

**INJURIES TO SURFACE WATER RESOURCES,
LOWER FOX RIVER/GREEN BAY NATURAL
RESOURCE DAMAGE ASSESSMENT**

Final Report

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CONTENTS

List of Figures	iii
List of Tables	v
Acronyms	vii
Chapter 1 Introduction	1-1
Chapter 2 Resource Description and Trustee Authority	2-1
2.1 Surface Water Resource Description	2-1
2.2 Trusteeship Authority	2-1
Chapter 3 Injury Assessment Approach and Pathway Determination	3-1
3.1 Injury Definitions	3-1
3.2 Summary of Pathway Determination	3-3
Chapter 4 Comparison of Surface Water PCB Concentrations with Injury Thresholds	4-1
4.1 Surface Water Data Sources	4-1
4.2 Lower Fox River	4-2
4.3 Green Bay	4-2
4.4 Conclusions	4-6
Chapter 5 Injury Determination and Conclusions	5-1
Chapter 6 References	6-1

FIGURES

4-1	Distribution of 1989-1990 Total and Dissolved PCB Concentrations Measured in the Lower Fox River Compared with the 0.12 ng/L Injury Threshold	4-3
4-2	Distribution of 1994-1995 Total and Dissolved PCB Concentrations Measured in the Lower Fox River Compared with the 0.12 ng/L Injury Threshold	4-4
4-3	Distribution of 1998 Total and Dissolved PCB Concentrations Measured in the Lower Fox River Compared with the 0.12 ng/L Injury Threshold	4-5
4-4	Surface Water Sampling Locations in the GBMBS, 1989 to 1990	4-7

TABLES

3-1	PCB Criteria for Determining Injury to Surface Water	3-2
4-1	1989-1990 GBMBS Total PCBs in Surface Water	4-8
4-2	1989-1990 GBMBS Dissolved PCBs in Surface Water	4-9

ACRONYMS

AWQC	ambient water quality criteria
BBL	Blasland, Bouck & Lee
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act
DOC	U.S. Department of Commerce
DOI	U.S. Department of the Interior
GBMBS	Green Bay Mass Balance Study
GLWQG	Great Lakes Water Quality Guidance
LMMBS	Lake Michigan Mass Balance Study
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NRDA	natural resource damage assessment
NTR	National Toxics Rule
PCBs	polychlorinated biphenyls
TSCA	Toxic Substances and Control Act
USFWS	U.S. Fish and Wildlife Service

CHAPTER 1

INTRODUCTION

This document presents a determination and quantification of injuries to the surface water resources¹ that have resulted from releases of polychlorinated biphenyls (PCBs) from paper company facilities along the Lower Fox River, Wisconsin. This injury assessment is part of the natural resource damage assessment (NRDA) being performed for the Lower Fox River/Green Bay environment by the U.S. Department of the Interior (the Department or DOI) through the U.S. Fish and Wildlife Service (USFWS, or the Service), the National Oceanic and Atmospheric Administration (NOAA), the Oneida Tribe of Indians of Wisconsin, and the Menominee Indian Tribe of Wisconsin (collectively, the Trustees).

The Trustees have issued several NRDA reports that address injuries to natural resources of the Lower Fox River/Green Bay ecosystem and the damages that result from the injuries. These reports provide documentation of:

- ▶ PCB releases and transport pathways from Lower Fox River paper companies to the entire Lower Fox River/Green Bay environment (Stratus Consulting Inc., 1999a)
- ▶ injuries to avian resources in the Lower Fox River/Green Bay environment that result from the PCB releases and transport (Stratus Consulting Inc., 1999b)
- ▶ injuries to fishery resources in the Lower Fox River/Green Bay environment that result from the PCB releases and transport (Stratus Consulting Inc., 1999c)
- ▶ compensable values of recreational fishing service flow losses to the public (referred to as recreational fishing damages) that result from the PCB releases and transport (Stratus Consulting Inc., 1999d).

