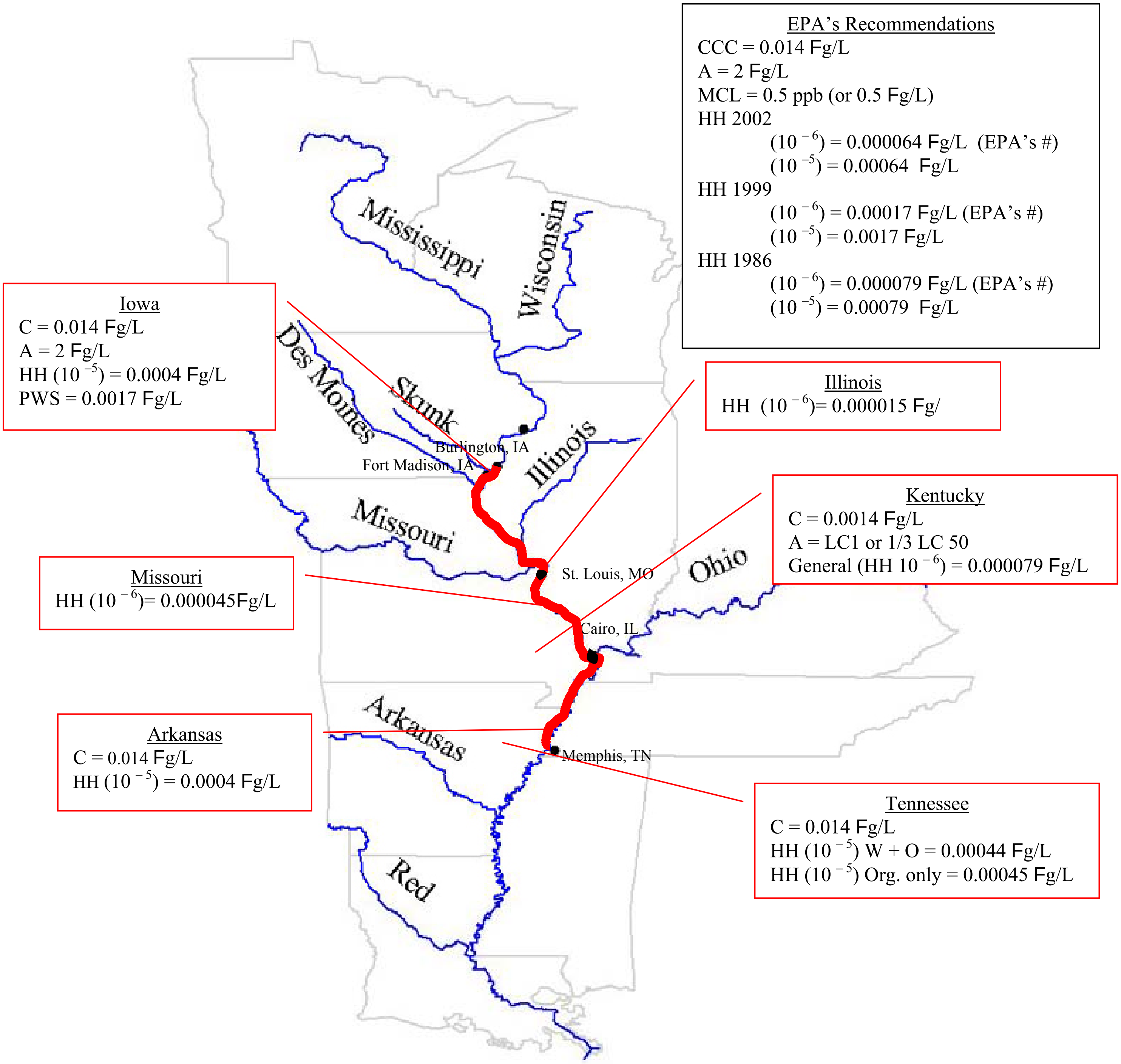
STATE	DESIGNATED USE										NUMERIC WATER QUALITY CRITERIA									
	Primary Rec	Secondary Rec	Aquatic Life	Aesthetics	Food Procurement/ Fish consumption	Public/Domestic Water Supply	Agricultural	Irrigation	Livestock & Wildlife watering	Industrial	chlordane (CCC = .0043 µg/l, water + organism = .00080 µg/l, organism only = .00081 µg/l) MCL=.002mg/L or 2 µg/l	atrazine 1500 µg/l freshwater, 760 µg/l saltwater, MCL = 3 ppb or 3 µg/l	Total PCBs (CCC = .014 µg/l, CMC = 2 µg/l, HH = .000064 µg/l updated) MCL = .5 ppb or .5 µg/l	e.coli (126 per 100 ml)	enterococci (33 per 100 ml)	DO (5 mg/l 1 day minimum)	Ammonia (1999 update, pH/temp. dependent)	Phosphorus (ecoregional based)	Nitrogen (ecoregional based)	Sediments (narrative. Sedimentation criteria in development)
IA (effective 6/16/04)																				
IA-MO state line to confluence w/ Big Sioux R.	X		Significant Resource Warm Water (Class B(WW))				X	X	X	X	C = .004 µg/l * A = 2.5 µg/l* HH = .006 µg/l*		C = .014 µg/l* A = 2 µg/l* HH = .0004 µg/l*	E. coli = 126/100 ml* (geometric) Mar 15 - Nov 15, 235/100 ml* (single sample max)		no less than 5 mg/l (at any time)				Turbidity shall not be increased by more than 25 NTU by any point source discharge
City of Council Bluffs Water Works Intake						X	X	X	X	X	PWS = .021 µg/l*	PWS = 3µg/l*	PWS = .0017µg/l*						Nitrate as N = 10 mg/l Nitrate + Nitrite as N = 10 mg/l Nitrite as N = 1 mg/l	Turbidity shall not be increased by more than 25 NTU by any point source discharge
NE (effective 8/8/03)	Water quality criteria to protect downstream beneficial uses shall be applicable to all surface waters, whether or not those beneficial uses are assigned to a given water body.																			
Platte R. to NE-KS border	X		Class A Warm Water	X		X	X			X	C = .0043 µg/l** A = 2.4 µg/l* PWS = 2 µg/l*	C = 12 µg/l (4 day average) A = 330 µg/l (1 hr average) PWS = 3 µg/l*	C = .0017 µg/l** A = 2 µg/l* PWS = .5 µg/l*	fecal = 200 (geometric mean)* or 400 (no more than 10% of samples shall equal or exceed) E.coli = 126/100ml* (5 samples, 30-day period)		1 day min no less than 5 mg/l (April 1 - Sep. 30 - early life stages) 1 day min no less than 3 mg/l (Oct. 1 - Mar. 31)			(AG) Nitrate + Nitrite = 100 mg/l* (PWS) Nitrate-nitrogen = 10 mg/L* (PWS) Nitrite-Nitrogen = 1 mg/L*	
Big Sioux R. to Platte R.	X		Class A Warm Water	X		X	X			X	C = .0043 µg/l** A = 2.4 µg/l* PWS = 2 µg/l*	C = 12 µg/l (4 day average) A = 330 µg/l (1 hr average) PWS = 3 µg/l*	C = .0017 µg/l** A = 2 µg/l* PWS = .5 µg/l*	fecal = 200 (geometric mean)* or 400 (no more than 10% of samples shall equal or exceed) E.coli = 126/100ml* (5 samples, 30-day period)		1 day min no less than 5 mg/l (April 1 - Sep. 30 - early life stages) 1 day min no less than 3 mg/l (Oct. 1 - Mar. 31)			(AG) Nitrate + Nitrite = 100 mg/l* (PWS) Nitrate-nitrogen = 10 mg/L* (PWS) Nitrite-Nitrogen = 1 mg/L*	
MO (10/31/99)																				
Mouth to Gasconade R.		X	WW & HH fish consumption			X		X	X	X	HH = .00048 µg/l* PWS = 2 µg/l*	PWS = 3 µg/l*	C = .000045 µg/l*			5 mg/l (no less than)			PWS Nitrate-Nitrogen = 10 mg/L	
Gasconade R. to Chariton R.		X	WW & HH fish consumption			X		X	X	X	HH = .00048 µg/l* PWS = 2 µg/l*	PWS = 3 µg/l*	C = .000045 µg/l*			5 mg/l (no less than)			PWS Nitrate-Nitrogen = 10 mg/L	
Chariton R. to Kansas R.		X	WW & HH fish consumption			X		X	X	X	HH = .00048 µg/l* PWS = 2 µg/l*	PWS = 3 µg/l*	C = .000045 µg/l*			5 mg/l (no less than)			PWS Nitrate-Nitrogen = 10 mg/L	
Kansas R. to State Line		X	WW & HH fish consumption			X		X	X	X	HH = .00048 µg/l* PWS = 2 µg/l*	PWS = 3 µg/l*	C = .000045 µg/l*			5 mg/l (no less than)			PWS Nitrate-Nitrogen = 10 mg/L	

Attachment B -- EPA Analysis of State Water Quality Standards in the Petition Area
(Missouri River)

STATE	DESIGNATED USE										NUMERIC WATER QUALITY CRITERIA									
	Primary Rec	Secondary Rec	Aquatic Life	Aesthetics	Food Procurement/ Fish consumption	Public/Domestic Water Supply	Agricultural	Irrigation	Livestock & Wildlife watering	Industrial	chlordane (CCC = .0043 µg/l, water + organism = .00080 µg/l, organism only = .00081 µg/l) MCL=.002mg/L or 2 µg/l	atrazine 1500 µg/l freshwater, 760 µg/l saltwater, MCL = 3 ppb or 3 µg/l	Total PCBs (CCC = .014 µg/l, CMC = 2 µg/l, HH = .000064 µg/l updated) MCL = .5 ppb or .5 µg/l	e.coli (126 per 100 ml)	enterococci (33 per 100 ml)	DO (5 mg/l 1 day minimum)	Ammonia (1999 update, pH/temp. dependent)	Phosphorus (ecoregional based)	Nitrogen (ecoregional based)	Sediments (narrative. Sedimentation criteria in development)
KS (effective 11/3/03)																				
Missouri R. (HUC 10240005, Seg. 1)	Class B	X	Special Aquatic Life Use (applicable criteria same for all aquatic life use designations. Only use name differs)		X	X		X	X	X	C = .0043 µg/l* A = 2.4 µg/l* HH (fish consumption) = .00048 µg/l* (3 µg/l for LWW) PWS = .00057 µg/l (EPA)	C = 3 µg/l* A = 170 µg/l* PWS = 3 µg/l*	C = .014 µg/l* A = 2 µg/l* HH (fish consumption) = .0000079 µg/l* PWS = .00017 µg/l (EPA)	E.coli (geometric mean)* = 262/100 mL		not less than 5 mg/l		Elemental P = .1 µg/l	Nitrate as N = 10 mg/l (PWS) Nitrite + Nitrate as N = 10 mg/l (PWS) or 100 mg/l (LWW)	
Missouri R. (HUC 10240005, Seg. 19)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240005, Seg. 2)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240005, Seg. 21)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 1)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 11)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 13)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 15)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 19)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 2)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 4)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 5)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 7)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 9)	"	X	Special Aquatic Life Use		X	X		X	X	X	"	"	"	"	"	"		"	"	
Missouri R. (HUC 10240011, Seg. 9099)	"	X	Expected Aquatic Life Use		X	X	X	X	X	X	"	"	"	"	"	"		"	"	

* Shall not exceed
** 24 hour average

ATTACHMENT C
PCB CRITERIA ON MISSISSIPPI RIVER



EPA's Recommendations
CCC = 0.014 Fg/L
A = 2 Fg/L
MCL = 0.5 ppb (or 0.5 Fg/L)
HH 2002
(10^{-6}) = 0.000064 Fg/L (EPA's #)
(10^{-5}) = 0.00064 Fg/L
HH 1999
(10^{-6}) = 0.00017 Fg/L (EPA's #)
(10^{-5}) = 0.0017 Fg/L
HH 1986
(10^{-6}) = 0.000079 Fg/L (EPA's #)
(10^{-5}) = 0.00079 Fg/L

Iowa
C = 0.014 Fg/L
A = 2 Fg/L
HH (10^{-5}) = 0.0004 Fg/L
PWS = 0.0017 Fg/L

Illinois
HH (10^{-6})= 0.000015 Fg/

Kentucky
C = 0.0014 Fg/L
A = LC1 or 1/3 LC 50
General (HH 10^{-6}) = 0.000079 Fg/L

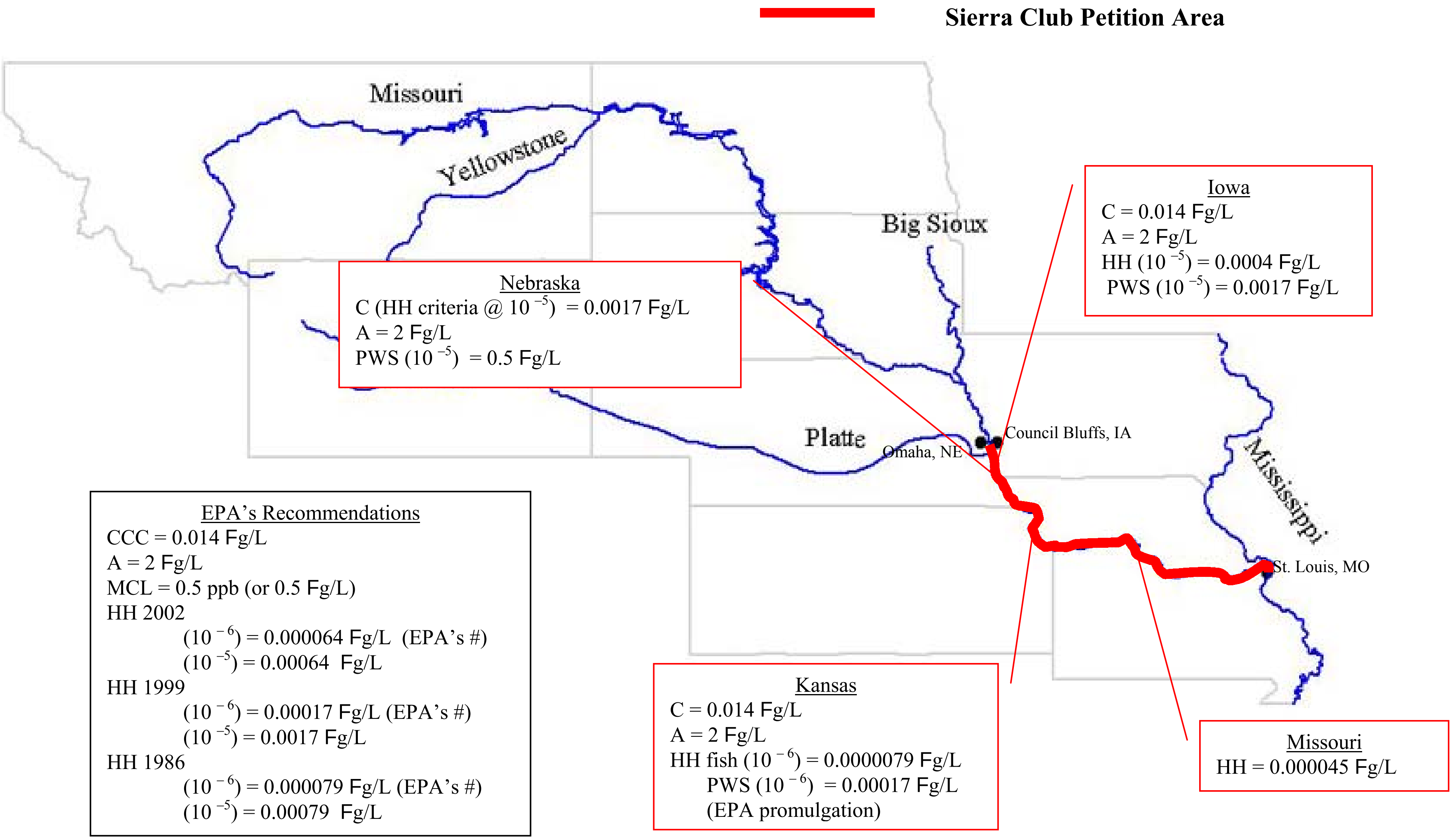
Missouri
HH (10^{-6})= 0.000045Fg/L

Arkansas
C = 0.014 Fg/L
HH (10^{-5}) = 0.0004 Fg/L

Tennessee
C = 0.014 Fg/L
HH (10^{-5}) W + O = 0.00044 Fg/L
HH (10^{-5}) Org. only = 0.00045 Fg/L

▬ **Sierra Club Petition Area**

ATTACHMENT D
PCB CRITERIA ON MISSOURI RIVER



Nebraska

C (HH criteria @ 10^{-5}) = 0.0017 Fg/L
A = 2 Fg/L
PWS (10^{-5}) = 0.5 Fg/L

Iowa

C = 0.014 Fg/L
A = 2 Fg/L
HH (10^{-5}) = 0.0004 Fg/L
PWS (10^{-5}) = 0.0017 Fg/L

EPA's Recommendations

CCC = 0.014 Fg/L
A = 2 Fg/L
MCL = 0.5 ppb (or 0.5 Fg/L)
HH 2002
(10^{-6}) = 0.000064 Fg/L (EPA's #)
(10^{-5}) = 0.00064 Fg/L
HH 1999
(10^{-6}) = 0.00017 Fg/L (EPA's #)
(10^{-5}) = 0.0017 Fg/L
HH 1986
(10^{-6}) = 0.000079 Fg/L (EPA's #)
(10^{-5}) = 0.00079 Fg/L

Kansas

C = 0.014 Fg/L
A = 2 Fg/L
HH fish (10^{-6}) = 0.0000079 Fg/L
PWS (10^{-6}) = 0.00017 Fg/L
(EPA promulgation)

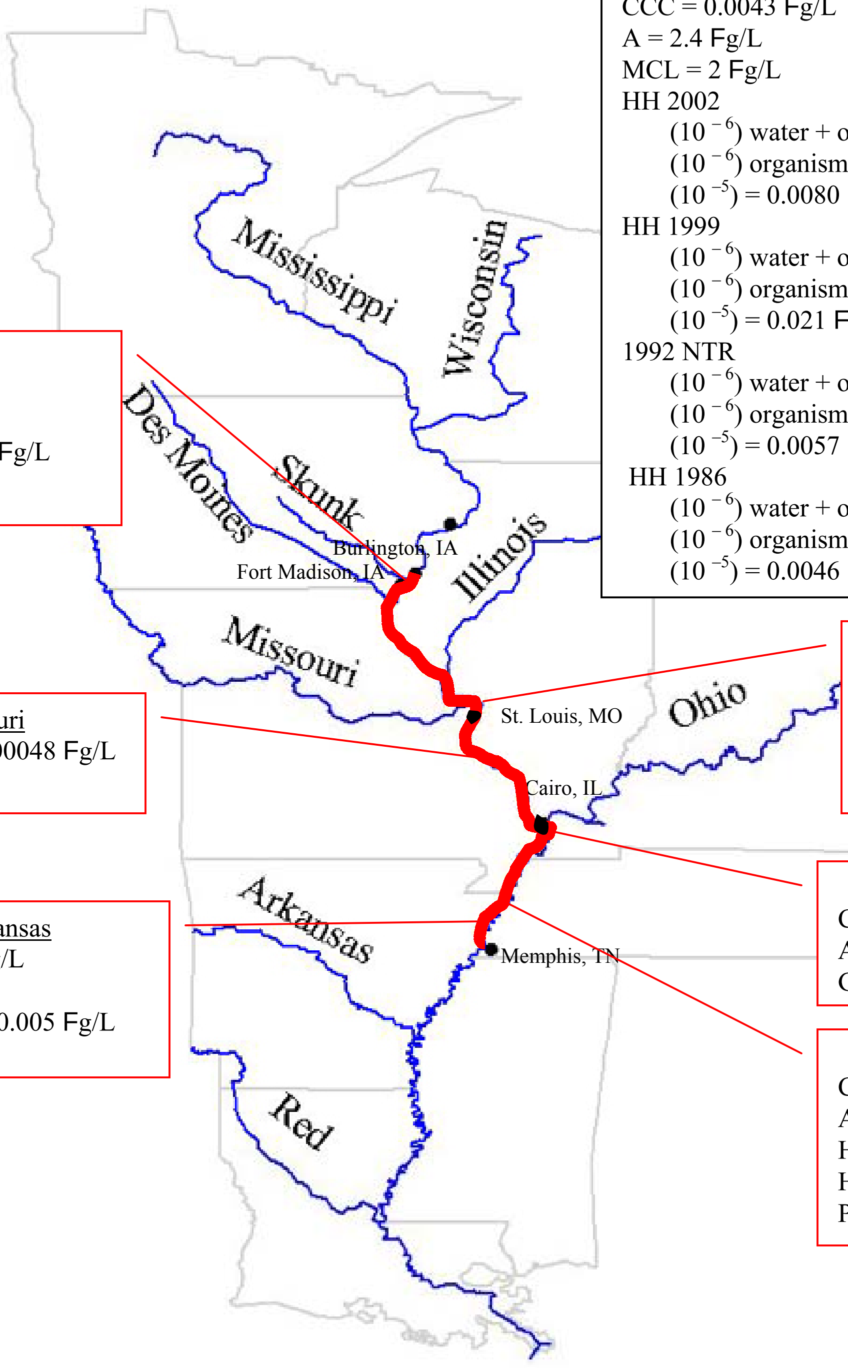
Missouri

HH = 0.000045 Fg/L

ATTACHMENT E
CHLORDANE CRITERIA ON MISSISSIPPI RIVER

EPA's Recommendations

CCC = 0.0043 Fg/L
A = 2.4 Fg/L
MCL = 2 Fg/L
HH 2002
  (10^{-6}) water + organism = 0.00080 Fg/L (EPA's #)
  (10^{-6}) organism only = 0.00081 Fg/L (EPA's #)
  (10^{-5}) = 0.0080 Fg/L (w + o) & 0.0081 Fg/L (org.)
HH 1999
  (10^{-6}) water + organism = 0.0021 Fg/L (EPA's #)
  (10^{-6}) organism only = 0.0022 Fg/L (EPA's #)
  (10^{-5}) = 0.021 Fg/L (w + o) & 0.022 Fg/L (org)
1992 NTR
  (10^{-6}) water + organism = 0.00057 Fg/L (EPA's #)
  (10^{-6}) organism only = 0.00059 Fg/L (EPA's #)
  (10^{-5}) = 0.0057 Fg/L (w + o) & 0.0059 Fg/L (org)
HH 1986
  (10^{-6}) water + organism = 0.00046 Fg/L (EPA's #)
  (10^{-6}) organism only = 0.00048 Fg/L (EPA's #)
  (10^{-5}) = 0.0046 Fg/L (w + o) & 0.0048 Fg/L (org)



Iowa

C = 0.004 Fg/L
A = 2.5 Fg/L
HH (10^{-5}) = 0..006 Fg/L
PWS = 0.021 Fg/L

Illinois

C = .0043Fg/L
A = 2.4 Fg/L
HH (10^{-6})= 0.00072 Fg/
PWS = 3 Fg/L

Missouri

HH (10^{-6})= 0.00048 Fg/L
PWS = 2 Fg/L

Kentucky

C = 0.0043 Fg/L
A = 2.4 Fg/L
General (HH 10^{-6}) = 0.0022 Fg/L

Arkansas

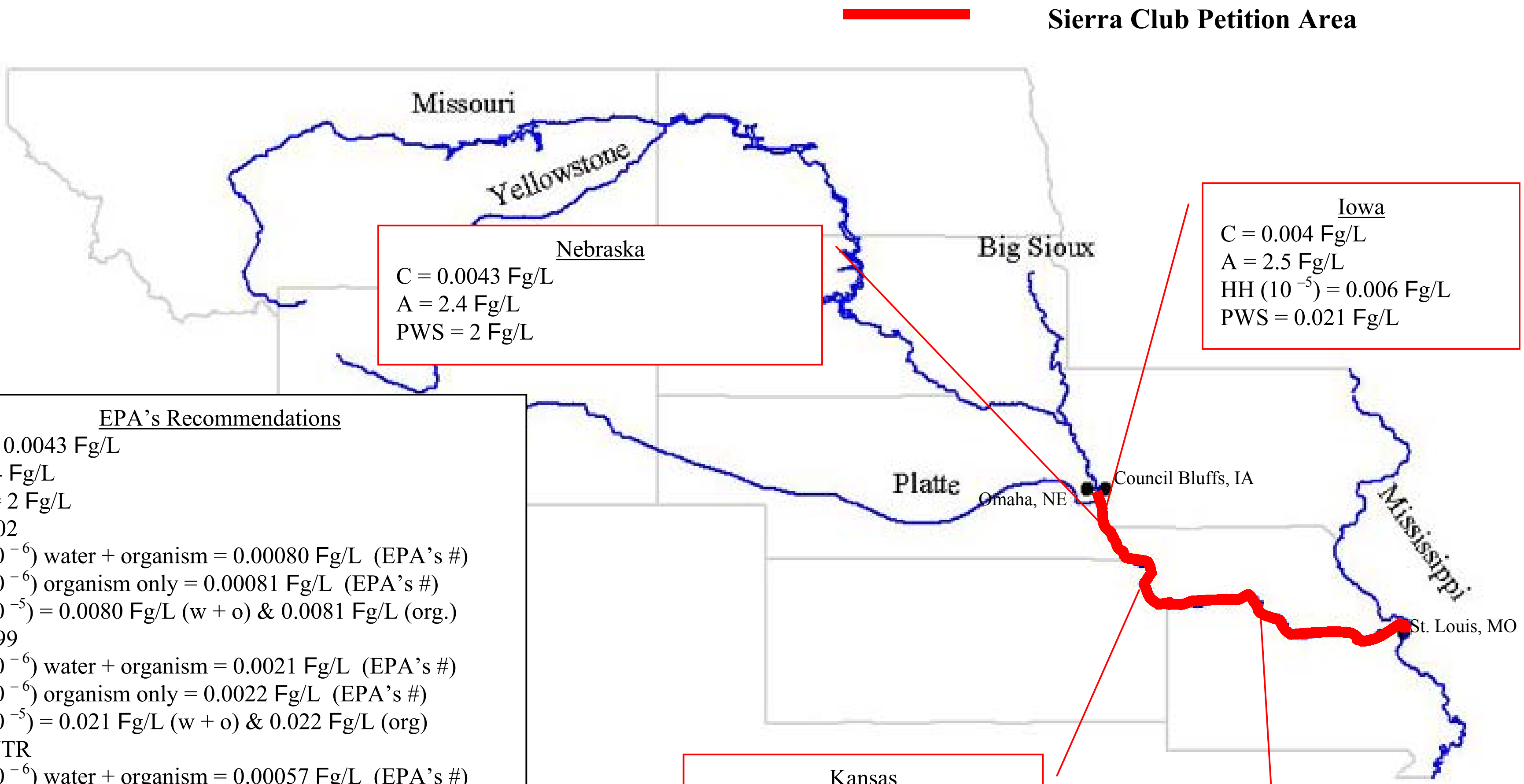
C = 0.0043 Fg/L
A = 2.4 Fg/L
HH (10^{-5}) = 0.005 Fg/L

Tennessee

C = 0.0043 Fg/L
A = 2.4 Fg/L
HH (10^{-5}) W + O = 0.0057 Fg/L
HH (10^{-5}) Org. only = 0.0059 Fg/L
PWS = 2 Fg/L

▬ **Sierra Club Petition Area**

ATTACHMENT F
CHLORDANE CRITERIA ON MISSOURI RIVER



Nebraska
C = 0.0043 Fg/L
A = 2.4 Fg/L
PWS = 2 Fg/L

Iowa
C = 0.004 Fg/L
A = 2.5 Fg/L
HH (10^{-5}) = 0.006 Fg/L
PWS = 0.021 Fg/L

EPA's Recommendations
CCC = 0.0043 Fg/L
A = 2.4 Fg/L
MCL = 2 Fg/L
HH 2002
- (10^{-6}) water + organism = 0.00080 Fg/L (EPA's #)
- (10^{-6}) organism only = 0.00081 Fg/L (EPA's #)
- (10^{-5}) = 0.0080 Fg/L (w + o) & 0.0081 Fg/L (org.)

HH 1999
- (10^{-6}) water + organism = 0.0021 Fg/L (EPA's #)
- (10^{-6}) organism only = 0.0022 Fg/L (EPA's #)
- (10^{-5}) = 0.021 Fg/L (w + o) & 0.022 Fg/L (org)

1992 NTR
- (10^{-6}) water + organism = 0.00057 Fg/L (EPA's #)
- (10^{-6}) organism only = 0.00059 Fg/L (EPA's #)
- (10^{-5}) = 0.0057 Fg/L (w + o) & 0.0059 Fg/L (org)

HH 1986
- (10^{-6}) water + organism = 0.00046 Fg/L (EPA's #)
- (10^{-6}) organism only = 0.00048 Fg/L (EPA's #)
- (10^{-5}) = 0.0046 Fg/L (w + o) & 0.0048 Fg/L (org)

Kansas
C = 0.0043 Fg/L
A = 2.4 Fg/L
HH fish (10^{-6}) = 0.00048 Fg/L
PWS (10^{-6}) = 0.00057 Fg/L
(EPA promulgation)

Missouri
HH (10^{-6})= 0.00048 Fg/L
PWS = 2 Fg/L

ATTACHMENT G
PETITION STATES' CWA SECTION 303(D) IMPAIRED WATERS LISTINGS FOR MISSISSIPPI AND MISSOURI RIVER
(As Of March 2004)

Mississippi River

	Segment	Location	Impairment	Use impaired
Iowa				
	IA-1-NEM-0010_2	L&D 15 to L&D 14	arsenic	Drinking water
	IA01-NEM-0010_4	Wapsipinicon R. to L&D 13	organic enrichment	Aquatic life
	IA-03-SKM-0010_1	MO state line to outfall of Ft. Madison WWTP	arsenic	Drinking water
Illinois				
	ILI01_I 05	Mississippi River South	PCBs	Overall use, drinking water supply, fish consumption, aquatic life, primary contact (swimming)
	ILJ81_J 01		PCBs	Overall use, drinking water supply, fish consumption, aquatic life
	ILJ83_J 05		PCBs, Siltation, Suspended Solids, Metals, Nutrients, Phosphorus, Total Ammonia-N, Nitrates	Overall use, fish consumption, aquatic life, primary contact (swimming)
	ILJ83_J 06		PCB siltation, flow alterations, habitat, nutrients	Overall use, fish consumption, aquatic life

	Segment	Location	Impairment	Use impaired
	ILJ03_J 11		Nonpriority Organics, Siltation, Habitat Alteration, Suspended Solids, Priority Organics	Overall use, drinking water supply, fish consumption, aquatic life
	ILK04_K 22		PCBs, Pathogens, Organic Enrichment, Priority Organics	Overall u7se, drinking water supply, fish consumption, aquatic life, primary contact (swimming)
	ILK03_K 17		PCBs, Organic Enrichment, Priority Organics	Overall use, drinking water supply, fish consumption, aquatic life
	ILK06_K 21		PCBs, Organic Enrichment, Priority Organics	Overall use, fish consumption, aquatic life
	ILM02_M 06		PCBs	Overall use, fish consumption, aquatic life
	ILM03_M 03		PCBs	Overall use, fish consumption, aquatic life
	ILM04_M 04		PCBs	Overall use, fish consumption, aquatic life, primary contact (swimming)
	ILM05_M 05		PCBs	Overall use, drinking water supply, fish consumption, aquatic life

	Segment	Location	Impairment	Use impaired
	ILM10_M 10		PCBs	Overall use, fish consumption, aquatic life, primary contact (swimming)
	ILI84_I 84		PCBs	Overall use, fish consumption, aquatic life, primary contact (swimming)
Missouri				
	WBID 1707	Ohio R to Missouri R. @ Herculaneum (5 mi)	lead, zinc	Aquatic life
	WBID 3152	Ohio R. to state line	chlordane, PCBs	Aquatic life (fish consumption)
	WBID 1707	Missouri R. to Ohio R.	chlordane, PCBs	Aquatic life (fish consumption)
	WBID 1	Des Moines R. to Missouri R.	chlordane, PCBs	Aquatic life (fish consumption)
Kentucky	No 303(d) listings			
Tennessee				
	TN08010100001 - 0200	BLUE BANK BAYOU	Nutrients. siltation	Fish and aquatic life use
	TN08010100001 –1000	MISSISSIPPI RIVER	PCBs, dioxin, chlordane, nitrate, siltation, other habitat alterations	Fishing advisory originally due to chlordane

	Segment	Location	Impairment	Use impaired
	TN08010100001 - 1100	MCKELLAR LAKE	PCBs, chlordane, dioxin, siltation, organic enrichment/low DO, pathogens	Fishing advisory originally due to chlordane.
	TN08010100001 - 2000	MISSISSIPPI RIVER	PCBs, dioxin, chlordane, nitrate, siltation, other habitat alterations	Fish and aquatic life use.
	TN08010100001 - 3000	MISSISSIPPI RIVER	PCBs, dioxin, chlordane, nitrate, siltation, other habitat alterations	Fish and aquatic life use
	TN08010100001 - 4000	MISSISSIPPI RIVER	PCBs, dioxin, chlordane, nitrate, siltation, other habitat alterations	Documented habitat for a federally listed fish: the pallid sturgeon (Scaphirhynchus albus).
	TN08010100001 - 5000	MISSISSIPPI RIVER	PCBs, dioxin, chlordane, nitrate, siltation, other habitat alterations	Fish and aquatic life use.
	TN08010100POPLARTLK	POPLAR TREE LAKE	Nutrients	No recent data on this 125 acre lake.
Arkansas	No 303(d) listings			

Missouri River

	Segment	Location	Impairment	Use impaired
Iowa				
	IA06-WEM-0020_2	Council Bluffs water supply intake to Boyer R.	arsenic	Drinking water
	IA06-WEM-0020_2	Council Bluffs water supply intake to Boyer R.	bacteria	Primary contact recreation
Nebraska				
	MT1-10000	Big Sioux R. to Platte R.	fecal coliform	Primary contact recreation
	NE1-10000	Platte R. to Kansas border	fecal coliform	Primary contact recreation
Kansas	No 303(d) listings			
Missouri				
	WBID 1604	Gasconade R. to mouth	chlordane, PCBs	Aquatic life (fish consumption)
	WBID 701	Chariton R. to Gasconade R.	chlordane, PCBs	Aquatic life (fish consumption)
	WBID 356	Kansas R. to Chariton R.	chlordane, PCBs	Aquatic life (fish consumption)
	WBID 226	Iowa sate line to Kansas R.	chlordane, PCBs	Aquatic life (fish consumption)
	WBID 356	Kansas R. to Chariton R.	mercury	Aquatic life (fish consumption)
	WBID 226	Kansas R. to Iowa State line	mercury	Aquatic life (fish consumption)

Spokane River
PCB Source Assessment
2003-2007

April 2011

Publication No. 11-03-013

DEPARTMENT OF
ECOLOGY
State of Washington

06808

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For more information contact:

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Cover photo: Spokane Falls (photo by Pat Hallinan)

Spokane River
PCB Source Assessment
2003-2007

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by

Dave Serdar, Brandi Lubliner, Art Johnson, and Dale Norton

Toxics Studies Unit
Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

Waterbody Numbers:

WA-57-1010: Middle Spokane River
WA-54-1010, WA-54-1020: Lower Spokane River
WA-54-9040: Lake Spokane (formerly Long Lake-Spokane River)
WA-55-1010: Little Spokane River

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Abstract

The Spokane River does not meet Washington State human health criteria for polychlorinated biphenyls (PCBs) in edible fish tissue. During 2003 to 2007, the Department of Ecology conducted a series of water quality studies in an effort to assess sources of these legacy pollutants to the river. PCBs were analyzed in river water, industrial and municipal wastewater effluents, stormwater, suspended particulate matter, bottom sediments, sediment cores, and fish tissue. The study area covered the Spokane River from the Idaho border (river mile 96.1) to the mouth at the Columbia River. The lower part of the river flows through the Spokane Tribe of Indians reservation.

Total PCB concentrations in water increased with successive reaches moving downstream from the Idaho border (106 pg/l, parts per quadrillion) to lower Lake Spokane (formerly Long Lake; 399 pg/l), with a corresponding eight-fold increase in loads (477 – 3,664 mg/day), on average. The Washington State PCB human health criterion for surface water is 170 pg/l. Although PCB concentrations in Spokane River fish are generally much lower than historical levels, fish in most areas did not meet the state's human health criterion in edible tissue (5.3 ng/g, parts per billion).

Overall, PCB loading to Washington reaches of the river can be divided into the following source categories; City of Spokane stormwater (44%), municipal and industrial discharges (20%), and Little Spokane River (6%). In addition, PCB loading from Idaho at the state line represented 30% of the overall loading.

A PCB loading scenario was proposed to meet the Spokane Tribe human health water quality criterion for total PCBs (3.37 pg/l, equivalent to 0.1 ng/g in tissue). The scenario requires a 95% PCB load reduction at the Idaho border, a 97% load reduction in the Little Spokane River, and ≥99% reductions in municipal, industrial, and stormwater discharges. A food web bioaccumulation model indicated that PCB loads in water and PCB concentrations in sediment would require large reductions to meet the Spokane Tribe criterion.

Acknowledgements

The authors of this report thank the following people for their contribution to this study:

- Pat Blau (Kaiser Trentwood), Rick Fink (Inland Empire), Dan Grogg (Liberty Lake Wastewater Treatment Plant), and Tim Pelton (Spokane Wastewater Treatment Plant) permitted sampling of their facilities.
- Gary Bussiere and Michael Coster (City of Spokane) arranged and conducted stormwater sampling.
- Bob Hughes (Plante Ferry Park), Dennis Dalton, Jack Hartt, and Mark Nickelson (Riverside State Park), Brett Walker (Washington Department of Natural Resources Long Lake Campground), Mark Bloss and Larry Ford (Avista Long Lake and Little Falls Dam), and Mark Cleveland (Upriver Dam) provided access to the Spokane River.
- John Sneva and Lucinda Morrow (Washington Department of Fish and Wildlife) aged fish specimens.
- Jim Huckins and David Alvarez (U.S. Geological Survey) provided advice on interpreting semipermeable membrane devices data.
- Larry Gadbois (Environmental Protection Agency) reviewed the report.
- Staff from the Washington State Department of Ecology (* formerly with Ecology):
    - John Roland of Ecology’s Eastern Regional Office (ERO) provided valuable advice from project inception through completion.
    - John Roland, David Moore, Patrick Hallinan, Arianne Fernandez, and Brendan Dowling reviewed the project report for ERO.
    - Nigel Blakley*, Brandee Era-Miller, Richard Jack*, Aspen Madrone, Dale Norton, Jim Ross, Lawrence Sullivan*, and Sandra Treccani assisted with sampling.
    - Steve Golding* conducted sampling at NPDES permitted facilities.
    - Chad Wiseman* identified benthic organisms in fish stomachs.
    - Nigel Blakley* assisted with food web modeling.
    - Casey Deligeannis and Keith Seiders helped prepare tissue samples.
    - Pam Covey* and Will White* tracked and transported samples for laboratory analysis.
    - Karin Feddersen managed outside laboratory contracts.
    - Heidi Chuhran, Kamilee Ginder, Meredith Jones, Randy Knox, Myrna Mandjikov, Jamie Martin, Bridget Mason, Dean Momohara, and Aileen Richmond analyzed samples at Manchester Environmental Laboratory.
    - David Sternberg reviewed the project report for the Toxics Cleanup Program.
    - Dale Norton supervised this project.
    - Joan LeTourneau, Cindy Cook, and Gayla Lord edited and formatted the final report.

Executive Summary

Section 303(d) of the federal Clean Water Act requires states to prepare a list every two years of waterbodies that do not meet water quality standards. In Washington, the 303(d) list is compiled by the Washington State Department of Ecology (Ecology). The Clean Water Act requires that waterbodies on the 303(d) list be cleaned up by pollution-control programs or that a Total Maximum Daily Load (TMDL) be developed for the pollutants of concern. A TMDL determines the amount of pollutant that can be discharged to a waterbody and still meet standards (loading capacity) and allocates that load among the various sources."

Fifteen waterbody segments of the Spokane River and Lake Spokane (also known as Long Lake), and one segment of the Little Spokane River are on the 2008 303(d) list for not meeting (exceeding) Washington State's human health water quality criterion for polychlorinated biphenyls (PCBs) in edible fish tissue (Table ES-1). PCBs are legacy pollutants no longer produced or no longer put into new use in the United States. PCBs had numerous industrial applications as insulating fluids, plasticizers, in inks, and carbonless paper, and as heat transfer and hydraulic fluids. Environmental Protection Agency (EPA) has classified these compounds as probable human carcinogens.

Table ES-1. 303(d) Listings for Total PCBs in the Spokane River.

Waterbody	Reach	Waterbody Number	Watercourse Number	Listing ID
Spokane River	Idaho Border to Latah Creek	WA-57-1010	QZ45UE	14397 14398 8201 8207 8202 14402
Spokane River	Latah Creek to Ninemile Dam	WA-54-1010	QZ45UE	14400 14385 9033
Little Spokane River	Near mouth	WA-55-1010	JZ70CP	9051
Lake Spokane (Long Lake)	Ninemile Dam to Lake Spokane Dam	WA-54-9040	QZ45UE	9021 36441 9015 36440
Spokane River	Lake Spokane Dam to Mouth	WA-54-1020	QZ45UE	9027

Ecology conducted the water quality studies described in this report from 2003 to 2007 to assess PCB sources to the Spokane River. The goal of these efforts was to quantify PCB contamination and identify necessary reductions in sources and the receiving waters to meet applicable PCB water quality criteria in the Spokane River. The studies analyzed PCBs in river water, industrial and municipal effluents, stormwater, suspended particulate matter, bottom sediments, sediment cores, and fish tissue.

The Spokane River, shown in Figure ES-1, begins in northern Idaho at the outlet of Lake Coeur d'Alene and flows west 112 miles to the Columbia River (Lake Roosevelt). The study area covered the Spokane River from the Idaho border (river mile 96.1) to the Columbia. The watershed encompasses over 6,000 square miles (15,500 km^2) in Washington and Idaho. The river flows through the smaller cities of Post Falls and Coeur d'Alene in Idaho and large urban areas of the Spokane Valley and Spokane in Washington. Other cities in the watershed include Liberty Lake, Deer Park, and Medical Lake Washington as well as Wallace and Kellogg Idaho upstream from Lake Coeur d'Alene. The Spokane Tribe of Indians reservation lies along the north bank of the lower river (Spokane Arm of Lake Roosevelt).

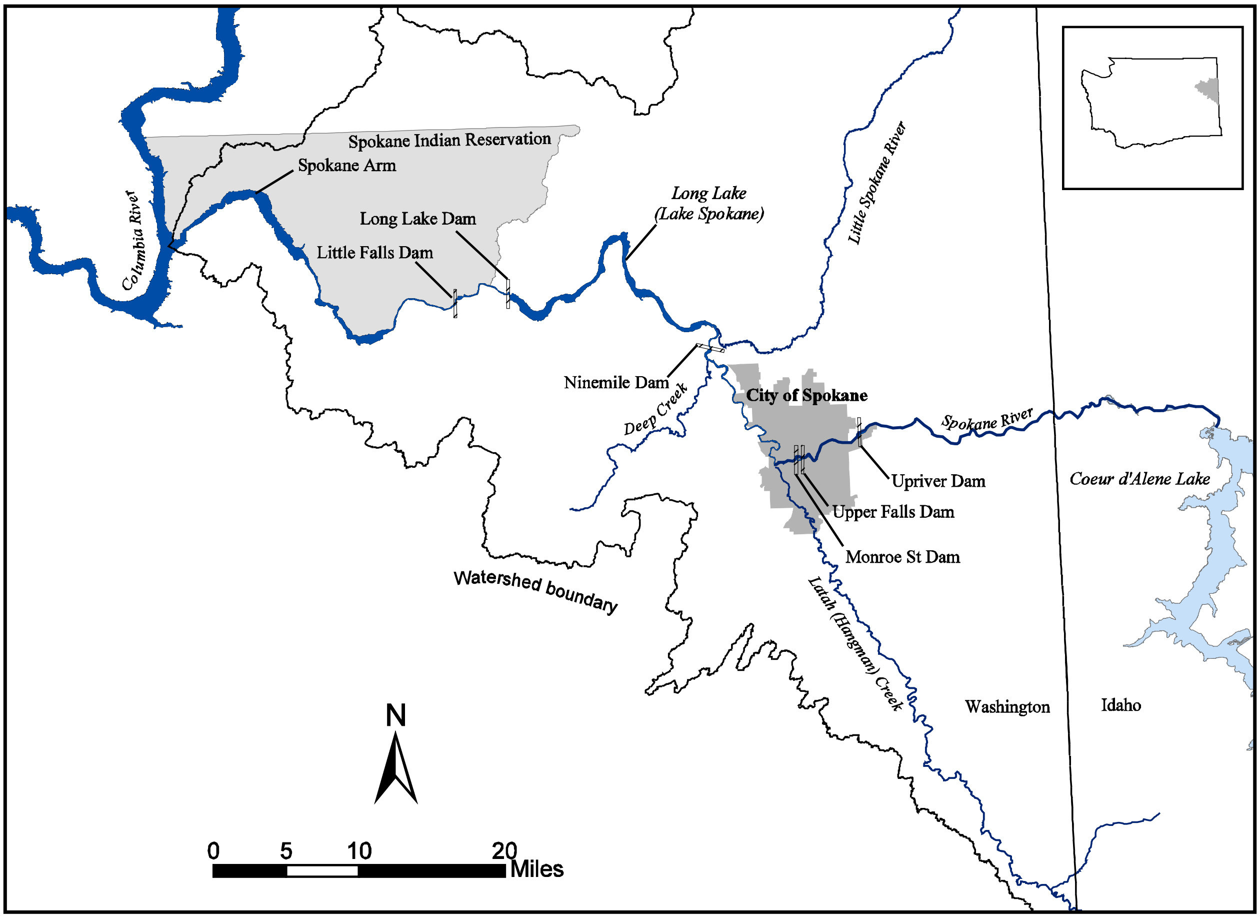

Figure ES-1: Spokane River Basin.

The Spokane Tribe human health PCB water quality criterion of 3.37 pg/l (parts per quadrillion) was used as the basis for calculating necessary PCB load reductions. The criterion is equivalent to 0.1 ng/g (parts per billion) in edible fish tissue. Although this criterion only applies to the Spokane Arm and lower half of the Little Falls reservoir, it cannot reasonably be met within these bounds unless PCB concentrations in upstream reaches are reduced to levels near the criterion. Washington State's human health criteria for PCBs is 170 pg/l (5.3 ng/g in fish tissue), the difference primarily being due to assumptions about human consumption rates of fish.

A PCB loading scenario is proposed to meet the Spokane Tribe human health criterion. The scenario requires a 95% PCB load reduction at the Idaho border, a 97% load reduction in the Little Spokane River, and ≥99% reductions in municipal, industrial, and stormwater discharges. Based on the loads estimated in this report, the largest current contributor of PCBs to the river (44%) is the City of Spokane's partially combined sewer-stormwater system. This is the most important source to reduce.

A food web bioaccumulation model used to predict PCB concentrations in fish tissue from the levels in water and sediments indicates that reductions of ≥99% would be required to meet the Spokane Tribe's fish tissue criterion where the Spokane River enters the reservation. Even with large reductions in PCBs, it seems unlikely that the Spokane tribal target (0.1 ng/g) in fish tissue is achievable. This concentration is approximately an order of magnitude lower than the median level (1.4 ng/g) reported in fish tissue from background areas of Washington in a 2010 statewide study conducted by Ecology (Johnson et al., 2010). Despite the extremely low tribal criteria, it is clear that further reductions in PCB loading are achievable. Implementing an adaptive management narrative limit in National Pollutant Discharge Elimination System (NPDES) permits might be a productive approach to establish a set of achievable targets for toxic chemical reductions.

Recommendations

Even though significant reductions in PCB levels have been measured in the Spokane River over the last two decades, achieving further reductions in PCBs will be a challenging long-term process which will require a strategy that uses a combination of activities to achieve water quality targets. To start meeting this challenge, Ecology has drafted a long-term strategy for reducing PCBs and other toxic chemicals in the Spokane River watershed.

The Spokane River Toxics Reduction Strategy requires coordination across several Ecology programs, including the Spokane River Urban Waters Program (UWP) which was formed in 2007. The primary purpose of this program is to identify and eliminate toxic chemicals at their source. The UWP also works cooperatively with local governments including the City of Spokane and the Spokane Regional Health District.

Under the reduction strategy, source identification and control will largely be carried out by the UWP. The strategy uses a three-pronged approach (prevention, management, and cleanup) to reduce sources. Priority is placed on using a systematic step-wise process for identifying potential PCB sources within a conveyance system, then reducing and/or eliminating sources as they are located.

The conceptual approach to reduce PCBs discharged to the Spokane River should continue to focus on:

1. Identifying PCB sources and reducing or eliminating them from stormwater and wastewater effluents.
2. Examining treatment alternatives for effluent PCB removal.
3. Implementing necessary treatment plant controls.
4. Characterizing PCB transport through groundwater.

Implementation of an adaptive management approach using narrative limits in NPDES permits should be explored as an option to establish a set of achievable targets for toxic chemical reductions. In addition, source reduction efforts should be coupled with an ongoing effectiveness monitoring program to evaluate progress in reaching water quality targets.

The 303(d) List

The federal Clean Water Act established a process to identify and clean up polluted waters. The Clean Water Act requires each state to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards include (1) designated uses for aquatic life, recreation, water supply, and harvesting (fish consumption) and (2) criteria, usually numeric criteria, to protect those uses.

Every two years, states are required to prepare a list of waterbodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list and is prepared by the Washington State Department of Ecology (Ecology). To develop the list, Ecology compiles its own ambient water quality data along with data from local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before being used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment (www.ecy.wa.gov/programs/wq/303d/index.html).

The last comprehensive freshwater and marine water 303(d) list for Washington was prepared in 2008. Listing updates are now staggered, with the marine list completed in 2010 and the freshwater list scheduled to be completed in 2012. The next opportunity to evaluate compliance with water quality standards in the Spokane River will be in 2012.

The Clean Water Act requires that waterbodies on the 303(d) list be cleaned up by pollution-control programs or that a TMDL be developed. A pollution-control program needs to address the sources of pollution and have a monitoring and enforcement component. A TMDL identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. When developing a pollution-control program or a TMDL, Ecology works with the local communities and other relevant stakeholders to identify all actions that need to occur to address the sources of pollution. A monitoring plan to assess the effectiveness of those implementation actions is also developed. That monitoring plan is used to determine success or the next steps needed.

Spokane River PCB Listings

The Spokane River begins in northern Idaho at the outlet of Lake Coeur d'Alene and flows west 112 miles to the Columbia River. Within Washington this includes Water Resource Inventory Areas (WRIAs) 54, 55, 56, and 57 (Figure 1). The designated uses for this area include aquatic life uses, recreation, fish consumption, and Spokane Tribe of Indians ceremonial, spiritual, and cultural uses (see *Water Quality Standards and Designated Uses* section).

Elevated levels of polychlorinated biphenyls (PCBs) are found in Spokane River water, sediments, fish tissue, and effluents being discharged to the river. Ecology first documented PCB contamination in Spokane River fish in the early 1980s (Hopkins et al., 1985), and numerous investigations have evaluated the extent of the contamination (e.g., Ecology, 1995; Johnson, 1997; Johnson, 2001; Anchor, 2004). One location behind Upriver Dam required clean-up of PCBs in bottom sediments under the Model Toxics Control Act (MTCA, WAC 173-340). Cleanup was completed in January 2007, and long-term monitoring for PCBs at this site began in the fall of 2008.

Most of the Spokane River fish analyzed for PCBs fail to meet (exceeded) state surface water quality standards established to protect beneficial uses of surface waters, such as fish consumption. Fish consumption advisories have been issued for parts of the river (Spokane Regional Health District and Washington State Department of Health, 2003).

Fifteen waterbody segments of the Spokane River and Lake Spokane (also known as Long Lake, herein referred to as Lake Spokane) and one segment of the Little Spokane River are on the 2008 303(d) list for exceeding human health water quality criteria for PCBs (Table 1; www.ecy.wa.gov/programs/wq/303d/index.html).

Table 1. 303(d) Listings for Total PCBs in Spokane River Fish Tissue for 2008.

Waterbody	Reach	WB number	Watercourse Number	Listing ID
Spokane River	Idaho Border to Latah Creek	WA-57-1010	QZ45UE	Spokane River
	Latah Creek to Ninemile Dam	WA-54-1010		
Little Spokane River	Near mouth	WA-55-1010	JZ70CP	Little Spokane River
Lake Spokane (Long Lake)	Ninemile Dam to Lake Spokane Dam	WA-54-9040	QZ45UE	Lake Spokane (Long Lake)
Spokane River	Lake Spokane Dam to Mouth	WA-54-1020	QZ45UE	Spokane River

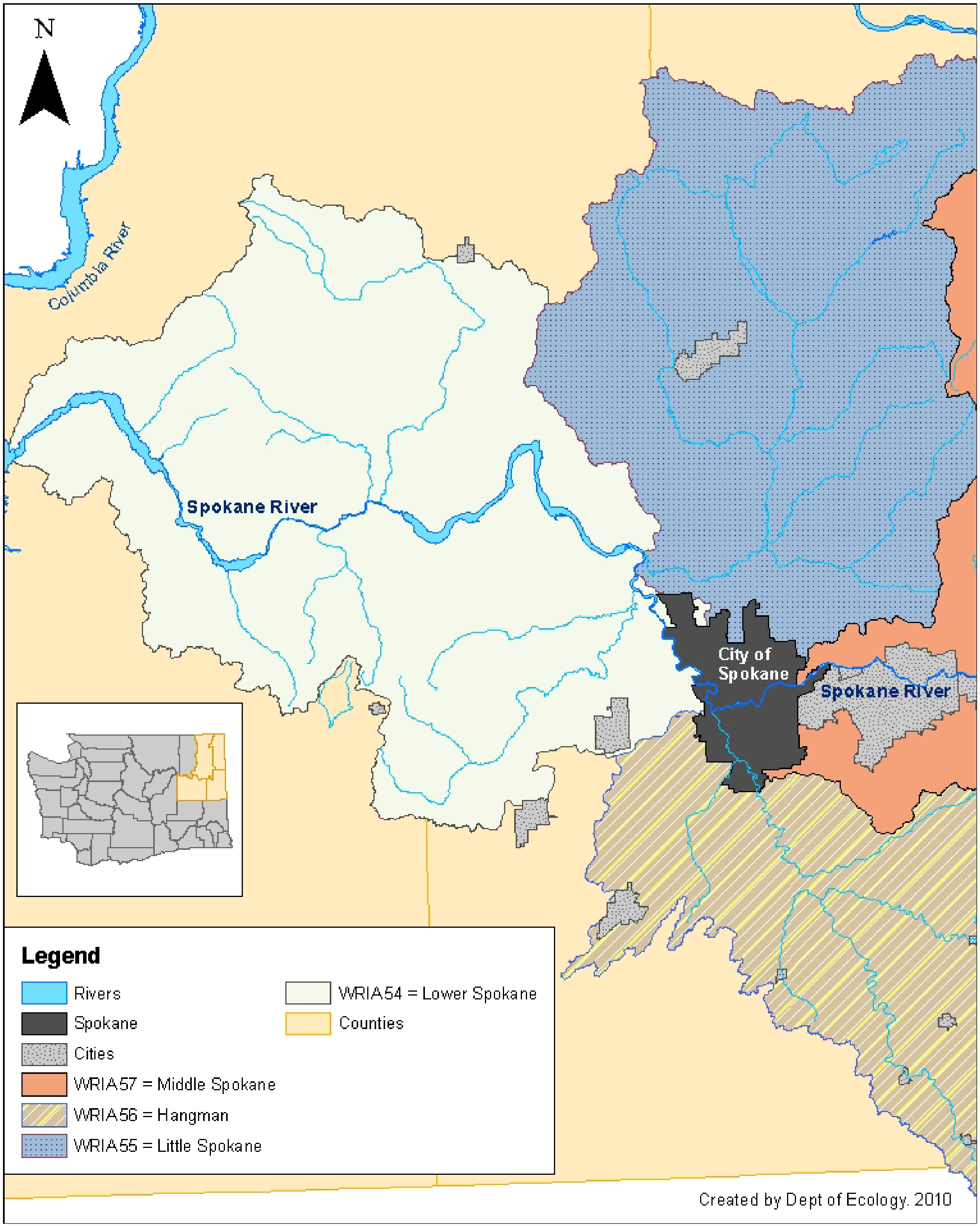

Figure 1. Location Map of Spokane River Showing Water Resource Inventory Areas.

The Spokane River and Lake Spokane have other water quality criteria exceedances that are not addressed in this source assessment. Table 2 shows the 303(d) listings for parameters other than PCBs that occur in the study area.

Table 2. Additional 303(d) Listings Not Addressed in this Report.

Waterbody	Parameter	Medium	Listing ID	Township	Range	Section
Spokane River	Temperature	Water	3737	25N	46E	06
	Total dissolved gas		15183	27N	39E	20
			15184	27N	39E	14
	Fecal coliform		16853	25N	42E	04
Lake Spokane (Long Lake)	Dioxin	Fish Tissue	42410	27N	41E	22
Spokane River			42411	26N	42E	20
			51586	26N	42E	28
			51587	25N	44E	03
Lake Spokane (Long Lake)	Dissolved oxygen	Water	40939	27N	40E	15
Spokane River			15188	26N	42E	17
			17523	25N	43E	02
			15187	25N	43E	18
			11400	25N	46E	06

The listings for dioxin in Spokane River and Lake Spokane fish are based on rainbow trout and mountain white fish collected by Ecology between 2001 and 2005 (Seiders et al., 2004, 2006, 2007). The listings are either for marginal exceedances of the human health criterion for 2,3,7,8-TCDD (dioxin) or for exceedances due to other polychlorinated dioxins and furans (PCDDs/PCDFs). These listings were not addressed in the present series of studies.

Ecology plans to address dioxin listings on a larger scale (possibly region- or state-wide) in the future. Because dioxins are often carried via air and can pollute sizeable areas not necessarily limited to watersheds, a larger TMDL footprint will likely be more effective and efficient at determining sources and subsequent evaluation of possible controls.

A TMDL for lead, cadmium, and zinc was completed for the Spokane River in 1999 (Pelletier and Merrill, 1998; Butkus and Merrill, 1999).

Water Quality Standards and Designated Uses

Applicable water quality criteria for PCBs to protect human health were promulgated by the U.S. Environmental Protection Agency (EPA) in the National Toxics Rule (NTR). The Washington State Water Quality Standards for Surface Waters (WAC 173-201A-240) contain aquatic life criteria for PCBs, and the Spokane Tribe of Indians' Surface Water Quality Standards (Resolution 2003-259) contain both human health and aquatic life-based PCB criteria. These regulations and other guidance are discussed separately below. The applicable numeric criteria are shown in Table 3.

Table 3. Water and Fish Tissue Criteria or Thresholds for Total PCBs [a] (pg/l: picograms per liter; parts per quadrillion; ng/g: nanograms per gram; parts per billion).

Regulation or Guidance	Aquatic Life - Water		Human Health [bc]		Fish Tissue Consumption Rate (kg/day)
	(chronic) (pg/l)	(acute) (pg/l)	Water (pg/l)	Tissue (ng/g)	
National Toxics Rule (40 CFR 131)	--	--	170	5.3	0.0065
Washington Water Quality Standards (Ch. 173-201A WAC)	1.4 x 10^4(d)	2 x 10^6(d)	--	--	--
Spokane Tribe Water Quality Standards (Resolution 2003-259)	1.4 x 10^4(e)	2 x 10^6(f)	3.37	0.1	0.0863
EPA National Recommended Water Quality Criteria (EPA, 2002)	--	--	64	2.0	0.0175
EPA Screening Value for Recreational Fishers (EPA, 2000a)	--	--	--	2.0	0.0175
EPA Screening Value for Subsistence Fishers (EPA, 2000a)	--	--	--	0.245	0.142

[a] total PCBs (sum of detected Aroclors, homologue groups, or congeners).
[b] based on a one-in-a-million (10^{-6}) excess lifetime cancer risk.
[c] for consumption of organisms and water.
[d] 24-hr average not to be exceeded.
[e] A one-hour average not to be exceeded more than once every three years on average.
[f] A four-day average not to be exceeded more than once every three years on average.

Regulations

National Toxics Rule

Criteria for the protection of human health were issued to the state in the NTR (40 CFR 130.36). Promulgated by EPA in 1992, and subsequently amended for PCBs in 1999, the NTR establishes numeric, chemical-specific water quality criteria for most priority pollutants. In fresh waters, human health criteria take into account the combined exposure of both drinking the water and eating fish and shellfish that live in the water. Criteria are calculated such that the upper-bound excess cancer risk is less than or equal to one in one million (10^{-6} risk level). Criteria for non-carcinogens are calculated such that effects should not be seen at exposures reflecting standard EPA exposure parameters (see equation below).

NTR human health criteria for PCBs (170 pg/l (parts per quadrillion) for a 10^{-6} risk level) were derived primarily to protect people from contaminated fish, the predominant exposure pathway. Exposure through water consumption is negligible, representing approximately 1% of the total PCB intake. The human health criteria are calculated using the following equation:

Equation 1. $$\boldsymbol{HHC = \frac{RF \times BW \times (10^9\ pg/mg)}{q1^* \times [WC + (FC\ x\ BCF)]}}$$

Where:

- HHC = human health criteria.
- RF (risk factor) = the acceptable level of cancer risk. Washington's acceptable upper-bound excess cancer risk is one in a million (10^{-6}) for a lifetime exposure.
- BW (body weight) = the average body weight of the consumer. The NTR uses an average consumer body weight of 70 kg.
- q1* (cancer slope factor) = the cancer potency of each chemical. The NTR uses a q1* of 2 per mg/kg-day for PCBs.
- WC (water consumption) = the average daily consumption of water by a consumer. The NTR uses a water consumption rate of 2 L/day.
- FC (fish consumption) = the average fish tissue consumption by a consumer. The NTR uses a fish tissue consumption rate of 0.0065 kg/day.
- BCF (bioconcentration factor) = the concentration of a chemical in tissue accumulated through gill and skin divided by the concentration in the water column. The NTR uses a BCF of 31,200 L/kg for PCBs.

The water quality criterion can be converted to an equivalent fish tissue criterion using the BCF in Equation 2, where Cw is the concentration in water and Ct is the concentration in tissue:

Equation 2. $$\boldsymbol{BCF = \frac{C_t}{C_W}}$$

NTR-equivalent fish tissue concentrations may then be calculated by $C_t = BCF \times C_w.$ The calculated NTR-equivalent concentration for PCBs in edible tissue (C_t) is 5.3 ng/g (parts per billion; Table 3).

The values used by EPA to derive the NTR human health criteria are not always used by public health agencies to establish fish consumption advisories in Washington and other NTR states. The Washington State Department of Health (WDOH), which has primary responsibility for assessing the need for fish consumption advisories, examines local information about higher fish consumption rates, and sub-populations at increased risk. Additionally, differences are present in the use of chemical toxicity factors and health effect endpoints. For example, water quality criteria for PCBs are based on protection against cancer, while state fish advisories for PCBs are based on protection against non-cancer effects.

Washington State

Water quality standards for surface waters of Washington State are contained in Chapter 173-201A of the Washington Administrative Code (WAC), last amended in 2006 and approved by EPA in 2008. The numeric criteria to protect aquatic life from PCB exposure is found in WAC 173-201A-240. The acute exposure criterion for PCBs in freshwater is 2 x 10^6 pg/l. The chronic exposure criterion is 1.4 x 10^4 pg/l (Table 3).

The standards also include a provision that "Toxic substances shall not be introduced above natural background levels in waters of the state which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent on those waters, or adversely affect public health as determined by the department (WAC 173-201A-240(1)."

Designated uses (defined in WAC 173-201A-200(1)) in the Spokane River, from its mouth to the Idaho border include:

- Core summer habitat
- Spawning/rearing
- Recreation
- Water supply
- Harvesting
- Other miscellaneous uses

Spokane Tribe

The Spokane Tribe of Indians (Spokane Tribe) Surface Water Quality Standards (Resolution 2003-259) are similar to the Washington State Water Quality Standards in terms of narrative and numeric criteria. They apply to the westernmost part of the river defined by a line bisecting the Spokane Arm and Little Falls reservoir from river mile (RM) 32.5 to RM 0 (see Figure 2). The Tribal standards consider the Spokane River and most of its tributaries to be Class A surface water, with the exception of Blue Creek, Orazada Creek, and Sand Creek which are all Class AA tributaries to the Spokane Arm between RM 8 and RM 13. Designated uses for Spokane Tribe Class A and AA waters are similar to the Washington State standards, but also include primary contact (Washington waters are also designated for primary contact), ceremonial and spiritual, and cultural uses.

The Spokane Tribal narrative section for toxic pollutant standards is nearly identical to that of Washington State, including the adoption of a 10^{-6} risk level of for carcinogens. However, the Tribal numeric human health criteria are substantially lower (more restrictive) than those issued to Washington in the NTR (3.37 vs. 170 pg/l) due to different values used to derive the human health criteria. Tribal standards employ an aquatic organism consumption rate of 0.0863 kg/day, as opposed to the 0.0065 kg/day fish consumption rate in the NTR. In addition, the Spokane Tribe PCB criteria include an older cancer slope factor of 7.7 per mg/kg-d. Using the same approach used to derive an NTR-equivalent tissue value as described above in Eq. 2, the Spokane Tribe human health criteria of 3.37 pg/l translates to an equivalent edible tissue concentration of 0.1 ng/g.

Guidance

EPA Recommended National Water Quality Criteria

In 2002, EPA recommended new national water quality criteria including a new human health criterion for PCBs based on an upward revision of the fish consumption rate to 0.0175 kg/day (EPA, 2002). All other factors used to derive the recommended criterion (RF, BW, q1*, WC, and BCF) remained unchanged. The resulting recommended criterion for PCBs is 64 pg/l for water. The equivalent fish tissue concentration for this criterion is 2.0 ng/g (Table 3).

EPA Screening Values for Fish Advisories

Other threshold values which have no regulatory standing but are often used to assess potential public health risk are the EPA (2000a) tissue screening values (Table 3) used to evaluate fish advisories. Tissue screening values are derived in the same manner as NTR criteria and EPA's 2002 recommended national criteria, with adjustments only to the fish consumption rates. The screening value for recreational fishers is 2.0 ng/g, based on a consumption rate representing the 90th percentile of sport fishers (0.0175 kg/day). The screening value for subsistence fishers (0.24 ng/g) is based on a 99th percentile consumption rate (0.142 kg/day).

Watershed Description

Hydrology

The Spokane River begins in northern Idaho at the outlet of Coeur d'Alene Lake and flows west 112 miles to the Columbia River (Franklin D. Roosevelt Lake) (Figure 2). The watershed encompasses over 6,000 square miles (15,500 km^2) in Washington and Idaho. The river flows through the smaller cities of Post Falls and Coeur d'Alene in Idaho and large urban areas of the Spokane Valley and Spokane in Washington. Other cities in the basin include Liberty Lake, Deer Park, and Medical Lake Washington as well as Wallace and Kellogg Idaho upstream from Lake Coeur d'Alene.

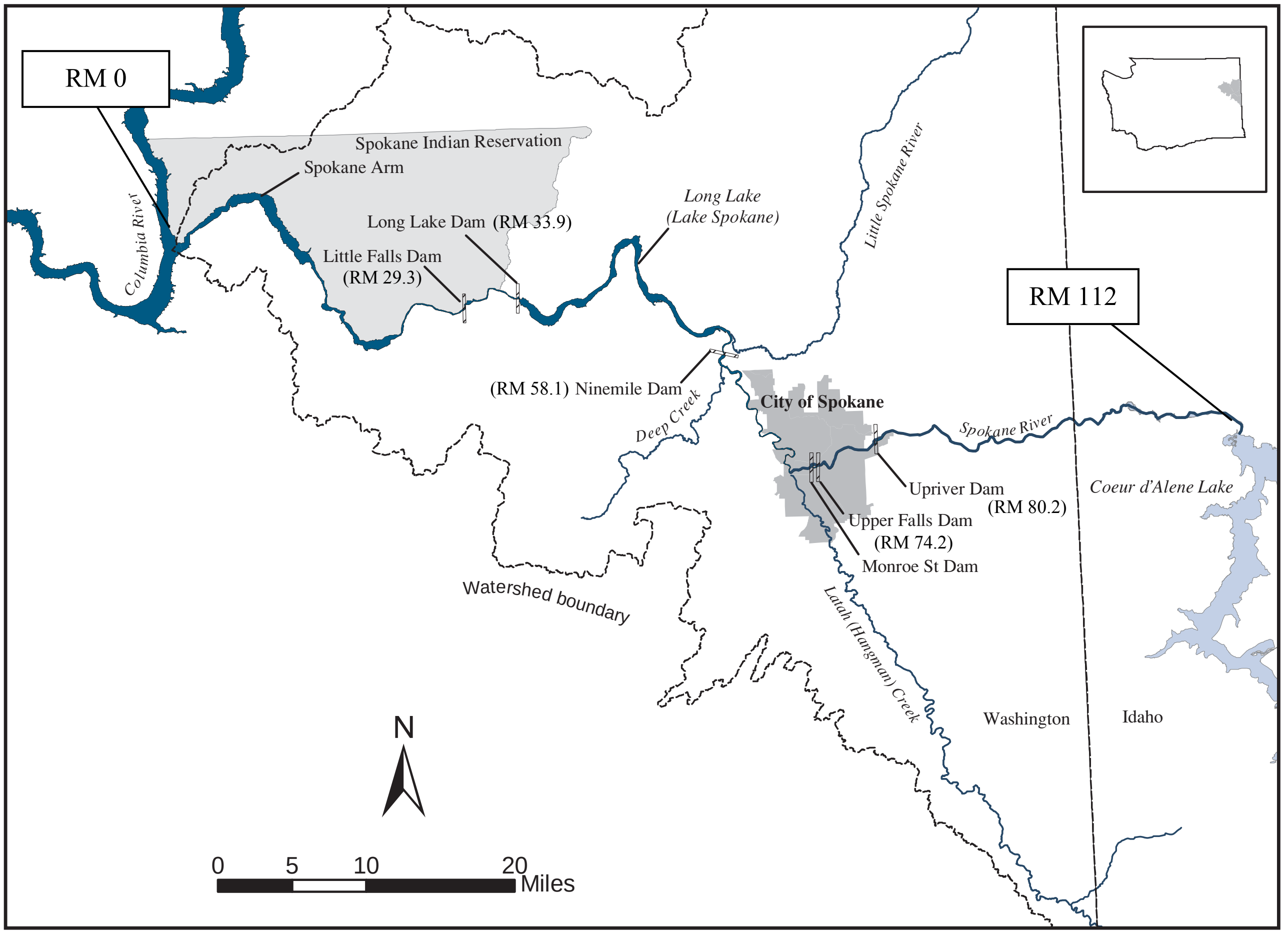

Figure 2. Spokane River Basin.

There are seven dams along the Spokane River:

1. Post Falls Dam (RM 100.8).
2. Upriver Dam (RM 80.2).
3. Upper Falls Dam (RM 74.5).
4. Monroe Street Dam (RM 74.0).
5. Ninemile Dam (RM 58.1).
6. Lake Spokane (Long Lake) Dam (RM 33.9).
7. Little Falls Dam (RM 29.3).

The dams create a series of pools which vary in length, the largest being 23-mile long Lake Spokane. Downstream from Lake Spokane, the Spokane River forms the southern boundary of the Spokane Tribe of Indians reservation from Chamokane Creek (RM 32.5) to the Columbia River at RM 639.0. The reservation occupies approximately 160,000 acres and is home to 2,441 tribal members (as of 2006).

The flow regime in the Spokane River is dictated largely by freezing temperatures in the winter followed by spring snowmelt. Figure 3 shows the harmonic mean flow at four points in the Spokane River. The harmonic mean is recommended by EPA (1991a) for use in assessing a river's loading capacity for long-term exposure to carcinogens such as PCBs. This is the appropriate measure of central tendency when dealing with rates, in this case rates of flow. Harmonic mean is discussed in more detail later in this report (see *Instream Loads*).

The annual mean flow for 1969-2002 was approximately 61,000 L/sec (2,154 cfs) where the Spokane River crosses the Idaho border. Flows increased to 82,000 L/sec (2,895 cfs) downstream of Spokane, reflecting the influx of groundwater through this river reach. Prior to 1969 there were un-quantified agricultural diversions for irrigation from the Spokane River in the vicinity of Post Falls.

Sediment

Downstream of Spokane the river corridor is largely undeveloped. The two major tributaries – Latah Creek (formerly Hangman Creek) and Little Spokane River – enter the Spokane River at RM 72.2 and RM 56.3, respectively. Latah Creek has an extremely flashy flow regime, responding rapidly to rainfall or snowmelt and is prone to erosion of its banks, thus delivering substantial sediment loads to the Spokane River (SCCD, 2002). In comparison, the Little Spokane River has an order of magnitude higher mean flow than Latah Creek, but carries slightly lower sediment loads.

One particular macro characteristic of the Spokane River is the general lack of fine depositional sediments in most of the river. Lake Coeur d'Alene acts as a settling basin for sediments transported in the upper watershed, and there are no tributaries to the river between the outlet of the lake and Latah Creek. Spokane River is essentially a free-stone stream environment. Although the dams break the river into a series of pools, there are few areas of placid water above Lake Spokane. The river velocities are high enough and the sediment load low enough to scour the bed or prevent settling of significant fine particulate matter, even immediately behind the dams. As a result, almost the entire riverbed upstream of Lake Spokane (the largest reservoir) is composed of gravel, cobble, and boulders with the finer sediment reserved for limited locations behind the dams, interstitial spaces within the river bed, isolated shoreline deposits, and certain fluvial bar features. One notable exception is the narrow band of fine, organic carbon rich sediments found near the Upriver Dam reservoir that constituted the MTCA cleanup site, previously mentioned.

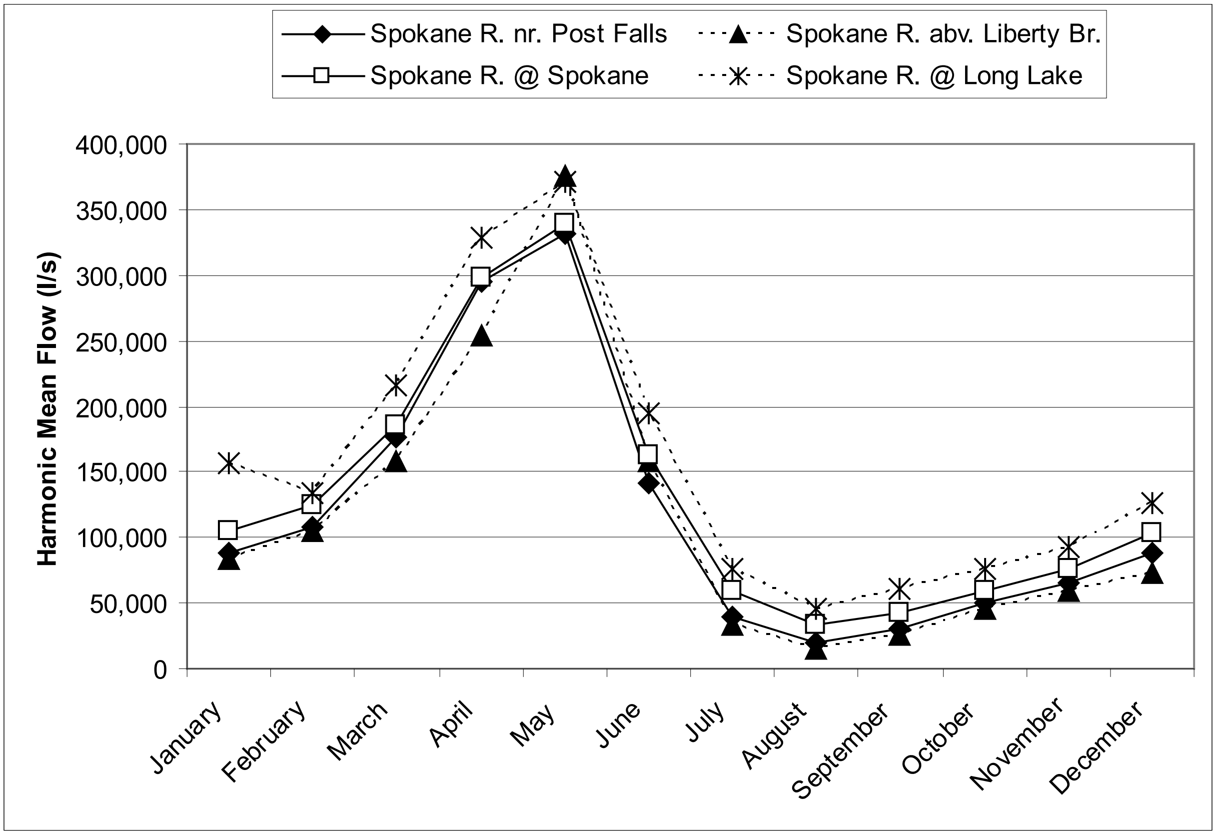

Figure 3. Spokane River Monthly Harmonic Mean Flows for Water Years 1969-2002.

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PCB Contamination of the Spokane River

Uses, Structure, and Analysis

PCBs were first produced for commercial use in 1929. Production continued until a 1979 ban on all PCB manufacturing, processing, and distribution due to evidence that PCBs build up in the environment and concerns about possible human carcinogenicity (Sittig, 1980). Principal uses were as heat transfer fluids, plasticizers, wax and pesticide extenders, lubricants, and fluids for hydraulic machinery, vacuum pumps, and compressors.

There are 209 individual forms of PCBs, known as congeners. The naming system for congeners is based on the number and location of chlorine atoms on the biphenyl rings (Figure 4).

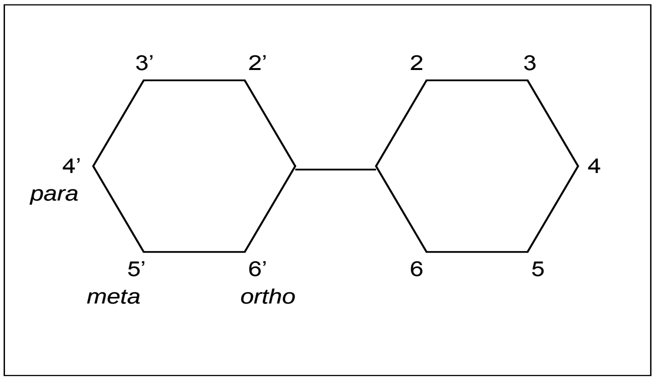

Figure 4. Generic PCB Molecular Structure and Numbering System.

In the U.S., PCBs were produced almost exclusively as Aroclors, the trade name for congener mixtures containing 21 to 68% chlorine by weight. The names given to the different Aroclors reflect this composition; Aroclor [PCB]-1248, for instance, contains approximately 48% chlorine by weight (12 refers to the number of carbon atoms in the biphenyl ring). Many different commercial Aroclor mixtures have been quantified as to their congener composition by Frame et al. (1996).

PCBs can be analyzed as individual congeners or Aroclor-equivalents. Congeners are usually analyzed by high-resolution gas chromatography/mass spectrometry (GC/MS) methods that are more costly, but more sensitive and thus give lower detection limits than the gas chromatography/electron capture (GC/ECD) method typically employed for Aroclor mixtures. Most of the historical fish tissue data for Washington State is from Aroclor analysis.

Much of the 600 million kg of PCBs used domestically has found its way into the environment through improper disposal or by leakage of sealed systems (Sittig, 1980). Loss to the environment through PCB use in open systems such as hydraulic fluids in die cast machinery, heat transfer systems, and specialty inks was also not uncommon (EPA, 2000a). Their primary uses are associated more with heavy industry or urban centers rather than agriculture (EPA, 1992). Direct application to the environment occurred on a lesser scale through use as pesticide extenders or oil mixtures applied to roads for dust control. Many of the same properties that made PCBs commercially desirable – their stability and resistance to degradation – make them extremely persistent in the environment. They have become one of the most ubiquitous of all environmental contaminants.

Environmental Fate

The persistence of PCBs increases with the degree of chlorination. Mono-, di- and tri-chlorinated biphenyls biodegrade relatively rapidly, tetrachlorinated biphenyls biodegrade slowly, and higher chlorinated biphenyls are resistant to biodegradation.

In soils, PCBs experience tight adsorption which generally increases with the degree of chlorination of the PCB. PCBs generally do not leach significantly in aqueous soil systems; the higher chlorinated congeners have a lower tendency to leach than the less chlorinated congeners. Vapor loss of PCBs from soil surfaces appears to be an important fate mechanism with the rate of volatilization decreasing with increasing chlorination.

In water, adsorption to sediment and suspended matter are important fate processes; PCB concentrations in sediment and suspended matter are typically much greater than in the water column. Although adsorption can immobilize PCBs (especially the higher chlorinated congeners) for relatively long periods of time, eventual re-solution into the water column has been shown to occur. The PCB composition in water will be enriched in the lower chlorinated PCBs because of their greater water solubility, and the least water soluble PCBs (highest chlorine content) will tend to remain adsorbed.

However, strong PCB adsorption to sediment significantly competes with volatilization, with the higher chlorinated PCBs having longer half-lives than the lower chlorinated PCBs. Lower chlorinated PCBs and ortho-substituted congeners are more volatile than the highly chlorinated PCBs. Henry’s Law constants generally range from approximately 1 to 400 Pa m^3/mol (Pascals cubic meter/mole), indicating volatilization is an important transport process for PCBs in the environment. PCB volatilization from water, particularly at falls or dams, and from exposed contaminated soils can be an important transport process for PCBs and, in the absence of adsorption, PCBs volatilize relatively rapidly from water.

Losses of PCBs from the Great Lakes have been estimated by Eisenreich et al. (1992) as 66% via volatilization, 27% via sedimentation, and 7% through the outflow to other waterbodies. Dam spillways may cause significant transformations of an Aroclor mixture, with differential loss of constituent congeners (McLachlan et al., 1990). The dams along the Spokane River likely modify the dissolved and particulate fractions of PCBs as water moves downstream.

The combination of differential solubility, variable octanol-water partitioning coefficients (K_{ow}), and volatilization leads to weathering of Aroclor mixtures. In environmental samples, these physical and chemical processes change the composition of released PCB mixtures over time. Thus, sediment and water samples rarely have congener patterns which match a commercial Aroclor due to weathering. If released to the atmosphere, PCBs will primarily exist in the vapor-phase; the tendency to become associated with the particulate-phase will increase as the degree of chlorination increases. Physical removal of PCBs from the atmosphere is accomplished by wet and dry deposition.

PCBs accumulate in the lipids (fats) of fish and other animals. Lipid solubility increases with the degree of chlorination (Mabey et al., 1982), reflected in their high K_{ow}. The range of log K_{ow} is from approximately 4.6 for monochlorinated congeners to 8.2 for decachlorobiphenyl. Peak bioaccumulation occurs between log K_{ow} 6.5 and 7.0 (Fisk et al., 1998), those congeners with 5 or 6 chlorines. It is believed that congeners with log $K_{ow} > 7.0$ are too large to be efficiently assimilated in the fish digestive tract.

All known aerobic and anaerobic biotic processes act to de-chlorinate PCBs (ATSDR, 1997). Substitution of either a hydrogen or chlorine atom is generally required by an organism to excrete a PCB molecule. Congeners which do not have chlorines in meta positions can be metabolized and excreted. Organisms preferentially metabolize and excrete different PCB congeners depending on their resistance to substitution. Substitution is generally more difficult for the richly chlorinated congeners, leading to preferential bioaccumulation of heavier, but not the heaviest, congeners.

Historical Data on PCBs in the Spokane River

Ecology has analyzed PCBs in a variety of water, sediment, and fish tissue samples collected from the Spokane River over the past two decades. Additional data have been collected by or in cooperation with the U.S. Geological Survey (USGS) and various NPDES dischargers. More recent work has focused attention on characterizing PCB contaminated sediments behind Upriver Dam. The various data collection efforts going back to 1980 are listed in Table 4.

PCBs were first analyzed in the Spokane River during Ecology statewide screening-level surveys of contaminants in fish from rivers and lakes (Hopkins et al., 1985; Hopkins, 1991; Serdar et al., 1994). Spokane River fish almost always had high PCB concentrations. For instance, total PCBs in whole fish ranged up to 2,300 ng/g (parts per billion) in northern pikeminnow (*Ptychocheilus oregonensis*) collected in 1983. Fillets from mountain whitefish (*Prosopium williamsoni*) and bridgelip sucker (*Catostomus columbianus*) from Riverside State Park in the City of Spokane were also elevated with total PCB concentrations of 230 and 370 ng/g, respectively. Largescale suckers (*Catostomus macrocheilus*) sampled from Lake Spokane had a whole body concentration of 720 ng/g.

In 1993, Ecology expanded its investigation of PCBs in the Spokane River by analyzing multiple fish species and sediments at reaches encompassing the entire river. Johnson et al. (1994) confirmed the high PCB levels seen earlier and found the highest fish tissue and sediment levels in the reach above Upriver Dam (up to 2,800 ng/g in whole largescale suckers and 3,200 ng/g in sediments) with levels gradually declining downstream.

Table 4. Summary of PCB Data Collected on the Spokane River, 1980-2007.

Investigator	Sample Type	Year Collected	Purpose
Ecology (Hopkins et al., 1985)	Fish tissue	1980-1983	Statewide survey of contaminants in rivers
Ecology (Hopkins, 1991)	Sediment	1989	Statewide survey of contaminants in rivers
Ecology (Serdar et al., 1994)	Fish tissue[1,2] Sediment	1992	Statewide survey of contaminants in lakes
Ecology (Johnson, et al., 1994)	Tissue Sediment	1993	Survey for PCBs in the Spokane River
Ecology (Davis et al., 1995)	Fish tissue		Statewide survey of pesticides and PCBs
Ecology (Ecology, 1995)	Fish and crayfish, tissue, sediment, surface water, effluent, sludge	1994	Synoptic survey of PCBs in the Spokane River
Hart Crowser, 1995	Effluent		Sampled Kaiser Trentwood effluent coincidental with Ecology sampling
Ecology (Huntamer, 1995)	Sediment		Microscopic examination and PCB analysis of sediments behind Upriver Dam
Ecology (Golding, 1996)	Effluent Sludge	1995	Follow-up to effluent and sludge sampling conducted during 1994 synoptic survey
Ecology (Johnson, 1997)	Fish tissue	1996	Survey to determine PCB levels in Spokane River fish
Ecology and USGS (Johnson, 2000)	Fish and crayfish tissue	1999	Survey to determine PCB levels in Spokane River fish
Ecology (Johnson and Norton, 2001)	Sediment	2000	Chemistry and bioassays of Spokane River
Ecology (Golding, 2001)	Surface water Effluent		Survey of PCBs in Kaiser Trentwood effluents and receiving waters
Ecology (Golding, 2002)	Effluent	2001	Survey of PCBs in industrial and WWTP effluents
Ecology (Jack and Roose, 2002)	Fish tissue		Intensive survey of PCBs in Lake Spokane fish
Exponent and Anchor, 2001	Sediment		Survey of PCBs in sediments behind Upriver Dam
SAIC, 2003a	Effluent Sludge	2002	Survey of PCBs in effluent and sludge from Inland Empire
SAIC, 2003b	Fish tissue		Intensive survey of PCBs in Lake Coeur d'Alene fish
Anchor Environmental (Anchor, 2004)	Surface water Groundwater	2003	Remedial investigation of PCBs in the vicinity of Upriver Dam MTCA site
Merill and Bala, 2004	Effluent	2002-2003	Bi-weekly monitoring of PCBs in Kaiser Trentwood effluent
Kaiser (Kaiser, 2005)	Effluent	2004-2005	PCBs in Kaiser Trentwood effluent
Merill and Bala, 2004	Effluent	2002-2003	Bi-weekly monitoring of PCBs in Kaiser Trentwood effluent
Ecology (Serdar and Johnson, 2006)	Fish tissue	2005	Synoptic survey of PCBs in Spokane River fish
Ecology (Seiders, Deligeannis, and Kinney, 2006)	Surface water Fish tissue		Statewide survey of toxic contaminants in waters and fish, including Spokane River
Parsons, 2007	Stormwater	2007	Survey of PCBs in Spokane stormwater

WWTP: wastewater treatment plant.

In 1994, Ecology further increased the number of organisms and locations analyzed for PCBs in the Spokane River. Results again confirmed the pattern of contamination among sites seen in 1993. The 1994 study also found that Little Spokane River fish had higher than expected PCB levels. Crayfish had low accumulations of PCBs.

The 1994 samples also included bottom sediments and potential industrial/municipal sources of PCBs to the river. This helped define the extent of contamination behind Upriver Dam, largely by delineating the area of depositional material. Nearly the entire river was surveyed for the presence of significant bulk fine sediment deposits between the state line and Lake Spokane, but the "hot spot" behind Upriver Dam was the only sediment deposit found during that study.

Perhaps the most important findings from 1994 were the characterizations of PCB sources to the river. Sewage treatment plants, industrial facilities, and industrial sites along the river were sampled to assess their relative contribution of PCBs. Results showed that sources upstream of the Idaho border were negligible, but downstream there was a substantial ongoing PCB source at the Kaiser Trentwood aluminum plant, potentially significant sources such as the Liberty Lake wastewater treatment plant (WWTP) and the former Inland Metals site, and a historically large source from the Spokane Industrial Park, which now discharged to the Spokane WWTP. Low PCB concentrations were found at a Washington Water Power yard, located just above the river bank, ruling this site out as a potentially significant source. PCB discharges from industrial and municipal treatment plants are discussed in more detail later in this section of the report.

Ecology analyzed more fish in 1996, specifically to determine if the trend toward decreasing PCB concentrations continued. The three species used most often for comparisons in the Spokane River – rainbow trout, mountain whitefish, and largescale suckers – all showed substantial decreases in PCB concentrations from earlier data (Table 5). However, PCB levels continued to remain high relative to other areas in the state.

Since 1999, surveys in the Spokane River have verified previous data or further characterized the contamination so that its implications are better understood. The three major areas where study efforts have concentrated in the past decade are:

- Continued sampling of fish to evaluate temporal trends and conduct human health risk assessment.
- Continued monitoring of known PCB sources.
- Characterization of the Upriver Dam cleanup site.

In July 1999, USGS collaborated with Ecology to further document PCB contamination in fish from the mainstem of the Spokane River (USGS, 1999; Johnson, 2000). This study found that whole largescale suckers exceeded a criterion of 110 ng/g used to protect fish-eating wildlife (Newell et al., 1987). Concentrations in whole suckers ranged from 120 to 700 ng/g total PCBs. For mountain whitefish and rainbow trout (*Oncorhynchus mykiss*), fillets and whole fish were analyzed. Peak concentrations were found in rainbow trout in the vicinity of RM 85 (Plante Ferry) and in mountain whitefish in the vicinity of RM 63 (Ninemile). Maximum concentrations were about 1,600 ng/g for both species.

Table 5. Summary of Total PCB Concentrations in Fish Tissue from the Spokane River (mean concentrations in ng/g, ww).

Location and Tissue Type	Total PCB Concentrations Measured by:					
	Aroclor Analysis					Congener Analysis
	1993[a]	1994[b]	1996[c]	1999[d]	2001[e]	2005[f]
Rainbow trout - fillet						
State line	--	--	--	106	--	55
Plante Ferry	918	424	799	891	--	153
Above Monroe Dam*	--	145	76	226	--	73
Ninemile	490	371	76	143	--	
Mountain whitefish - fillet						
Above Monroe Dam	--	568	381	339	--	234
Ninemile	522	139	444	632	--	139
Little Spokane	--	222	145	--	--	--
Upper Lake Spokane	--		--	--	73	43
Lower Lake Spokane	780	113	--	--	--	76
Largescale suckers - whole						
State line	--	--	--	120	--	56
Plante Ferry	2,005	531	530	283	--	122
Above Monroe Dam	--	201	116	445	--	1,823
Ninemile	1,210		345	680	--	--
Little Spokane	--	440	366	--	--	--
Upper Lake Spokane	--	--	--	--	265	327
Lower Lake Spokane	410	820	--	--	357	254

--no data
[a] Johnson et al., 1994
[b] Ecology, 1995
[c] Johnson, 1997
[d] Johnson, 2000
[e] Jack and Roose, 2002
[f] Serdar and Johnson, 2006
*Same reach as Mission Park

In 2001, Ecology, WDOH, and the Washington Department of Fish and Wildlife (WDFW) collaborated in the collection of five species to evaluate PCB concentrations in Lake Spokane fish tissues (Jack and Roose, 2002). In general, largescale suckers and mountain whitefish had the highest PCB concentrations. Total PCBs in whole suckers ranged from 160 to 340 ng/g, while mountain whitefish fillets ranged from 60 to 89 ng/g. The greater uptake and retention of PCBs in suckers is likely influenced by their relatively high lipid content, benthic (bottom feeding) habits, limited capabilities for PCB excretion, and longevity. Largescale suckers analyzed from Lake Spokane were up to 24 years old (Jack and Roose, 2002). Fish consumption advisories were issued in 2003 and are further discussed below.

In 2005, another intensive study was conducted to expand and update the information on chemical contaminants in Spokane River fish (Serdar and Johnson, 2006). Fish from six locations between the Washington/Idaho state line and lower Lake Spokane were collected. Samples of fillets and whole fish were analyzed for PCBs, polybrominated diphenyl ether flame retardants (PBDEs), arsenic, cadmium, lead, and zinc. A subset of samples was also analyzed for polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDFs).

Compared to historical levels, PCB concentrations appeared to have decreased in all parts of the Spokane River except the Mission Park reach. Relative to other parts of the state, Spokane River fish were within the mean and median for fillet PCB concentrations. However, whole fish results for Mission Park and Lake Spokane were at or above the upper end of the range of whole fish statewide.

Spokane River fish also substantially exceeded statewide comparisons for concentrations of PBDEs, zinc, lead, and cadmium (whole fish samples only). The Urban Waters Program at Ecology is currently pursuing sources of PBDEs to the river. Metals contamination of the Spokane River is from historic mining in Idaho's Silver Valley and has been the subject of many past studies. As previously mentioned, a TMDL has been established for lead, cadmium, and zinc in the Spokane River.

Ecology's Washington State Toxics Monitoring Program also sampled fish from the Spokane River in 2003-04 for a suite of toxic compounds. PCBs were not analyzed due to concurrent intensive PCBs surveys on the river. A recommendation from this effort was to list the Spokane River as impaired on the 303(d) list for 2,3,7,8-TCDD (dioxin) (Seiders et al., 2006).

Table 5 provides a comparison of the total PCB concentrations from the various Ecology studies.

Fish Consumption Advisories

Based on the elevated PCB and lead levels in Spokane River fish, WDOH and the Spokane Regional Health District issued an advisory in 2003 to avoid or limit consumption of fish in parts of the Spokane River (www.doh.wa.gov/ehp/oehas/fish/consumpadvice.htm#Spokane%20River). The health departments later concluded that the advisory would also be protective for PBDEs. The advisory, updated in April 2008 based on fish tissue samples collected for the present 2003-07 study, is summarized in Table 6.

Table 6. April 2008 Spokane River Fish Consumption Advisories.

Location	Species	Consumption Advice
Spokane River – All Areas	All Species	Do not eat the fish head or entrails.
Idaho Border to Upriver Dam	All Species	Do not eat
Upriver Dam to Ninemile Dam	Largescale Sucker	Do not eat
	All Other Species	One meal per month
Lake Spokane (Long Lake)	Largescale Sucker	One meal per month
	Brown Trout	
	Largemouth Bass	Two meals per month
	Smallmouth Bass	
	Rainbow Trout	Two meals per week
	Yellow Perch	

National Pollutant Discharge Elimination System (NPDES) Permits

Ecology has issued NPDES wastewater discharge permits to a variety of industrial and municipal facilities in the Spokane River basin. Some of these facilities have discharged PCBs in the past. Ecology-directed MTCA sediment cleanup actions upstream of Upriver Dam identified the Kaiser Trentwood facility and the Spokane Industrial Park as the most prominent historic sources of PCB releases in that portion of the river. Recent studies have confirmed the presence of PCBs in the waste streams of some permitted Spokane River dischargers. Appendix A lists the permitted discharges to the greater Spokane watershed by WRIA and permit number.

The NPDES permits in Appendix A are coded based on the type of discharge to waters of the state. Those permit numbers beginning with ST are for the discharge of municipal and industrial effluents to ground or industrial effluents to municipal sewer systems. The City of Spokane WWTP receives effluent from a number of these industrial dischargers. Permit numbers beginning with WAG are general NPDES permits. “WA” permits are those allowing discharge of effluents to surface waters.

In addition to the industrial and municipal discharges in Appendix A, the City of Spokane has a partially combined sewer-stormwater system. Spokane is permitted for stormwater discharges under the NPDES Phase II program. A combined sewer is a conjoined system of (1) stormwater collection from areas such as roofs and parking lots and (2) raw sewage. During heavy rain or snowmelt events, the influx of stormwater to the combined system may overwhelm its carrying capacity. At that time, a combined sewer overflow (CSO) event occurs, and a portion of the stormwater-sewage mixture bypasses the local WWTP and discharges directly to the river.

There are a total of 24 CSO points within the City of Spokane (City of Spokane, 2002). These sewers may discharge during high-flow periods or inadvertently during maintenance activities. Because of the variety of previous uses of PCBs, they may be discharged to the river during these overflow events. Some of the stormwater is delivered directly to the river through storm sewers and into ground via drywells or infiltration basins.

Historic NPDES Effluent PCB Concentrations

Some of the NPDES-permitted effluents discharged to the Spokane River have been sampled for PCBs by Ecology and others (Table 7). Ecology (1995), Golding (1996, 2001, 2002), and SAIC (2003a) report effluent data from July 1994 through June 2002 (Table 7). These samples were analyzed by both Aroclor-equivalents and congener-specific methods. While the methods may not be directly comparable to each other, these data are included to illustrate the range of loads and potential variability from these sources.

Historic PCB loads from the Kaiser Trentwood aluminum mill were consistently higher than other facilities by about an order of magnitude, although loads appear to have declined from 1994 to 2001. Kaiser also monitored PCBs in their outfall bi-weekly in 2002 and 2003 (Merrill and Bala, 2004). The median concentration of total PCBs in 2002 was 2,700 pg/l (140 mg/day), decreasing to 1,200 pg/l (90 mg/day) in 2003.

PCB concentrations in Kaiser effluent during 2002-2003 were generally consistent, with variability expressed by peaks – an order of magnitude increase from normal levels – occurring at two to five month intervals. The monitoring result for 4/9/2002 showed an unusually high PCB level in the effluent, 2.2 x 10^6 pg/l (0.125 kg/day), which persisted for a maximum of three weeks before returning to typical levels. PCB levels jumped again in November 2002 when four consecutive monitoring events from 11/18/2002 to 12/29/2002 found effluent concentrations of 2.6 x 10^7 pg/l, 3.2 x 10^6 pg/l, 4.8 x 10^7 pg/l, and 3.4 x 10^6 pg/l. Assuming an average daily load of 0.99 kg/day for a period of six weeks (one week prior to discovery until one week following the last elevated measurement), approximately 53 kg total PCB was delivered to the Spokane River from the Kaiser facility during this period.

Table 7. Summary of Spokane Area PCB Point Source Data.

Source	Date	Method	Total PCBs (pg/l)	Identified Aroclor	Effluent Flow (ML/day)	PCB Load to River (mg/Day)
Kaiser Trentwood	08/1/94 [a]	Aroclor	21,000	PCB-1248	109	2,290
	12/5/95 [b]		29,000		67.8	1,970
			34,000			2,300
	12/6/95 [b]		25,000		68.5	1,710
			29,000			1,990
	08/14/00 [c]		53,000		96.1	5,100
			900 U	NA	96.1	0
	08/15/00 [c]		900 U			0
			25,000	PCB-1248		2,400
	05/1/01 [d]		10,174 NJ	NA	62.1	630
	05/2/01 [d]		5,165 NJ			320
Spokane WWTP	05/1/01 [d]	congener	1,813 NJ	NA	142	260
	05/2/01 [d]		1,767 NJ			250
Liberty Lake WWTP	05/1/01 [d]	congener	1,917 NJ	NA	2.46	4.7
	05/2/01 [d]		1,543 NJ			3.8
Inland Empire Paper	05/1/01 [d]	congener	2,436 NJ	NA	16.3	40
	06/5/02–a.m. [e]		5,484		20.0	110
	06/5/02–p.m. [e]		4,305		18.0	78
Spokane Industrial Park	07/31/94 [a]	Aroclor	9,000 U	NA	*	*
	08/4/94 [a]		31,000 U			
	05/1/01 [d]	congener	9,371 NJ			
	05/2/01 [d]		7,108 NJ			

Bold: Analyte detected
NJ: There is evidence that the analyte is present. Associated numerical result is an estimate.
U: Analyte not detected at or above the reported value.
NA: not applicable
ML/day: 0.264 MGD (million gallons per day)
* Currently discharges to Spokane WWTP; formerly discharged to Spokane River.
[a] Ecology, 1995
[b] Golding, 1996
[c] Golding, 2001
[d] Golding, 2002
[e] SAIC, 2003a

PCB levels in effluent samples collected from the Spokane WWTP, Liberty Lake WWTP, and Inland Empire Paper in 2001-2002 ranged from 1,543 to 5,484 pg/l. Higher concentrations of 7,108 and 9,371 pg/l were reported in effluent from the Spokane Industrial Park analyzed in 1994. This facility now discharges to the Spokane WWTP.

PCBs Behind Upriver Dam, 1995-2004

As mentioned previously, bulk fine sediment deposits are sparse in the Spokane River upstream of Lake Spokane, with the exception of scattered shoreline, bar feature, and lower energy zones. Two notable exceptions are the narrow bands of silt and organically-enriched sediments deposited behind Upriver Dam (Figure 5).

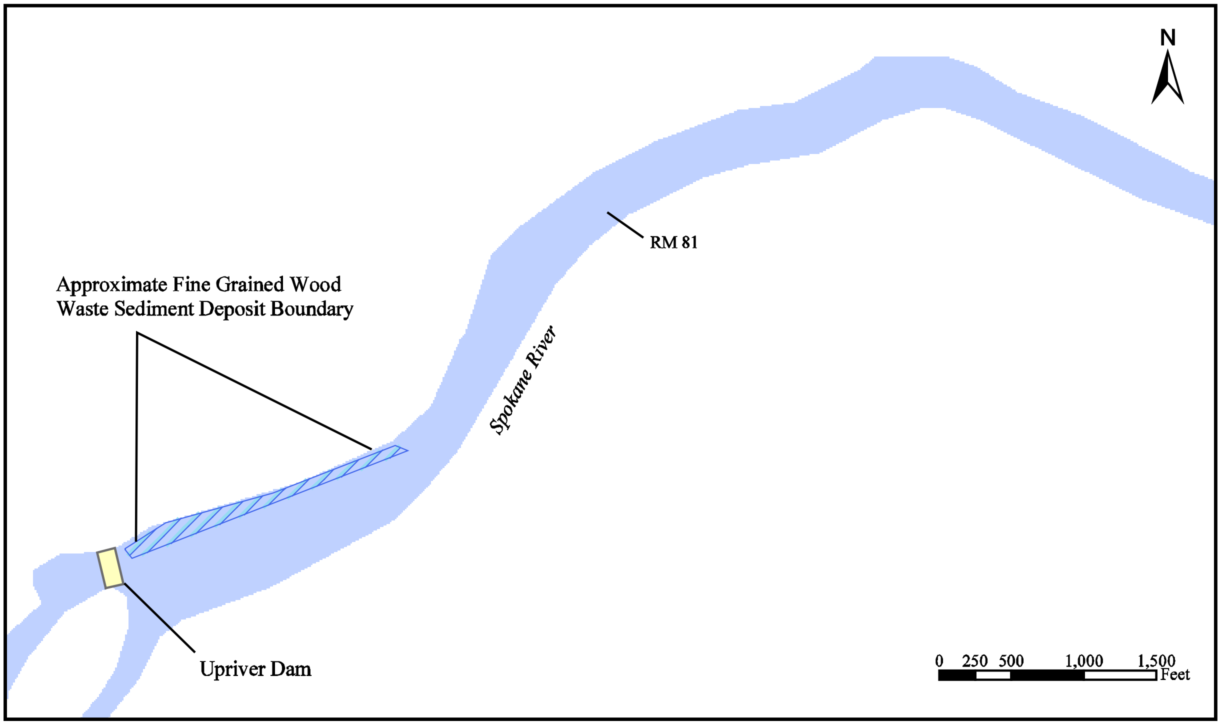

Figure 5. Location of Fine-Grained Wood Waste Sediment Deposit Behind Upriver Dam.

Following discovery of PCB contamination behind Upriver Dam in 1993 and confirmation of high PCB levels in 1994, subsequent sampling consisted mainly of defining the boundary of contamination and distribution of fine sediments upstream of the dam. Sediments within a band located immediately behind the dam generally showed PCBs at 1,000-5,000 ng/g dry weight (dw) and in some samples contained >10% total organic carbon, gradually becoming sandier at the margins (Ecology, 1995; Johnson and Norton, 2001). Huntamer (1995) conducted a microscopic analysis of the organic-enriched sediments and found them to be largely composed of wood particles, consistent with un-aided visual observation made earlier. Huntamer also observed charcoal which he speculated may have originated from recent wildfires in the area.

In February 2003, Ecology entered into a Consent Decree with Kaiser and Avista (formerly Washington Water Power) to evaluate site conditions at Upriver Dam. The remedial investigation (RI) and feasibility study (FS) (Anchor 2005a and 2005b) required under the Consent Decree informed decisions that led to the completion of a cleanup under MTCA. Aside from sediment characterization, the RI/FS addressed other components of the aquatic ecosystem associated with the Upriver Dam contamination, such as sampling PCBs in the water column and in hydraulically-connected groundwater wells, as well as bathymetric surveys of the reach.

Groundwater monitoring in the area indicates there is localized loss of surface water to the aquifer due to the hydraulic difference between the reservoir pool and the river surface downstream of the dam. Monitoring wells located downgradient of the dam showed low PCB concentrations (9-116 pg/l), which were in the range of associated field and laboratory blanks (10-226 pg/l), suggesting the presence of PCBs was due to sampling or lab contamination rather than PCB movement from the reservoir to groundwater (Anchor, 2004).

Surface water sampling was conducted both upstream and downstream of the Upriver Dam site as part of the RI/FS. During the RI/FS, upstream surface water samples and surface water samples collected at the Upriver Dam site (120 and 110 pg/l respectively) exceeded the EPA National Recommended Water Quality Criterion of 64 pg/l. As being an applicable, relevant, and appropriate requirement (ARAR) under MTCA, the 64 pg/l criterion was selected as the surface water criterion at the Upriver Dam site.

Numerous sediment samples were analyzed in and around the known area of contamination as part of the RI/FS. Samples were also collected upstream in backwaters identified as potential depositional areas. Results identified a second significant fine sediment deposit above Upriver Dam at RM 83.4 (Donkey Island) and corroborated earlier findings that deposited fine material and elevated PCB concentrations are absent outside the known areas of bulk fine sediment accumulation.

The Cleanup Action Plan by Ecology (2005) identified a sediment cleanup value of 62 µg/kg total PCBs as protective of human health and the river ecological community. The 62 µg/kg PCB sediment cleanup value was derived for the protection of aquatic life inhabiting the upper layer (0 - 10 cm) of the sediment. The selected sediment cleanup level is based on the lowest apparent effects threshold (AET) suggested for use in freshwater sediments (Michelson, 2003).

The Upriver Dam cleanup was completed in January 2007. A sediment cap was placed over the primary contaminated area on the river bed behind Upriver Dam (Deposit 1) using an excavator on a floating barge. A second smaller area of contaminated sediment was excavated in the Donkey Island area just east of Argonne Road (Deposit 2). The sediment cap that was placed at Deposit 1 was required to be 13 inches in depth. Of the 13 inches, 4 inches were bituminous coal, followed by 6 inches of clean sand, and then armored with 3 inches of gravel. The total size of the cap at Deposit 1 encompassed approximately 3.5 acres. Deposit 2 covered approximately 0.2 acres of contaminated sediment that was excavated as part of the remedial action. The estimated amount of contaminated sediment that was excavated at Deposit 2 is 600 cubic yards.

The first scheduled monitoring event at Deposit 1 to check the integrity of the sediment cap and sample the sediments for PCBs began in the fall of 2008. The results of the 2008 monitoring event found that the cap was fully intact with an additional 1 to 2 feet of deposited sand and woody material on top of the cap. The additional material is suspected to be as a result of the high spring-runoff flows that occurred in 2008. The core samples that were taken of the cap and the grab samples of the newly deposited sand did not detect PCBs higher than the cleanup value.

2003-2007 PCB Source Assessment

Goals

Sampling for the Spokane River PCB source assessment study was initially conducted by the Ecology Environmental Assessment Program from September 2003-July 2004. Additional fish and stormwater samples were collected in late 2005 and early 2007, respectively. The overall goal of this effort was to quantify PCB contamination and identify necessary reductions in sources and the receiving waters to meet applicable PCB water quality criteria for the Spokane River.

Objectives

Specific objectives of the study were to:

1. Obtain representative data on PCB concentrations and ancillary parameters in the Spokane River water column, NPDES permitted discharges, bottom sediments, and fish tissue.
2. Assess trends and natural recovery rates for PCBs in Spokane River sediments.
3. Determine the Spokane River's loading capacity for PCBs.
4. Evaluate a food web bioaccumulation model to predict PCB concentrations in Spokane River fish.

The first objective was addressed by sampling PCBs in industrial and municipal effluent, surface water, suspended particulate matter, stormwater, surface and sub-surface sediments, and fish tissue.

The second objective was achieved by analyzing PCBs in sediment cores.

Water column PCB measurements from semi-permeable membrane devices, a passive sampling technique, were used to assess the loading capacity of the Spokane River. Estimates of the PCB load reductions needed to meet the more stringent human health criteria of the Spokane Tribe were based on loading capacity and on current estimates of PCB discharges in effluent and stormwater.

The Arnot-Gobas food web bioaccumulation model (Arnot and Gobas, 2004) was employed to estimate site-specific critical PCB concentrations in water and sediment. Needed load reductions to meet water quality criteria were then estimated using PCB loading capacities derived from the model.

Field Data Collection

Sampling Locations

Sampling station locations for the source assessment study are shown in Figures 6-10. Coordinates and a description of each station location are in Appendix B.

For the purpose of this report, “Stations” are identical to the “User Location ID” in Ecology’s Environmental Information Management (EIM) database (available on the internet at www.ecy.wa.gov/eim/). All of the data for this project are available through EIM under the User Study ID named “DSER0010”, with two exceptions:

1) The Ninemile rainbow trout fillet data are under the User Location ID “Spokane-F” or the User Study ID “WSTMP03T”.
2) The 2007 stormwater data from the Parsons, (2007) study were entered into EIM under the User Study ID “brwa0004”.

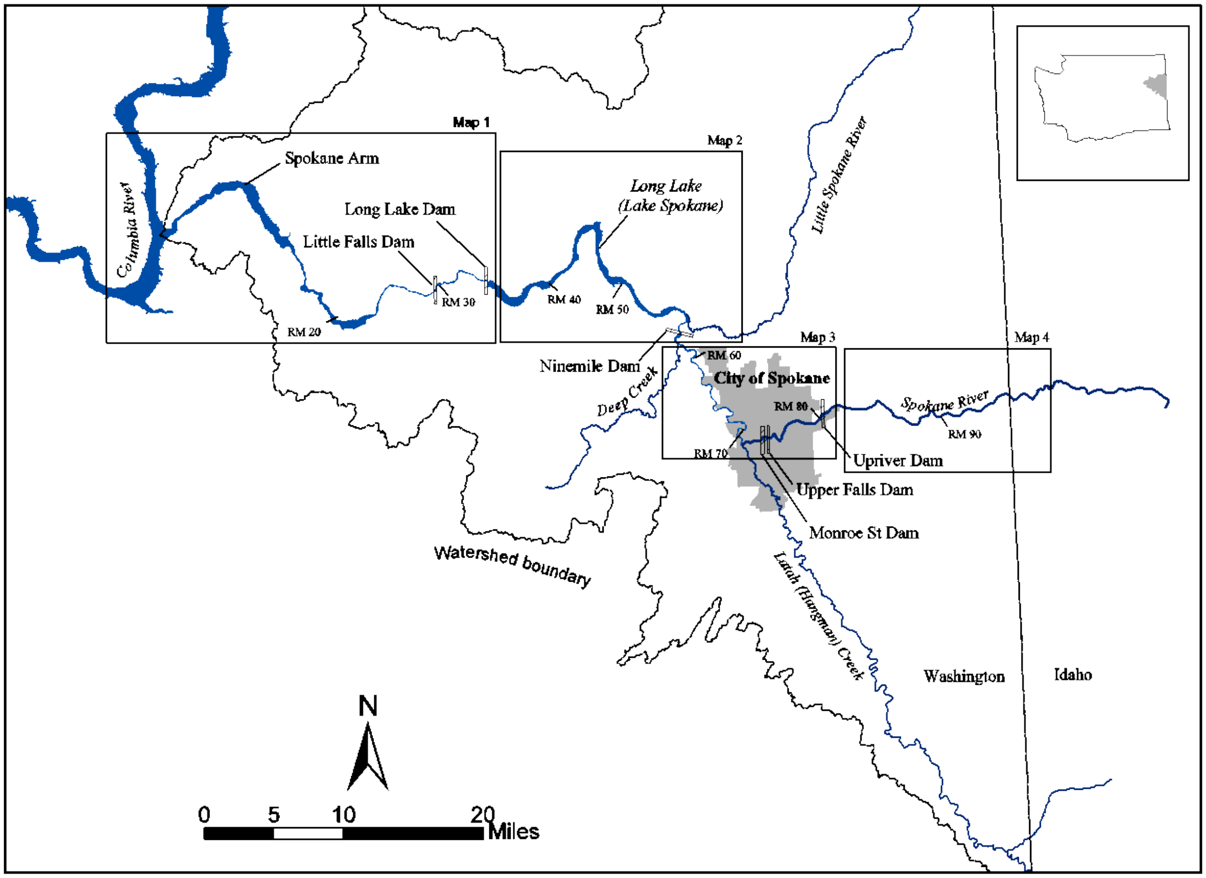

Figure 6. Sampling Maps for Spokane River PCB Source Assessment Study.

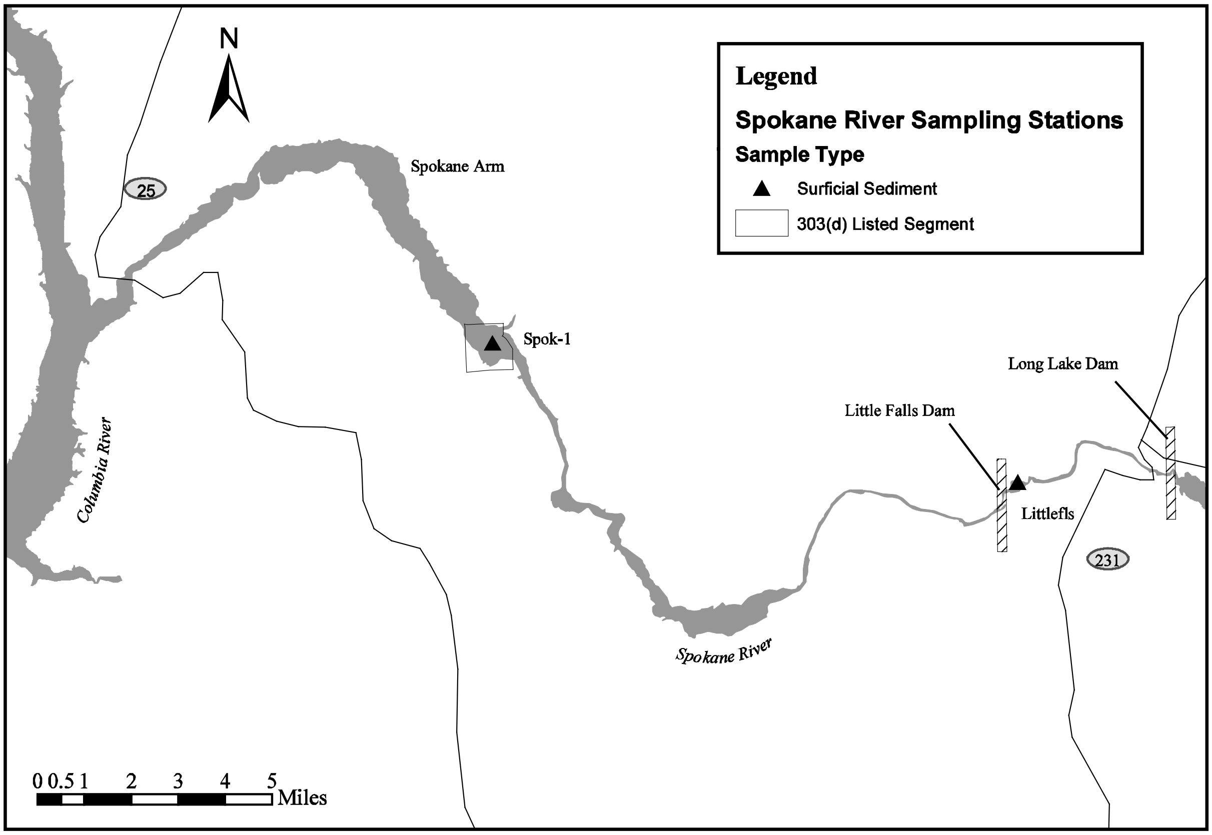

Figure 7. Sampling Map 1: Spokane River Mouth to Long Lake (Lake Spokane) Dam.

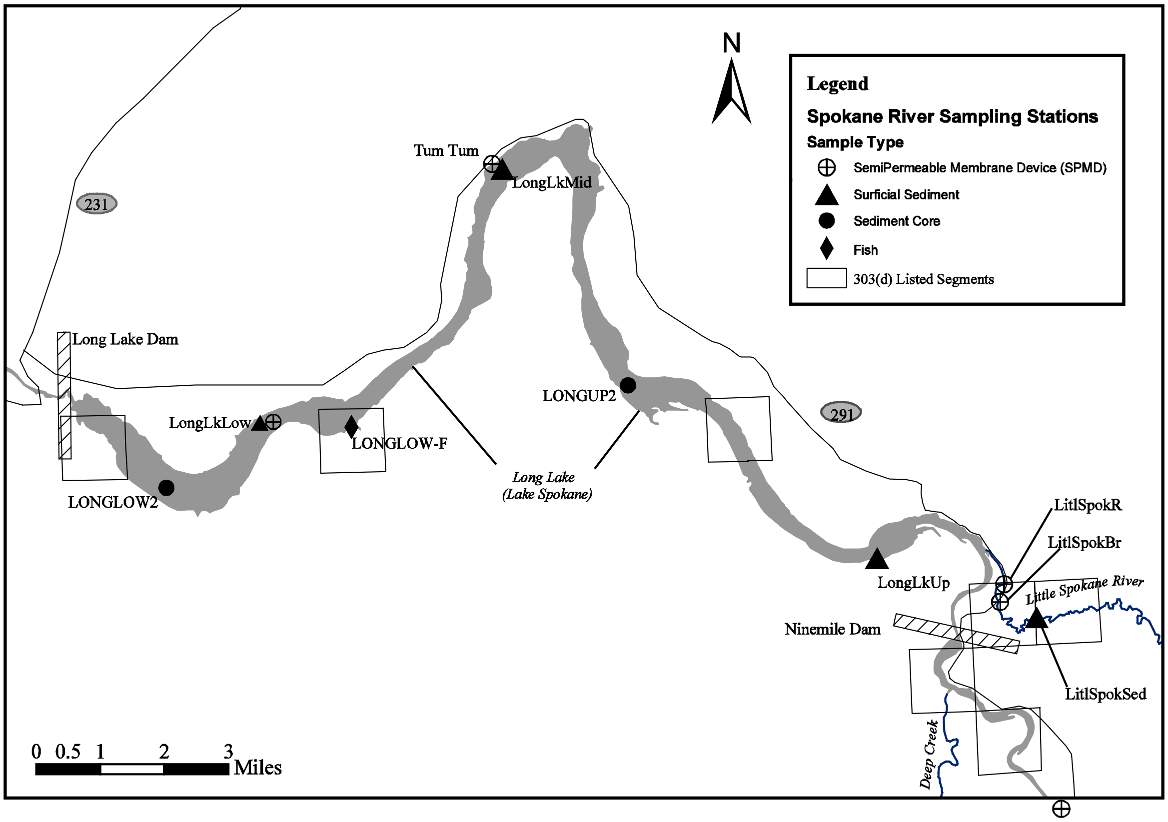

Figure 8. Sampling Map 2: Long Lake (Lake Spokane) Dam to Ninemile Dam.

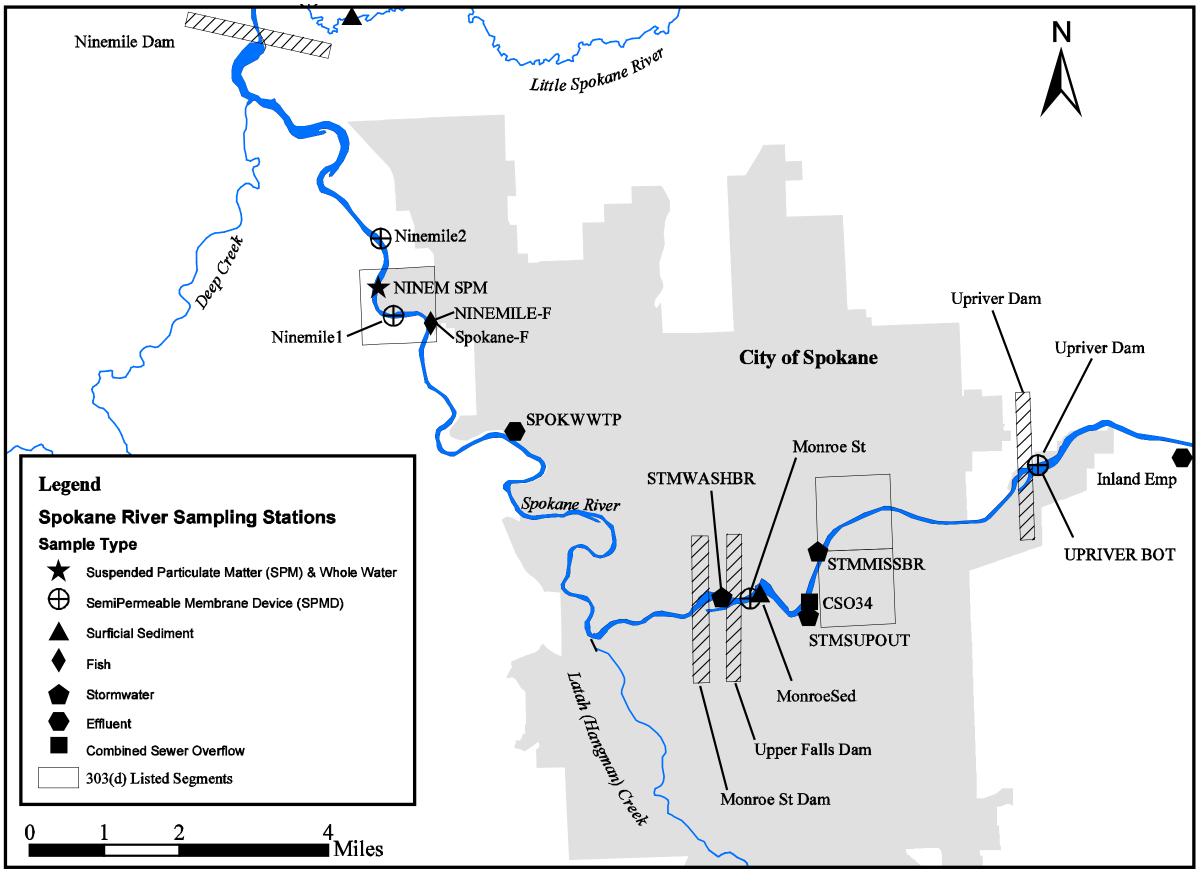

Figure 9. Sampling Map 3: Ninemile Dam to Upriver Dam.

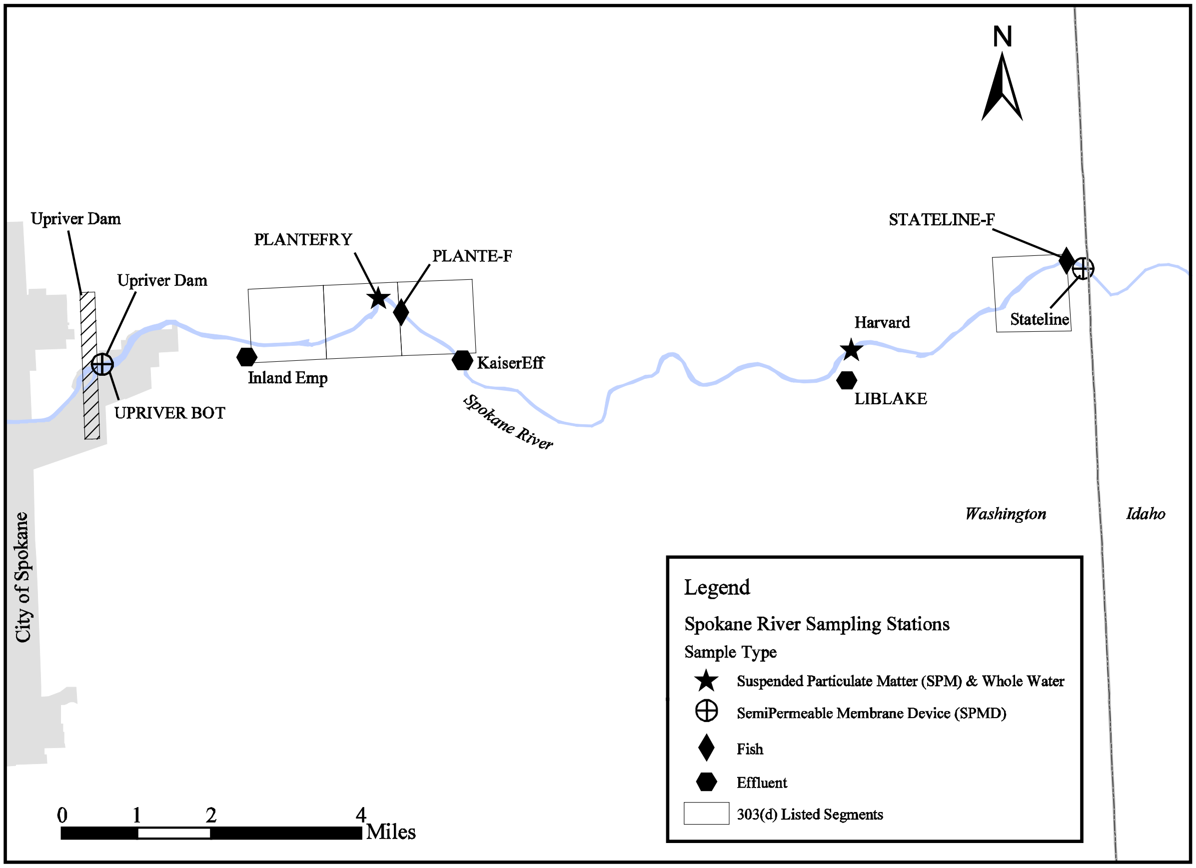

Figure 10. Sampling Map 4: Upriver Dam to Idaho Border.

Surface Water

Semipermeable Membrane Devices

Surface water at five Spokane River and one Little Spokane River locations was sampled using semipermeable membrane devices (SPMDs) obtained from Environmental Sampling Technologies (EST). SPMDs are passive samplers which consist of a 91 x 2.5 cm lay-flat polyethylene membranes filled with 1 mL triolein, a synthetic lipid that mimics biological uptake of dissolved organic compounds like PCBs. Membranes are mounted on “spider carriers” that hold the membranes during deployment and placed inside perforated stainless steel canisters, up to five membranes per can. The chemical residues accumulated in an SPMD can be used to calculate the ambient water column concentration for the chemicals of interest. Detailed information on SPMDs is in Appendix C. Table 8 shows locations where SPMDs were deployed.

Table 8. Locations and Dates of SPMD Deployments.

Location	Station	RM	Dates
State line	Stateline	96.1	10/1 - 10/29/2003 1/28 - 2/24/2004 4/14/04 - 5/12/2004
Behind Upriver Dam at mid-depth	Upriver Dam	80.3	10/1 - 10/29/2003 1/28 - 2/25/2004 4/14 - 5/12/2004
Behind Upriver Dam near bottom	UPRIVER BOT	80.3	10/1 - 10/29/2003 1/28 - 2/25/2004 4/14 - 5/12/2004
Behind Monroe St./Upper Falls Dam	Monroe St	74.8	10/2 - 10/29/2003 1/28 - 2/25/2004 4/14 - 5/12/2004
Ninemile Dam Pool upstream of Plese Flats	Ninemile1	63.6	10/1 - 10/29/2003 1/28 - 2/24/2004*
Ninemile Dam Pool near Sevenmile Bridge	Ninemile2	62.4	4/14 - 5/12/2004
Tum Tum	Tum Tum	44.2	1/29 - 2/24/2004
Lower Lake Spokane	LongLkLow	38.4	10/2 - 11/4/2003 4/13 - 5/11/2004
Little Spokane River at Rt. 291 bridge	LitlSpokBr	1.1	1/29 - 2/24/2004 4/14 - 5/12/2004
Little Spokane River ½ mile upstream of mouth	LitlSpokR	0.5	10/2 - 10/30/2003

*SPMD lost.

Canisters were deployed in the middle of the water column at Stateline, behind Upriver Dam, behind Upper Falls Dam (Monroe St.), upstream of Seven Mile Bridge (Ninemile), in Lake Spokane, and in the Little Spokane River near the mouth. In addition to the mid-depth SPMDs, deployments were also done approximately one foot above the bottom at the Upriver Dam site. The project plan called for one additional SPMD deployment in the lower two miles of Deep Creek, but the creek was too shallow for the sampler (Jack et al., 2003).

SPMD deployments occurred during October 2003, January-February 2004, and April-May 2004. These periods were selected to represent a range of river conditions: low flow in October, moderate flow in February, and high flows during spring runoff. Exposure periods were generally 28 days.

On arriving at the sampling site, the cans were opened, spider carriers were slid into the canisters, and the device was suspended in the water column. Because SPMDs are potent air samplers, the procedure was done as quickly as possible, typically one minute or less. Air exposure times were recorded for each event. Three SPMD membranes were used in each canister, with two canisters per sampling site. The dual canisters were used to minimize the risks of loss or vandalism. If both canisters were successfully recovered, the six membranes were combined for extraction. During each deployment period, one of the SPMD pairs from Upriver Dam was analyzed separately as a replicate. The dual canisters were deployed several meters apart at each station.

In some cases, alternative site selection was necessary due to variable flows or ice. The Lake Spokane SPMD was moved upstream to Tum Tum in January-February because the lower lake was frozen. The April deployment at Ninemile was moved downstream due to high flows, and the Little Spokane site was moved upstream from its original location for February and April sampling to improve accessibility. One of the two canisters was lost at Ninemile during October and at Stateline in April-May. In both instances the single canister (with three membranes each) contained enough material for complete analysis without compromising data quality. Both canisters were lost from Ninemile during January-February, the only event with lost data.

The SPMD retrieval procedure was essentially the opposite of deployment. Cans holding the SPMDs were sealed and shipped back to EST for extraction. EST then shipped the extracts to an accredited contract laboratory, Pace Analytical Services Inc., for PCB analysis.

A trip/field blank was prepared for each SPMD deployment by exposing dedicated membranes to air for the average time sample membranes were exposed. Trip blank membranes were treated the same as other membranes before and after sampling.

Temperature was monitored at 30-minute intervals throughout each deployment using a Tidbit® or I-button® temperature logger attached to the SPMD canister. At the beginning and end of each deployment period, grab samples for total organic carbon (TOC), dissolved organic carbon (DOC), and total suspended solids (TSS) were collected.

Suspended Particulate Matter and Whole River Water

Suspended particulate matter and whole water samples were collected at several locations to further assess water column PCB concentrations. Since hydrophobic organic chemicals like PCBs preferentially sorb to suspended particles, concentrations are more readily detectable, making it a useful surrogate for whole water. Suspended particles were collected using Sedisamp II continuous-flow centrifuges (model 101IL) in a manner described by Serdar et al. (1997) and previously used to collect particles in the Spokane River (Ecology, 1995). Table 9 shows locations and dates for sampling.

Table 9. Locations and Sampling Dates for Suspended Particulate Matter and Whole River Water.

Location	Station	RM	Dates (2003)
Harvard Road	Harvard	92.8	10/20 – 10/22
Plante Ferry Park	PLANTEFRY	84.8	10/28 – 10/30
Ninemile Pool at Plese Flats	NINEM SPM	63.2	11/3 – 11/5

A peristaltic pump set at a rate of 3-4 L/min. was used to draw water from an intake strainer situated in the middle of the water column approximately 10-20 meters offshore. All tubing and fittings were Teflon®, except for Silastic® tubing used at the pump head, and all centrifuge bowl parts in contact with samples were high quality stainless steel.

Water samples for TSS were collected from the centrifuge intake and outlet water each day to estimate particle removal efficiency. TOC and DOC samples were also collected during suspended particle sampling. Aliquots of intake water were periodically collected to provide a composite sample of whole river water for PCB analysis. Once sufficient material was obtained, the centrifuges were disassembled. Then the particulate matter was removed using a Teflon® spatula, and the particulate matter placed in appropriate sample containers. All samples were stored on ice in locked coolers while in the field.

Total mass of particulate matter collected was 9-17 g (dry weight), extracted from 8,700-9,600 L of river water. TSS concentrations in whole river water averaged 1-2 mg/L, and no TSS was detectable in the centrifuge outlet water at a reporting limit of 1 mg/L. Based on the average TSS values in the river and the dry weight of the particulate matter collected, the centrifuge extraction efficiencies were 71-89%, which is in the range of typical values using these centrifuges in similar water conditions (Yake, 1993). Ancillary data for suspended particulate samples are in Appendix D.

Effluents

Industrial and Municipal Wastewater Effluent

Final effluent from wastewater streams of four facilities were collected during unannounced visits on three occasions (Table 10). Samples were composites from two consecutive days, except at Kaiser Trentwood where final effluent was collected as discrete samples each day. Composite grab samples were also collected at the Kaiser wastewater stabilization lagoon and at the outlet of bed filters to assess the effect of particle removal on PCB concentrations.

Table 10. Outfall Locations and Dates of Industrial and Municipal Wastewater Effluent Samples.

Facility	Station	RM	Dates
Liberty Lake Sewer District WWTP	LIBLAKE	92.7	10/21– 22/2003 2/2 – 3/2004 4/26 – 27/2004
Kaiser Trentwood - Effluent	KaiserEff	86.0	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004
Kaiser Trentwood - Lagoon	KaiserLag	--	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004
Kaiser Trentwood - Below Filter	KaiserFilt	--	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004
Inland Empire Paper Company	Inland Emp	82.5	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004
City of Spokane WWTP	SPOKWWTP	67.4	10/21 – 22/2003 2/2 – 3/2004 4/26 – 27/2004

Samples were obtained by dipping a pre-cleaned glass container into the waste stream, either by hand or a stainless steel pole. Two-day composites included two quart grabs per day (morning and afternoon). A transfer blank was also collected during each round of sampling by pouring deionized water prepared at Manchester Environmental Laboratory into sample containers while on site. TSS samples were also collected as two-day grab composites at all facilities. Samples were placed on ice while in the field and maintained in coolers for transport with a chain-of-custody record.

Urban Stormwater

2004 Sampling

Three storm drains and one CSO were sampled during June 2004 (Table 11). Sampling was conducted by City of Spokane personnel during a runoff event produced by approximately 0.5 inches of rain in a 24-hour period. This event represented approximately one-half of the total precipitation for the month.

The storm-drain and CSO sites were selected by City of Spokane personnel based on recommendations by Ecology that the sites should be heavily developed with industrial land use preferred, outfalls should be upstream of the Monroe St. Dam, and at least one should be a CSO outfall.

Table 11. Outfall Locations and Date of 2004 Storm Drain and CSO Samples.

Drain	Station	RM	Date
Mission Ave. and Perry St.	STMMISSBR	76.5	6/10/04
CSO at Erie St.	CSO34	75.8	
Superior St. near Cataldo St.	STMSUPOUT	75.7	
Washington St. Bridge	STMWASHBR	74.3	

The plan called for five storm drain/CSOs sampled during two runoff events, but a lack of precipitation, poor timing, and interference with other priorities of the City's stormwater sampling program precluded the successful completion of the plan.

2007 Contracted Sampling

In 2007 Ecology commissioned Parsons Inc. to conduct a Spokane stormwater study that sampled 14 sites including the four previously sampled storm drains/CSO. Stormwater sites were selected to be within the city limits and to discharge stormwater directly to the Spokane River. Parsons' subcontractor, TerraGraphics Environmental Engineering Inc., collected stormwater grab samples for PCBs and TSS during three storm events in May and June of 2007. The storm-event rainfall measured ranged from 0.29 to 0.86 inches and was preceded by more than four days of dry weather (Parsons, 2007).

Stormwater sampling locations for the Parsons study are described in Table 12.

Table 12. 2007 Stormwater Sampling Locations

Location ID	City Manhole Identifier	Latitude†	Longitude†	Location Description
STMWTR_ HWY291	0106436ST	47.73423	-117.507	Near the southwest corner of the intersection of Parkway Road and Ninemile Road (Hwy 291).
STMWTR_ 7TH	2000318ST	47.64898	-117.445	Next to light pole on southeast side of curb at intersection of 7th Street and Inland Empire. This is a combined sewer overflow (CSO 26).
STMWTR_ HSTREET	0400621ST	47.69031	-117.464	In the middle of H Street next to the alley north of Glass and south of Northwest Boulevard. This is a combined sewer overflow (CSO 07).
STMWTR_ COCHRAN	0501142ST	47.68353	-117.448	In the middle of Cochran Street, north of Grace Avenue west of TJ Meenach Drive Southern (and downstream) of two manholes.
STMWTR_ LINCOLN	0906615IN	47.66256	-117.425	Catch basin in sidewalk east of Lincoln Street next to Anthony’s Restaurant, north of Post Street Bridge.
STMWTR_ CLARKE	1900330ST	47.65836	-117.439	Off north side of the curb of Clarke Street, east of Elm Street. This is a combined sewer overflow (CSO 24A).
STMWTR_ HOWARDBR	1000124ST	47.66485	-117.421	Northeast of Howard Bridge (walking bridge), just south of intersection with Mallon Avenue. In the middle of the trail. South of circle, approximately 12 feet east of catch basin, near map sign.
STMWTR_ UNION	1382924ST	47.66148	-117.392	In the middle of the street in front of the Union Gospel Mission, just south of intersection of Erie Street and Trent Avenue.
STMWTR_ RIVERTON	1800130ST	47.66751	-117.389	At the intersection of South Riverton Avenue and Desmet Avenue on the river side of the guardrail.
STMWTR_ GREENE	1680120ST	47.67772	-117.364	South of the Greene Street bridge, located on the sidewalk east of the bridge.
STMWTR_ WASHINGT	1100230ST	47.664	-117.418	North and west of Washington Street bridge. Located where the two paved walking trails converge. Previously named “stmwashbr.”
STMWTR_ SUPERIOR	1300136ST	47.66579	-117.393	In the middle of Superior Street, south of Cataldo Avenue. Previously named “stmsupout .”
STMWTR_ ERIECSO	0521966CD	47.66108	-117.393	South of Trent Avenue on Erie Street south of site 4217. Middle of three manhole covers in parking area of park. This is a combined sewer overflow (CSO 34). Previously named “CS034.”
STMWTR_ MISSION	1400224ST	47.67227	-117.39	Northeast of the intersection of Perry Street and Mission Avenue near Avista. Previously named “stmmissbr .”

† in decimal degrees
From Parsons, 2007.

Bottom Sediment

Surficial Deposits

Ecology collected surficial (top 2 cm) bottom sediments at several locations in the Spokane River, Little Spokane River, and a reference site. Surface sediment samples were collected from an Ecology boat using a 0.1 m^2 stainless steel van Veen or a 0.01 m^2 Petite Ponar grab sampler. Sediments from the Little Spokane were taken from the right bank using a pipe dredge. Sites were selected to assess the possibility of high concentrations of PCBs behind Monroe St. Dam, assess the longitudinal PCB concentration gradient in Lake Spokane, evaluate the potential of the Little Spokane River as a significant PCB source, and assess PCB concentrations in previously unexamined Spokane River reaches downstream of Lake Spokane.

The same reference site (Buffalo Lake) selected for an earlier bioassay survey of the Spokane Arm of Lake Roosevelt (Era-Miller, 2004) was used to provide reference sediments for the present 2003-07 study. It is located in a remote area of Okanogan County west of Spokane and receives contamination only through atmospheric deposition. An EPA study conducted during 2002 found low a PCB concentration (5.6 ng/g total PCBs) in largemouth bass fillets from Buffalo Lake (unpublished EPA data).

Table 13 lists locations for surficial sediment sampling. The riverbed behind the Monroe St. Dam in the vicinity of RM 76 and downstream of Little Falls Dam in the vicinity of RM 18-29 was composed almost entirely of gravel and cobble, and therefore no samples were collected.

Table 13. Locations and Dates of Surficial Sediment Samples.

Location	Station	RM	Date
Behind Monroe St./Upper Falls Dam	MonroeSed	74.9	4/14/2004
Lake Spokane (Long Lake)	LongLkUp	54.3	5/11/2004
	LongLkMid	44.3	11/4/2003
	LongLkLow	38.4	11/4/2003
Little Falls Pool	Littlefls	29.9	11/4/2003
Spokane Arm at Porcupine Bay	SPOK-1	12.6	11/6/2003
Little Spokane River	LitlSpokSed	2.3	12/10/2003
Buffalo Lake (reference)	BUFFALO REF	--	11/5/2003

Sediment Cores

Ecology collected sediment cores from the upper and lower reaches of Lake Spokane to assess trends in historic PCB deposition and to estimate sediment recovery rates (Table 14). Cores were collected using a Wildco 50-cm stainless steel gravity box corer fitted with a 13 cm by 13 cm (inner diameter) transparent acrylic liner.

Table 14. Locations and Dates of Sediment Cores.

Location	Station	RM	Date
Upper Lake Spokane	LONGUP2	49.2	6/9/2004
Lower Lake Spokane	LONGLOW2	36.0	11/4/2003

Fish and Crayfish Tissue

Ecology obtained fish and crayfish for PCB analysis from seven locations in the Spokane River from 2003 to 2005 (Table 15). For 2003 and 2004, the goal was to collect rainbow trout (>250 mm) and two size classes of largescale suckers (250-350 mm and <200 mm) at each site except Upriver Dam. Crayfish were collected at Upriver Dam due to interest in their possible accumulation of PCBs at the cleanup site. All biological data on specimens used for analysis are in Appendix E.

The goal for 2005 sampling was to provide high quality representative data to WDOH for use in a human health assessment and in reviewing the current fish consumption advisory stemming from data collected in 1999 and 2001. A secondary objective was to examine contaminant trends within the river system. Rainbow trout were not found during extensive efforts to capture them at Stateline and lower Lake Spokane. Largescale suckers were numerous at all sites except in the Ninemile reach where bridgelip suckers were the dominant species. The smaller size class of largescale suckers was not found at any of the sites sampled, even when various capture methods were employed.

Fish were collected primarily using Ecology's 16' Smith-Root electrofishing boat. Largescale suckers from Lake Spokane were captured using variable mesh gillnet sets on the lake bottom. Specimens were held in the vessel's live well and checked for species identification and desired length. Crayfish were collected using basket-cone style crayfish traps baited with cat food and set on the bottom overnight.

Fish selected for analysis were killed by a blow to the head. Each fish was given a unique identifying number, and its length and weight were recorded. The fish were individually wrapped in aluminum foil, put in plastic bags, and placed on ice for transport to Ecology headquarters, where the samples were frozen pending preparation of the tissue samples.

Crayfish were placed in a pre-cleaned 1 gallon glass jar and held on ice in coolers while in the field. Upon returning to Ecology headquarters, specimens were measured, weighed, and identified using an invertebrate species key. Following identification, specimens were returned to the jar and frozen until resection.

Table 15. Locations and Dates of Fish and Crayfish Samples.

Location	Station ID	RM	Latitude	Longitude	Species	Tissue	Dates
Near state line with Idaho	STATELINE-F	96.0	47.6981	-117.044	Largescale sucker	Whole body	7/14/04[*]
	SPK 96	96.0	47.69832	-117.044			8/22/05[†]
Near Plante Ferry Park	PLANTE-F	85.0	47.69459	-117.239	Rainbow trout	Fillet Gut contents	9/15/03[*]
					Largescale suckers	Whole body Gut contents	
	SPK 85	85.0	47.69498	-117.24	Rainbow trout Largescale suckers	Fillet Whole body	8/23/05[†]
Behind Upriver Dam	Upriver Dam	80.3	47.6869	-117.325	Crayfish	Tail muscle	5/13/04[*]
Mission Park	SPK 77	77.0	47.67655	-117.382	Mountain whitefish	Fillet	9/28/05-9/29/05[†]
	SPK 75.2	75.2	47.66401	-117.404	Largescale sucker Rainbow trout	Whole body Fillet	9/28/05[†]
Ninemile reservoir (near Seven Mile Bridge)	Spokane-F	61.7	47.7324	-117.51	Rainbow trout	Fillet	9/16/03[*]
	NINEMILE-F	61.7	47.74299	-117.522	Rainbow trout	Gut contents	
	NINEMILE-F	61.7	47.74299	-117.522	Bridgelip sucker	Whole body Gut contents	7/13/04[*]
	SPK 64.0	64.0	47.72043	-117.501	Rainbow trout	Fillet Whole body	9/29/05[†]
					Mountain whitefish	Fillet Whole body	
					Bridgelip sucker	Fillet Whole body	
Upper Lake Spokane	SPK 55.6	55.6	47.80089	-117.549	Largescale sucker Smallmouth bass Mountain whitefish	Whole body Fillet Fillet	9/27/05[†]
	SPK 55.2	55.2	47.80156	-117.558	Brown trout	Fillet	11/3/05[†]
Lower Lake Spokane	SPK 40.1	40.1 40.8	47.83472 47.84152	-117.737 -117.725	Mountain whitefish Smallmouth bass	Fillet Fillet	11/3/05[†]
	LONGLOW-F	39.4	47.82769	-117.745	Largescale sucker	Whole body	7/13/04-7/14/04[*]

[*] Sampling conducted in support of the present study. See Jack et al. (2003) for Quality Assurance Project Plan.

[†] Serdar and Johnson (2006).

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Sample Preparation

Sample containers and holding times for 2003-2005 are shown in Table 16. The fish and crayfish tissue preparation techniques used are described in Appendix F. See Parsons (2007) for sample preparation, analytical methods, and data quality information for stormwater samples collected in 2007.

Analytical Methods

All PCB congener samples and percent lipid in tissue were analyzed at Pace Analytical Services, Inc., Minneapolis, MN. PCB Aroclors, TOC in sediments, and TOC, DOC, and TSS in water were analyzed at Manchester Environmental Laboratory. SPMD preparation and dialysis was done at Environmental Sampling Technologies (EST), St. Joseph, MO. Radioisotope analysis of sediment cores was done at Teledyne Brown Engineering, Knoxville, TN. Grain size analysis was done at Analytical Resources, Inc., Tukwila, WA.

Table 16 shows analysis methods and reporting limits for sample media.

Table 16. Preparation Methods, Analytical Methods, and Reporting Limits for the Spokane River Samples.

Sample Media	Parameter	Preparation Method	Analytical Method	Reporting Limits
Semipermeable Membrane Device (SPMD)	PCB Congeners	Dialysis and ampulization - EST SOP	GC/HRMS, EPA Method 1668A	100 ng/4 ML dialysate (per congener) translates to approx. 0.1 - 1 pg/l (per congener)
Water	PCB Congeners	--	GC/HRMS, EPA Method 1668A	100 pg/l (per congener)
	TSS	--	EPA Method 160.3	1 mg/L
	TOC	--	EPA Method 415.1	1 mg/L
	DOC	--	EPA Method 415.1	1 mg/L
Sediment (Suspended particulate matter and surficial sediment)	PCB Congeners	Soxhlet extraction	GC/HRMS, EPA Method 1668A	0.05 ng/g (per congener)
Sediment	PCB Congeners	Soxhlet extraction	GC/HRMS, EPA Method 1668A	0.05 ng/g (per congener)
	TOC (104 °C)	--	Combustion	0.1%
	Grain size	--	Sieve and Pipet	±0.5% for each fraction
Sediment (Core)	PCB Aroclors	Soxhlet extraction	GC/ECD, EPA Method 8082	1 - 25 ng/g (per Aroclor)
	TOC (104 °C)	--	Combustion	0.1%
	Pb-210	--	Gamma detection	--
Tissue	PCB Congeners	Soxhlet extraction	GC/HRMS, EPA Method 1668A	0.01 - 0.05 ng/g (per congener)
	% lipids	--	Gravimetric	0.1%

SOP = Standard operating procedure.

Data Quality Assessment

Ecology's Manchester Laboratory reviewed the chemical data for this project. For results generated by Manchester, final data review was performed by the unit supervisor or an analyst experienced with the method. Manchester chemists performed the review for analytical work sub-contracted to commercial laboratories. Quality assurance and quality control at Manchester are described in the *Lab Users Manual* http://aww.ecologydev/programs/eap/forms/labmanual.pdf (Ecology Intranet).

Manchester prepared written case narratives assessing the quality of all data collected. These reviews include a description of analytical methods and an assessment of holding times, initial and continuing calibration and degradation checks, method blanks, surrogate recoveries, internal standard recoveries, matrix spike recoveries, laboratory control samples, and laboratory duplicates. The reviews and the complete Manchester data reports are available from the author on request.

A Quality Assurance Project Plan (Jack, 2003) established measurement quality objectives (MQOs) for accuracy, bias, and reporting limits. To determine if MQOs were met, the project lead compared results on field and laboratory quality control samples to the MQOs. To evaluate whether the reporting limit targets were met, the results were examined for non-detects and to determine if any values exceeded the lowest concentration of interest. Based on these assessments and a review of the laboratory data packages and Manchester's data verification reports, the data were either accepted, accepted with appropriate qualifications, or rejected and re-analyzed or re-sampled where possible.

The precision and accuracy of the 2003-2005 data reported here can be gauged from results on laboratory duplicates, field replicate samples, and standard reference materials, detailed in Appendix G. The relative percent difference (RPD) between duplicate (split) and replicate (separately collected) samples was 20% or better for PCBs in effluents, fish tissue, and sediment. Greater variability was encountered in analyzing PCBs in SPMD extracts, 9-55% RPD. Results from analyzing PCB congeners in a sediment standard reference material agreed within 13% of certified values, on average.

Results and Discussion

Dissolved PCBs in Spokane River Water

Ancillary water quality data collected in concert with SPMD deployments are shown in Table 17. Organic carbon concentrations were low at all sites. DOC constituted approximately 92% of the TOC on average. TSS concentrations were generally ≤3 mg/L with higher values (4-10 mg/L) occurring in February and April.

With a few exceptions, average temperatures were similar at all mainstem locations during each deployment. Stateline and Lake Spokane were approximately 1.5ºC warmer than other sites in October, but Stateline temperatures were slightly colder in February. Lake Spokane temperatures were also the warmest among mainstem sites in February. At Upriver Dam, bottom and middle water column temperatures were nearly identical.

Dissolved PCB concentrations determined from analyzing the SPMD membranes are shown in Table 18. A summary of the PCB residues accumulated in the membranes (raw data) is in Appendix C.

Concentration estimates for dissolved total PCBs ranged from 34 pg/l (parts per quadrillion) at Stateline during February (2004) to a maximum of 656 pg/l at lower Lake Spokane during October (2003). PCBs were composed primarily of tri- through heptachlorobiphenyl congeners. Spokane River total PCBs showed a fairly consistent trend of increasing concentrations moving downstream. Generally, dissolved total PCB concentrations were comparatively low at Stateline and Upriver Dam (34-145 pg/l), intermediate at Monroe St. and Ninemile (76-305 pg/l), and highest at Lake Spokane (78-656 pg/l). Total PCB concentrations in the Little Spokane River were 118-178 pg/l. The PCB mixture in the Little Spokane was enriched in octa, nona, and deca homologues compared to the mainstem Spokane River, suggesting a difference in sources.

There was evidence of seasonal differences in total PCB levels, with concentrations highest during October and lowest during February (Figure 11). Total PCB measured during October and April appeared similar at all reaches except for a large divergence at Lake Spokane. One possible reason for the much higher PCB concentration in Lake Spokane in October is the fall breakdown of stratification, which allowed bottom water enriched in PCBs to mix with the upper water column. This is consistent with SPMD findings for Upriver Dam, discussed below.

Table 17. Ancillary Parameters at SPMD Sites (mg/L).

Station Name	Sample Number	Collection Date	DOC		TOC		TSS		Mean Temp. (ºC)
Stateline	3408971	10/1/03	1.1		1.3		1	U	14.4
	3448107	10/29/03	1.1		1.2		2		
	4058111	1/28/04	1.4		1.3		1	U	3.2
	4094040	2/24/04	1.2		1.3		1		
	4164041	4/14/04	1.2		1.6		3		10.8
	4208134	5/12/04	1		1.2		2		
Upriver Dam	3408966/72*	10/1/03	1.2		1.5		2		12.7
	3448108	10/29/03	1		1.2		1		
	4058112	1/28/04	1.2		1.4		1		3.5
	4094044/5*	2/25/04	1.2		1.3		2		
	4164042/3*	4/14/04	1.6		1.7		3		10.8
	4208135	5/12/04	1		1.1		2		
UPRIVER BOT	--	10/1/03	--		--		--		12.7
	--	10/29/03	--		--		--		
	--	1/28/04	--		--		--		3.6
	4094046	2/25/04	1.1		1.3		2		
	4164044	4/14/04	1.3		1.4		3		9.8
	4208136/7*	5/12/04	1.1		1.1		2		
Monroe St	3408968	10/2/03	1	U	1	U	1	U	12.0
	3448109	10/29/03	1	U	1.1		1		
	4058113	1/28/04	1	U	1.1		2		4.0
	4094047	2/25/04	1.2		1.2		1		
	4164045	4/14/04	1.4		1.3		3		10.8
	4208138	5/12/04	1	U	1.3		2		
Ninemile1	3408967	10/1/03	1	U	1	U	1	U	12.3
	3448110	10/29/03	1.1		1.3		2		
	4058114/5*	1/28/04	1.2		1.3		2		--
	4094041	2/24/04	1.4		1.8		4		
Ninemile2	4164046	4/14/04	1.4		1.4		6		10.8
	4208139	5/12/04	1		1.1		2		
LongLkLow	3408969	10/2/03	1.1		1.1		2		14.4
	3454120	11/4/03	1	U	1	U	2		
	4164040	4/13/04	1.1		1.5		4		10.8
	4208133	5/11/04	1.1		1.3		3		
Tum Tum	4058117	1/29/04	1		1.1		2		4.5
	4094043	2/24/04	2.1		2.6		4		
LitlSpokR	3408970	10/2/03	1	U	1	U	1		14.4
	3448111	10/30/03	1	U	1	U	2		
LitlSpokBr	4058116	1/29/04	1	U	1	U	8		4.5
	4094042	2/24/04	2.7		2.2		10		
	4164047	4/14/04	1.3		1.7		7		10.8
	4208140	5/12/04	1.1		1	U	5		

*Mean of replicate analysis.

U: The analyte was not detected at or above the reported result, equivalent to <1.

Stateline: Spokane River at the Idaho state line just downstream of Interstate 90 bridge.
Upriver Dam: Spokane River upstream of Upriver Dam.
UPRIVER: Spokane River upstream of Upriver Dam, 2 feet from bottom of riverbed.
Monroe St: Spokane River upstream of Monroe Street Dam.
Ninemile1: Spokane River at Riverside State Park.
Ninemile2: Spokane River downstream of boat launch at Plese Flats
LongLkLow: Lower Lake Spokane.
Tum Tum: Lake Spokane near Tum Tum.
LitlSpokR: Little Spokane River at State Route 291 bridge.

Table 18. SPMD Dissolved PCB Concentrations Grouped by Homologues (pg/l), 2003-2004.

Station Name	Sample Number	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
October 2003												
Stateline	474155	0.4	1.5	11	15	56	19	7.9	2.4	0.0	0.0	113
Upriver Dam	474156/7*	0.7	5.5	25	26	32	10	3.7	0.0	0.0	0.0	103
UPRIVER BOT	474158	0.4	5.0	31	48	43	13	4.8	0.7	0.0	0.0	145
Monroe St	474159	0.6	8.6	32	60	65	42	18	3.0	0.0	0.0	231
Ninemile1	474160	0.3	13	63	61	95	49	21	3.1	0.0	0.0	305
LongLkLow	474161	0.7	15	59	269	195	74	32	9.3	2.3	0.0	656
LitlSpokR	474162/3*	0.2	1.0	12	27	33	16	12	11	6.4	0.0	118
February 2004												
Stateline	194130	0.0	0.0	1.8	4.6	14	8.9	5.0	0.0	0.0	0.0	34
Upriver Dam*	194131/2*	0.1	0.6	5.6	12	15	3.7	19	0.0	0.0	0.0	56
UPRIVER BOT	194133	0.0	0.3	10	40	22	4.1	0.8	0.0	0.0	0.0	78
Monroe St	194134	0.0	1.0	9.5	21	20	13	11	0.0	0.0	0.0	76
Ninemile1	--	--	--	--	--	--	--	--	--	--	--	--
Tum Tum	194135	0.0	1.4	12	24	18	8.9	13	0.1	0.0	0.0	78
LitlSpokBr*	194136/7*	0.1	0.4	9.1	35	51	16	12	13	6.9	0.0	143
April 2004												
Stateline	208134	0.0	0.3	8.0	17	60	32	27	2.1	0.0	0.0	145
Upriver Dam	208135	0.0	0.0	2.1	16	14	6.6	4.6	0.9	0.0	0.0	45
UPRIVER BOT*	208136/7*	1.8	1.0	24	78	57	17	11	0.5	0.0	0.0	191
Monroe St	208138	0.1	1.8	21	53	80	40	31	4.0	0.0	0.0	231
Ninemile2	208139	0.5	2.6	25	57	68	40	28	3.9	0.0	0.0	225
LongLkLow	208133	0.6	6.0	25	94	84	34	16	3.3	0.0	0.0	263
LitlSpokBr*	208140/1*	0.4	0.8	18	37	53	19	23	14	10	3.1	178

*Mean of replicate analysis.
Note: Reporting limits were variable, 0.1 – 10 pg/l.

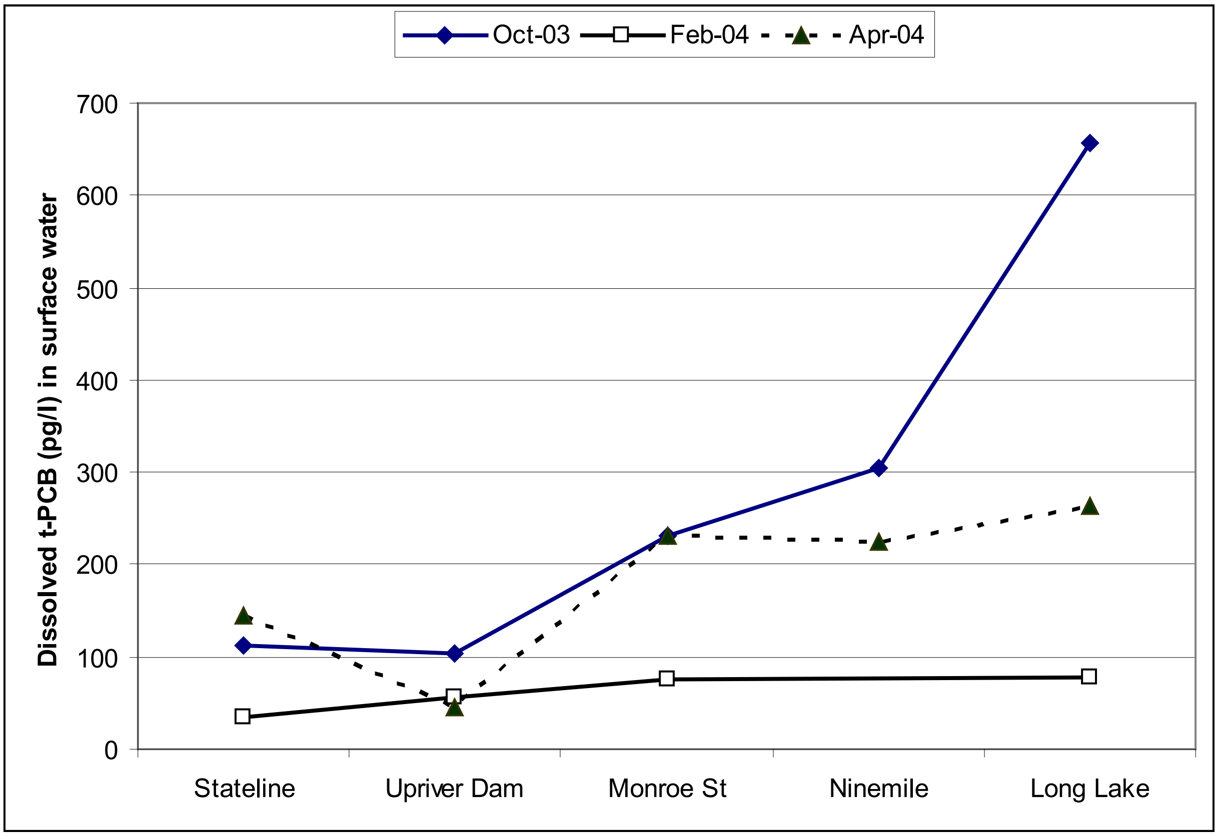

Figure 11. Dissolved Total PCBs in the Spokane River, 2003-2004.

Dissolved PCBs at Monroe Street, Ninemile, and lower Lake Spokane did not meet (exceeded) Washington State's human health water quality criterion of 170 pg/l. During October, the total PCB concentrations at these sites ranged from 231 to 656 pg/l. In April, the concentration range was 231 to 263 pg/l. The Little Spokane River was at the criterion in April (178 pg/l).

The February total PCB concentrations were similar among reaches and low compared to other months. Lower concentrations during this deployment may have been more a result of colder temperatures which reduce the SPMD sampling rate but is not accounted for in calculations used to translate SPMD PCB residues to surface water concentrations (see Appendix C). This may also explain the consistent total PCB concentrations in the Little Spokane River, since February and April temperatures at this location were 2-3ºC warmer. Simple flow dilution does not explain the differences among deployments since Spokane River discharge was highest during April (325 m^3/s at Spokane), lowest during October (49 m^3/s), and intermediate during February (114 m^3/s).

One objective of the SPMD sampling at the Upriver Dam cleanup site was to assess PCB levels at different depths. Samplers deployed 1-2 feet from the bottom had consistently higher concentrations than those at mid-depth (12-13 feet above bottom, Figure 12). The difference was pronounced in April when the bottom sample was four times the mid-column sample, even though the temperature was 1ºC lower (and thus a slightly lower sampling rate) at the bottom. Temperatures at both depths were identical during the other deployments.

At the time of sampling, higher PCB concentrations near the bottom were expected at this site which has PCB contaminated sediments that had yet to undergo state-directed cleanup (see previous Upriver Dam discussion). Although the high level of organic carbon in some of the PCB contaminated sediments theoretically sequesters PCBs, some diffusion to the water column occurs which was captured by the near-bottom SPMDs.

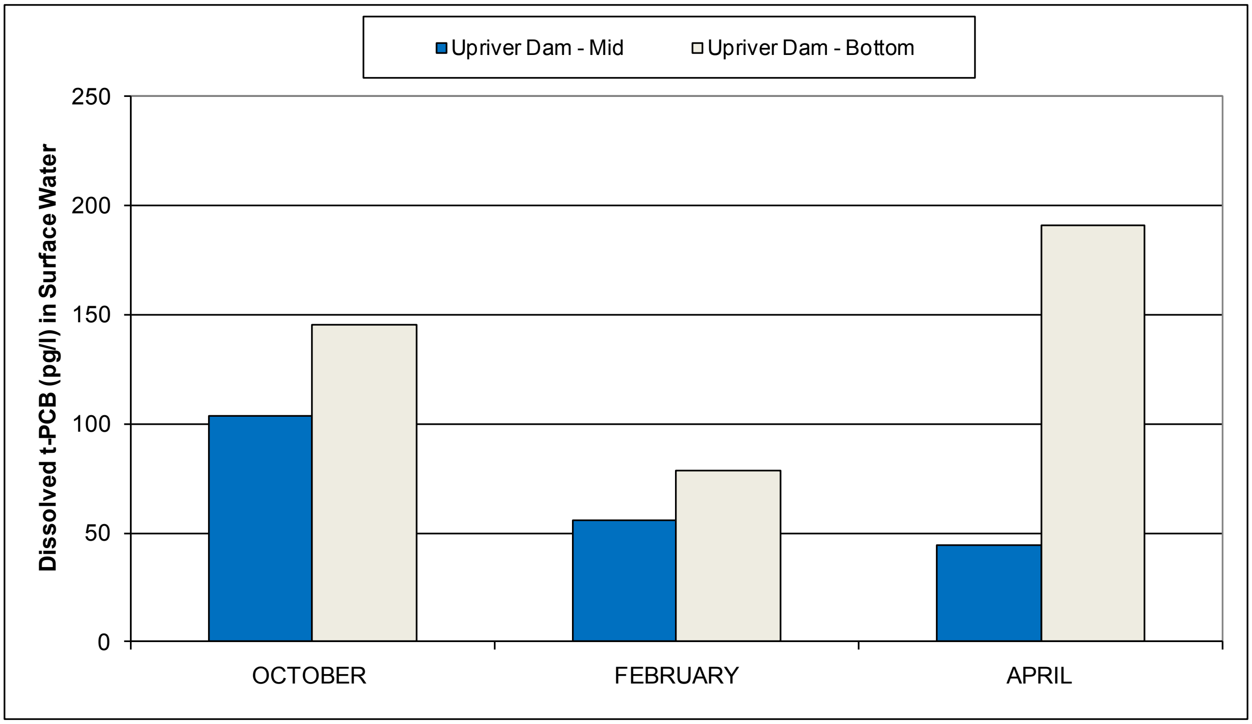

Figure 12. Dissolved Total PCBs at Mid-depth and Near the Bottom at Upriver Dam.

PCBs in Spokane River Suspended Particulate Matter

PCBs were measured in suspended particulate matter (SPM) and whole water from the Spokane River at Harvard Rd., Plante Ferry, and Ninemile during three two-day events in October-November 2003. For each sample collection (Oct 20-21, Oct 28-29, and Nov 3-4), a generator run pump was used to draw water up to a large centrifuge. Whole water samples were pumped to a sample container immediately upstream of the centrifuge. Ancillary water quality parameters included TOC, DOC, and TSS (Appendix D). TOC and DOC values were generally ≤1 mg/L. TSS averaged 1 mg/L at Harvard Road and Ninemile and 2 mg/L at Plante Ferry.

In SPM, PCBs were composed primarily of tetra-, penta-, and hexachlorobiphenyl congeners (Table 19). [Compared to dissolved PCBs which were composed primarily of tri- through heptachlorobiphenyl congeners. See previous discussion on dissolved results for the Spokane River.] Total PCB concentrations in suspended particles from Ninemile (69 ng/g, parts per billion) were an order of magnitude higher than those upstream (7.1-9.6 ng/g). The low TSS concentrations during all three sampling events indicate that differences in total PCB concentrations were not due to sediment entrainment.

For the most part, detection limits in the whole surface water samples were not low enough to afford a useful comparison with the SPM data. No PCBs were detected in the whole water samples collected at Harvard Rd. or Plante Ferry at the 110 pg/l level, and only a low concentration (130 pg/l) of dichlorobiphenyl congeners was detected at Ninemile (Table 19). This is an unusual finding considering the relatively low concentration of this homologue group in SPM and SPMDs.

Earlier (1994) SPM sampling by Ecology (1995) at Plante Ferry yielded much higher PCB concentrations (220 ng/g) using the same collection methods as the present 2003-07 study. Although that result was obtained using an Aroclor rather than congener analysis, river conditions were similar, TSS was low (<1 mg/L), and the sampling site was nearly identical.

To examine the proportion of solid and dissolved phase PCB concentrations in the Spokane River, the following partition formula was applied to the SPM data:

Equation 3. $$\boldsymbol{Fraction\ of\ dissolved\ PCB} = \frac{\mathbf{1}}{(\mathbf{1}+(\boldsymbol{f_s}*\boldsymbol{f_{oc}}*\boldsymbol{K_{oc}}))}$$

Where:

- f_s = fraction of solid in water.
- f_{oc} = fraction of organic carbon in the solid phase.
- K_{oc} = sediment-water partition coefficient normalized for organic carbon.

This formula assumes that PCBs are in equilibrium between the solid and dissolved phases, and the proportion in each phase is governed by the amount of solids in the water and the organic carbon content of the solid material. K_{oc}, the sediment-water partition coefficient normalized for organic carbon, is a field or laboratory-derived constant for each chemical. Values for f_s were from TSS measurements (1 or 2 mg/L; i.e., f_s = 0.000001 or 0.000002). Values for f_{oc} (0.15) and K_{oc} (449,000) are from EPA (1994) and DiToro et al. (1991), respectively, and are the same values used by Ecology (1995) to calculate a dissolved PCB concentration in water from earlier sampling.

Based on sediment-water partitioning, approximately 94% of the PCBs are in the dissolved phase. Dissolved total PCB concentration for Harvard Rd. and Plante Ferry are 142 and 105 pg/l, respectively, similar to results derived from SPMD deployments at Stateline and Upriver Dam during the same period (≈110 pg/l). The theoretical dissolved concentration of total PCBs was 1,020 pg/l at Ninemile, more than three times the concentration measured with SPMDs (305 pg/l) during October (in Table 18).

Table 19. PCB Concentrations Grouped by Homologues in Suspended Particulate Matter (ng/g, dw) and Whole River Water Collected at the Centrifuge Inlet (pg/l) During Three Sampling Events from October to November 2003.

	Station	Sample Number	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
Suspended Particulate Matter													
Spokane R at Harvard Rd	Harvard	3438100	<0.09	0.11	0.51	0.96	2.91	3.40	1.39	0.32	<0.09	0.09	9.60
Spokane R at Plante Ferry Park	PLANTEFRY	3448100	<0.05	0.09	0.41	1.34	2.49	1.98	0.70	0.08	<0.05	0.05	7.09
Spokane R at Riverside State Park	NINEM SPM	3454105	<0.07	0.39	3.71	12.9	24.6	18.6	6.30	1.71	0.39	0.15	68.8
Whole Water Centrifuge Inlet													
Spokane R at Harvard Rd	Harvard	3438100	REJ	<111	<111	<111	<111	<111	<111	<111	<111	<122	<111
Spokane R at Plante Ferry Park	PLANTEFRY	3448100	<109	<109	<109	<109	<109	<109	<109	<109	<109	<120	<109
Spokane R at Riverside State Park	NINEM SPM	3454105	<108	130	<108	<108	<108	<108	<108	<108	<108	<119	130

Detected values are in green highlight.
<: The analyte was not detected at or above the reported result.
REJ: Data are unusable for all purposes.

Figure 13 shows the two-day whole water PCB concentrations estimated from the suspended matter data and illustrates the relative importance of the dissolved PCB component, at least during low-flow conditions. Results also suggest that the analysis of whole surface water samples collected during particulate matter sampling underestimated actual PCB concentrations.

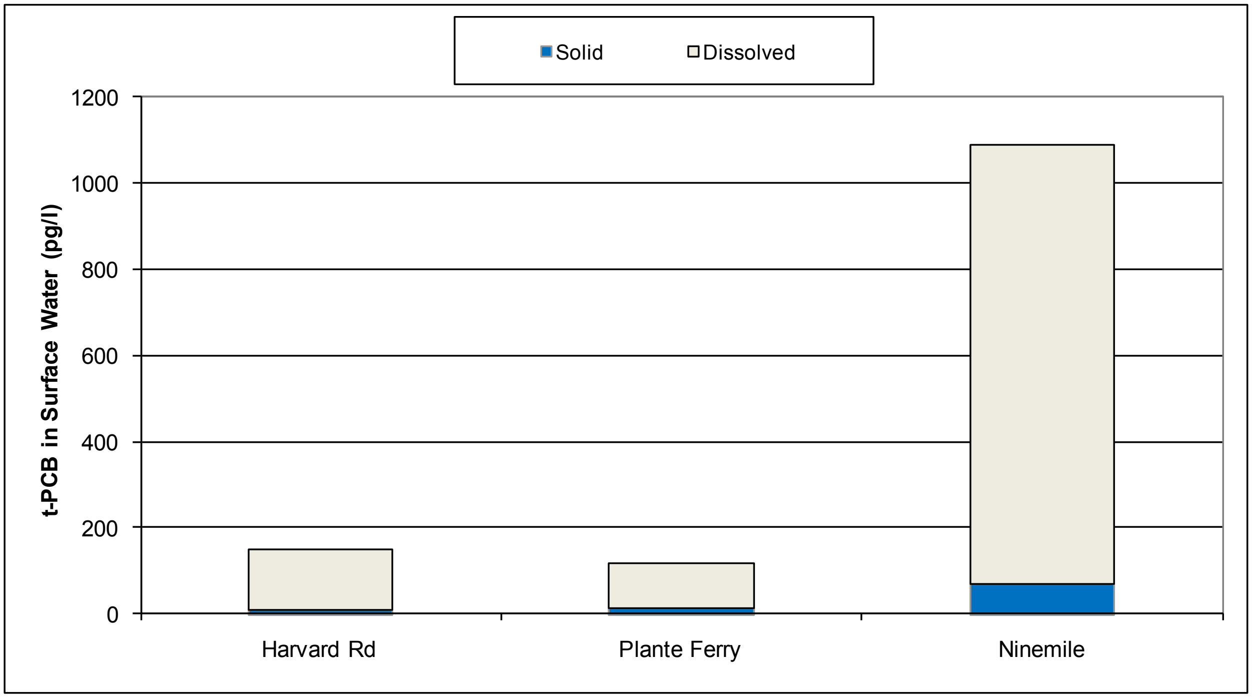

Figure 13. Measured Particle-Bound PCB Concentrations and Theoretical Dissolved PCB Concentrations Based on Suspended Particulate Matter Collected by Three 2-Day Centrifugation Sampling Events of Spokane River Water in October and November 2003.

PCBs in Industrial and Municipal Effluents Discharged to the Spokane River

In late 2003, Kaiser Trentwood installed a black walnut shell filtration system for their process wastewater discharge. Results of 2004-2005 effluent sampling showed an order of magnitude decrease in PCB concentrations and loads compared to 2001, presumably due to the filter and other facility management improvements. Table 20 shows the results of effluent PCB monitoring by Kaiser in 2004-2005 (unpublished).

Table 20. Kaiser Trentwood Effluent Concentrations of Total PCBs (Kaiser, 2005).

Source	Date	Total PCBs (pg/l)*	Effluent Flow (ML/day)	PCB Load to River (mg/day)
Kaiser Trentwood	6/25/04	1,170	63.9	75
	7/7/04	1,230	64.6	79
	7/23/04	1,340	66.2	89
	8/9/04	914	62.4	57
	4/20/05	669	56.2	38
	5/7/05	928	56.1	52
	5/19/05	1,370	59.7	82
	6/11/05	971	56.5	55
	6/14/05	1,130	55.4	63

*sum of detected congeners.

PCBs monitored by Ecology in effluents from four industrial and municipal facilities during three periods – October 2003, February 2004, and April 2004 – are shown in Table 21. Descriptions of the station names and sampling dates were listed in Table 10.

Spokane WWTP was the only facility where PCBs were detected in effluent during all three sampling collections, with an average PCB concentration of 940 pg/l.

Total PCBs in the Kaiser Trentwood effluent were generally <110 pg/l except during October when 330 pg/l was detected on 10/21/2003. Total PCBs were undetected at the 100 pg/l detection limit the following day. Samples from the treatment lagoon at Kaiser showed much higher PCBs (110 – 7,400 pg/l), but these concentrations were reduced substantially by the bed filtration system prior to discharge.

Liberty Lake WWTP had variable concentrations, as did Inland Empire to a lesser degree. Total PCB concentrations at Liberty Lake WWTP were an order of magnitude higher during April than during October and February, while Inland Empire had only one sample with PCBs detected, 670 pg/l total PCBs in October.

Overall, it appears that PCB concentrations in the effluents of the four facilities have decreased substantially since previous sampling. The smallest decrease occurred at the Spokane WWTP where 2003-04 average concentrations were about one-half those during 2001. However, the bulk of this apparent decrease may be due to higher detection limits used for the 2003-2004 samples compared to earlier samples. Effluent samples analyzed by Golding (2002) and SAIC (2003a) typically had detection limits <5 pg/l for individual congeners, and nearly all detected congeners were found at concentrations <100 pg/l. Therefore, the 2003-2004 results are likely all biased low due to the omission of these detections.

The reason for the relatively high level of monochloro-biphenyls in the 2004 Liberty Lake and Spokane WWTP replicate samples is unknown. The poor agreement between the Spokane WWTP replicate samples suggests contamination either from the field or laboratory. These values do not have a significant impact on the PCBs loading scenarios presented later in the report.

Table 21. PCB Concentrations Grouped by Homologues in Industrial/Municipal Effluent (pg/l).

Station Name	Sample ID	TSS mg/L	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
October 2003													
LIBLAKE	3434025	7	<98	161	<98	<98	<98	<98	<98	<98	<98	<98	161
KaiserEff	3434020	1	<100	100 J	228	<100	<100	<100	<100	<100	<100	<110	328 J
KaiserEff	3434023	1	<101	<101	<101	<101	<101	<101	<101	<101	<101	<112	<101
KaiserLag	3434021	3	<102	292 J	911	1,350	<102	<102	<102	<102	<102	<112	2,550 J
KaiserFilt	3434022	1	<100	167 J	104	<100	<100	<100	<100	<100	<100	<110	271 J
Inland Emp	3434026	5	<101	670	<101	<101	<101	<101	<101	<101	<101	<111	670
SPOKWWTP	3434027	6	<99	143	<99	112	218	<99	<99	<99	<99	<108	473
February 2004													
LIBLAKE	4064113	31	<111	<111	<111	<111	<111	<111	<111	<111	<111	<122	<111
KaiserEff	4064105	1	<112	<112	<112	<112	<112	<112	<112	<112	<112	<123	<112
KaiserEff Rep.	4064106	1	<106	<106	<106	<106	<106	<106	<106	<106	<106	<116	<106
KaiserEff	4064107	1	<109	<109	<109	<109	<109	<109	<109	<109	<109	<119	<109
KaiserLag	4064110	5	<106	422	2,580	3,720	647 J	<106	<106	<106	<106	<117	7,370
KaiserFilt	4064109	1	<109	<109	307	125 J	<109	<109	<109	<109	<109	<120	432 J
Inland Emp	4064111	9	<109	<109	<109	<109	<109	<109	<109	<109	<109	<120	<109
SPOKWWTP	4064112	10	<108	<108	<108	123	259	122	<108	<108	<108	<119	504
April 2004													
LIBLAKE	4188205	43	999 NJ	<112	<112	265	<112	<112	<112	<112	<112	<123	1,260 NJ
KaiserEff	4188198	1	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112
KaiserEff	4188199	1	<107	<107	<107	<107	<107	<107	<107	<107	<107	<107	<107
KaiserLag	4188202	1	<104	112 J	<104	<104	<104	<104	<104	<104	<104	<104	112 J
KaiserFilt	4188201	1	<106	<106	<106	<106	<106	<106	<106	<106	<106	<106	<106
Inland Emp	4188203	2	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112	<112
SPOKWWTP	4188204	5	<102	<102	<102	342	588	329	<102	<102	<102	<113	1,260
SPOKWWTP Rep.	4188206	6	865 NJ	<107	<107	360	826	358	<107	<107	<107	<117	2,410 NJ

Detected values are in green highlight.
<: The analyte was not detected at or above the reported result (U or UJ).
NJ: There is evidence that the analyte is present. The associated numerical result is an estimate.
J: The analyte was positively identified. The associated numerical value is an estimate.

PCBs in Stormwater Discharged to the Spokane River

Stormwater sampling during the 2003-04 PCB source assessment study was conducted by City of Spokane personnel during one runoff event on June 10, 2004. Only four locations were sampled, although the sampling plan proposed more sites and storm events. Samples were collected from manholes nearest the outfalls draining the particular stormwater conveyance systems.

Due to the limited data from 2004, a second and larger set of stormwater samples was collected in the spring of 2007 by Parsons, a consultant hired by Ecology. Locations are shown in Figure 14. Results from both the 2004 and 2007 efforts are presented in Tables 22 to 26. The location IDs that correspond to the location descriptions were shown in Tables 11 and 12.

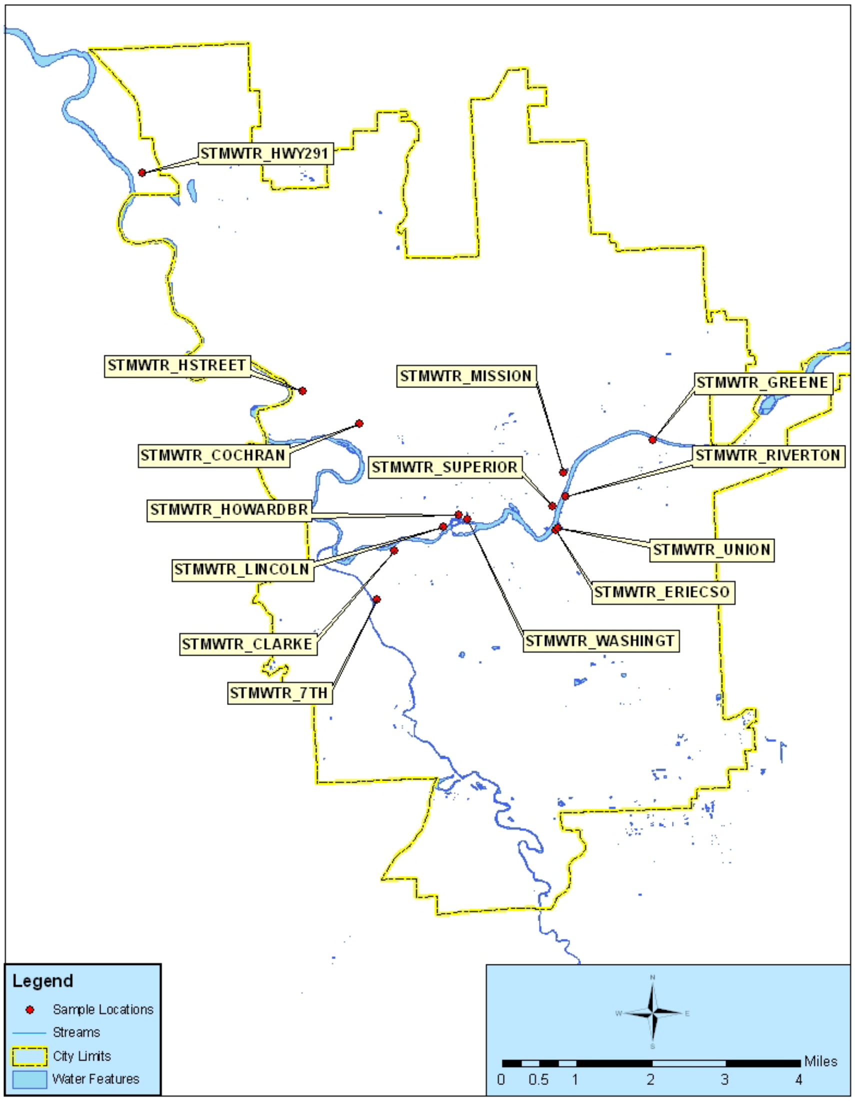

Figure 14. Stormwater Basins in the City of Spokane Sampled for PCBs During 2007 by Parsons.

Table 22. June 10, 2004 Stormwater PCB Concentrations Grouped by Homologues (pg/l).

Location ID*	Sample Number	TSS (mg/L)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
Stmwtr_Mission (STMMISSBR)	4254001	58	<117	<117	117	5,490	28,800 J	19,200	6,660	1,600	283	254	62,400 J
Stmwtr_ErioeCSO (CSO 34)	4254000	126	<111	<111	685	3,120	10,200	28,500	32,400	7,800	678	<123	83,400
Stmwtr_Superior (STMSUPOUT)	4254003	26	<102	<102	<102	843	1,920	1,270	749	120	<102	<112	4,900
Stmwtr_Washingt (STMWASHBR)	4254002	91	<113	<113	285	2,560	8,380 J	5,290 J	2,530	690	198	<124	19,900 J

Detected values are in green highlight.

* Location ID in parentheses is presented for access to data in EIM. The Location IDs correspond to Table 12, which is the ID given for the 2007 stormwater sampling.

<: The analyte was not detected at or above the reported result (U or UJ).

J: The analyte was positively identified. The associated numerical value is an estimate.

Table 23. May 2, 2007 Stormwater PCB Concentrations Grouped by Homologues (pg/l).

Location ID*	Sample ID	TSS (mg/L)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
HWY291	07184210	19	76	78	45	483 J	572	408	446	70	<20	<20	2180 J
7TH (CSO 26)	07184211	22	<80	<80	<80	<80	713 J	575	120	<80	<80	<80	1410 J
HSTREET (CSO 7)	07184212	63	<20	120	135	855 J	1,380	973	768	190	54	48	4520 J
COCHRAN	07184213	155	85	578	953	2,430 J	5,770	4,440	2,890	813	293	<20	18,250 J
LINCOLN	07184214	8	<20	<20	88	622 J	1,130	556	315	56	44	<20	2810 J
CLARKE (CSO 24A)	07184215	4	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80	<80[1]
HOWARDBR	07184216	7	<20	102	194	849 J	734	408	309	29	27	42	2700 J
UNION	07184217	67	75	1,960	8,500	21,990	27,660	39,350	42,050	24,860	1,570	160	168,160
RIVERTON	07184218	27	23	336	919	6,570	17,200	10,050	6,050	1,900	99	<20	43,140
WASHINGT	07184221	26	57	295	408	1,700 J	2,800	1,330	1,110	514	82	<20	8,290 J
SUPERIOR	07184222	43	61	440	859	4,970 J	21,340	10,830	2,620	996	84	33	42,230 J
ERIECSO (CSO34)	07184223	40	115	2,960	13,650	29,140	48,120	85,070	78,890	20,190	2,000	296	280,430
MISSION	07184224	34	<100	319 J	381 J	2,990 J	9,720	6,690	2,220	452	<100	<100	22,770 J
SUPERIOR-Replicate	07184225	306	<100	342 J	527	2,350	9,250	6,670	1,410	690	<100	<100	21,230 J
SUPERIOR-Replicate	07184226	27	65	496	971	2,620	6,720	5,310	1,740	1,310	40	<20	19,260

Detected values are in green highlight.

*: In EIM these Locations IDs have the prefix STMWTR_; CSO number in parentheses is not part of the EIM Location ID.

[1]: The Clarke 07184215 Total PCB was revised from 0.062 to <80, post publication in the 2007 Parsons Report. The online report reflects the change.

<: The analyte was not detected at or above the reported result (U or UJ).

J: The analyte was positively identified. The associated numerical value is an estimate.

Table 24. May 21, 2007 Stormwater PCB Concentrations Grouped by Homologues (pg/l).

Location ID*	Sample ID	TSS (mg/L)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
HWY291	07214210	8	110	105 J	<40	66 J	231	<40	<40	<40	<40	<40	512 J
7TH (CSO 26)	07214211	7	<40	158	51 J	296	342	144	<40	<40	<40	<40	991
HSTREET (CSO 7)	07214212	41	<40	137 J	<40	315 J	801 J	514	305	108	<40	<40	2,179 J
COCHRAN	07214213	12	43 J	135 J	<40	125 J	275 J	95 J	46 J	<40	<40	<40	719 J
LINCOLN	07214214	3	<40	164 J	<40	132 J	353 J	187	<40	<40	<40	<40	836 J
CLARKE (CSO 24A)	07214215	2	<40	101 J	<40	124	<40	<40	<40	<40	<40	<40	225 J
HOWARDBR	07214216	3	<40	122 J	57 J	302 J	317 J	42 J	<40	<40	<40	<40	839 J
UNION	07214217	18	142	373 J	645	1,795 J	3,006 J	4,325	4,631	1,121	62 J	<40	16,099 J
RIVERTON	07214218	14	52 J	<40	47 J	422 J	856 J	997	1,511	356	<40	<40	4,240 J
GREENE	07214219	38	54 J	233 J	828	2,367 J	3,033 J	2,254	2,238	403	<40	<40	11,409 J
WASHINGT	07214221	11	159	132 J	<40	<40	395 J	247	49 J	<40	<40	<40	981 J
WASHINGT-Replicate	07214225	8	108	136 J	<40	169 J	396 J	132	<40	<40	<40	<40	939 J
WASHINGT-Replicate	07214226	9	74 J	80 J	<40	156 J	402 J	239	65 J	<40	<40	<40	1,017 J
SUPERIOR	07214222		196	110 J	<40	155 J	304 J	202	185	<40	<40	<40	1,152 J

Detected values are in green highlight.
*: In EIM these Locations IDs have the prefix STMWTR_
<: The analyte was not detected at or above the reported result (U or UJ).
J: The analyte was positively identified. The associated numerical value is an estimate.

Table 25. June 5, 2007 Stormwater PCB Concentrations Grouped by Homologues (pg/l).

Location ID*	Sample ID	TSS (mg/L)	1-Cl	2-Cl	3-Cl	4-Cl	5-Cl	6-Cl	7-Cl	8-Cl	9-Cl	10-Cl	Total PCBs
HWY291	07234710	6	<40	<40	<40	<40	98 J	143	<40	<40	<40	<40	241 J
7TH (CSO 26)	07234711	26	150	121	91 J	702 J	2,708 J	2,382	1,059	382	64 J	48 J	7,707 J
HSTREET (CSO 7)	07234712	46	<40	<40	<40	<40	422 J	266 J	62 J	<40	<40	<40	749 J
COCHRAN	07234713	298	65 J	552	724	2,458 J	5,257	6,301	2,535	1,078	518	110	19,598 J
LINCOLN	07234714	51	<40	215	378	1,187 J	3,163 J	2,818	852	495	255	61 J	9,423 J
CLARKE (CSO 24A)	07234715	92	<40	108	72 J	452 J	1,725 J	1,628	591	196	94 J	<40	4,867 J
HOWARD BR	07234716	67	<40	605	4,404	4,662	2,366 J	1,722	773	210	111	86 J	14,940 J
HOWARD BR-Replicate	07234725	63	<40	528	4,393	4,158	2,549 J	1,222	627	121	122	93 J	13,813 J
HOWARDBR-Replicate	07234726	46	<40	433	3,591	3,302	1,760 J	1,410	566	130	79 J	123	11,393 J
UNION	07234717	65	49 J	511	2,387	5,037	12,488	39,653	36,975	9,056	602	44 J	106,802
RIVERTON	07234718	82	<40	200	500	1,465 J	3,824 J	6,735	5,309	1,222	124	<40	19,380 J
GREENE	07234719	117	<40	295	1,770	3,631	5,599	9,275	5,463	1,315	232	43	27,622
WASHINGT	07234721	158	<40	216	404	1,947 J	2,726 J	2,489	681	318	171	80 J	9,031 J
SUPERIOR	07234222	55	<40	116	109	742 J	1,451 J	1,622	593	227	53 J	<40	4,912 J
ERIECSO (CSO34)	07234223	159	62 J	582	2,094	4,987	10,768	28,081	19,456	6,027	568	62 J	72,686
MISSION	07234224	30	<40	120	152	897 J	3,131 J	3,593	1,884	446	90 J	<40	10,311 J

Detected values are in green highlight.
*: In EIM these Locations IDs have the prefix STMWTR_
<: The analyte was not detected at or above the reported result (U or UJ).
J: The analyte was positively identified. The associated numerical value is an estimate.

Summary statistics for PCB concentrations in City of Spokane stormwater samples from 2004 and 2007 are shown in Table 26. Stormwater PCB concentrations ranged over two orders of magnitude in both data sets from 2004 and 2007. Individual total PCB concentrations varied widely from <80 to 280,000 pg/l in the 2007 Parsons study, and from 4,900 to 83,400 pg/l in 2004.

Table 26. Summary Statistics for Total PCB Concentrations in Spokane Stormwater (pg/l).

Statistic	Stormwater Sampling	
	Ecology in 2004	Parsons in 2007
minimum	4,900	240
10th	9,400	777
25th	16,150	1,118
mean	42,650	23,023
median	41,150	8,000
75th	67,650	19,290
90th	77,100	42,867
95th	80,250	101,684
maximum	83,400	280,430

Parsons provided an in-depth review of the 2007 data in their report (Parsons, 2007). They concluded that:

- Stormwater basins CSO 34 and Union Street showed the highest average concentrations for the three events.
- Total PCB concentrations showed a direct correlation with TSS.
- Sources of PCBs are similar in the stormwater systems, with the exception of the Howard Bridge site. The greater relative abundance of less chlorinated PCBs at Howard Bridge may indicate the presence of a different source.

Post publication of the Parsons report, Union Street was found to drain to the CSO34 (Erie Street) system. Their relative drainage areas are 109 and 1,951 acres, respectively. Thus, Union Street, at <6% of the CSO 34 area, may be largely responsible for the high PCB levels detected at CSO 34.

The Clarke 07184215 total PCB result was revised post publication of the Parsons (2007) report from 0.062 to <80 pg/l.

A wide range of PCB homologues was detected in Spokane stormwater (Tables 22-25) and in particulate samples from the Spokane River (Table 19). A similar homologue range was seen in Spokane River sediment samples (see Table 30). In contrast, a relatively narrow group of dichloro through pentachlorobiphenyl homologues was found in industrial and municipal effluents (Table 21). This finding, coupled with the loading analysis that follows, supports a conclusion that stormwater is a significant PCB source to the Spokane River.

Stormwater Discharges

Streamflow data were not collected during stormwater sampling. Therefore the discharge was estimated using calculations based on rainfall. The average annual stormwater discharge predicted by the Simple Method (www.stormwatercenter.net) was calculated by Parsons (2007). Briefly, the Simple Method uses the equation:

Equation 4. $R = P * Pj * Rv$

where R is annual runoff (inches), P is annual rainfall (inches), Pj is the fraction of annual rainfall events that produce runoff (assumed 0.9), and Rv is a runoff coefficient.

In this method, the runoff coefficient is calculated based on impervious area in the subwatershed (Ia). Watershed imperviousness is a reasonable predictor of Rv (Schueler, 1987), with the relationship best defined as:

Equation 5. $Rv=0.05+0.9Ia$

Geographical data were provided by the City of Spokane Wastewater Management Department. Annual rainfall was estimated to be 18 inches in Spokane, based on data from Ecology's Eastern Washington Stormwater Manual Precipitation Maps (Ecology, 2004 www.ecy.wa.gov/biblio/0410076maps.html). A value of 0.9 was used as the fraction of runoff.

The first step for developing flow estimates using the Simple Method was to determine the area draining to each of the sampling locations. To do so, a shapefile of stormwater boundaries provided by the City of Spokane was merged with the shapefile of areas contributing stormwater to the various CSOs (also provided by the City of Spokane) in a geographic information system. Figure 15 presents the combined stormwater-CSO boundaries for the entire city.

The second step was to determine the impervious areas. Pervious surfaces were determined in each drainage area based on 2007 geographic data. The total impervious area contributing was calculated as the sum of transportation and off-street impervious areas. Percent impervious for all the stormwater basins in the City of Spokane ranged from roughly 12 to 54% for the basins with any development (Parsons, 2007). This stormwater assessment did not take the Census-defined urban areas nor the Urban Growth boundary into account. The Spokane city limits were defined by the 2005 city boundary.

The total PCB average for each sampling station, as well as the calculated impervious fraction, area, and runoff, are shown in Table 27.