These reports will be used by the Trustees to assist in the determination of the amount and type of restoration required to compensate the public for injuries to natural resources. This process was

1. The Department's regulations define the surface water resource as including both surface water and sediments suspended in water or lying on the bank, bed, or shoreline [43 CFR §11.14(pp)]. Therefore, in this report, the term "surface water resource" is used to refer to both surface water and bed, bank, or shoreline sediments.

described in the initial Restoration and Compensation Determination Plan, published September 21, 1998 [63 FR 50,254].²

This report is organized as follows:

Chapter 2 describes the surface water/sediment resources and the basis for the trusteeship authority over the resources.

Chapter 3 describes the injury assessment approach, including injury definitions and criteria used to determine injuries. The pathway determination for surface water/sediment resources presented in Stratus Consulting Inc. (1999a) is also summarized.

Chapter 4 presents a comparison of measured surface water PCB concentrations to national and state water quality criteria and standards that serve as injury thresholds, and demonstrates that PCB concentrations throughout the Lower Fox River and Green Bay have exceeded and continue to exceed injury thresholds by orders of magnitude.

Chapter 5 presents the injury determination and quantification, and concludes that the surface water resource of the Lower Fox River/Green Bay environment has been and continues to be injured by releases of PCBs from Lower Fox River paper company facilities. This injury stems from the impairment of the surface water resource to provide habitat services to the biological resources of the river and bay.

2. In accordance with the July 1997 Memorandum of Agreement among the governmental parties, the federal and tribal trustees are working closely with EPA and the Wisconsin Department of Natural Resources to ensure that the remedial action selected by EPA at the conclusion of the ongoing remedy selection process is as protective of human health and the environment as possible. As a result, the Trustees expect that the remedial action will contain or remove, to the maximum extent practicable taking into account the applicable remedial decision criteria, the PCBs present in the sediments and surface water within the assessment area. Therefore, the Trustees do not expect to propose, or seek to estimate the amount of money required to perform, any restoration actions whose purpose would be to contain or remove the PCBs from the sediments or surface water. Rather, the Trustees expect to propose restoration actions that are distinct from the remedy selected by EPA at the conclusion of the remedial process.

CHAPTER 2

RESOURCE DESCRIPTION AND TRUSTEE AUTHORITY

2.1 SURFACE WATER RESOURCE DESCRIPTION

The surface water resource considered in this injury assessment includes the Lower Fox River (from Lake Winnebago to the river mouth at Green Bay) and Green Bay. The findings of the pathway determination report (Stratus Consulting Inc., 1999a), which are summarized in Chapter 3, demonstrate that surface water resources throughout the Lower Fox River and Green Bay are exposed to PCBs released from Fox River paper company facilities.

One of the key services provided by the surface water resource of the Lower Fox River/Green Bay environment is habitat for biological resources, including plants, invertebrates, and fish. The waters and sediment of the Lower Fox River and Green Bay support a diverse ecosystem that includes nationally significant recreational fisheries (Stratus Consulting Inc., 1999c). The health of the surface water resource and the quality of the ecological habitat services provided by the resource are vital to the plants, invertebrates, and fish of the system. As a result, human uses of these biological resources, such as recreational fishing or tribal cultural values, and other biological resources such as birds and mammals that depend on fish and invertebrates for food, are also closely linked to the quality of the surface water resource of the Lower Fox River and Green Bay.

2.2 TRUSTEESHIP AUTHORITY

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Federal Water Pollution Control Act (Clean Water Act) authorize the President to recover, on behalf of the public, damages for injuries to natural resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States [42 U.S.C. §§ 9607(f)(1), 9601(16); 33 U.S.C. § 1321(f)(5)]. The President has designated federal natural resource trustees in the National Oil and Hazardous Substances Pollution Contingency Plan (“NCP”) [40 C.F.R. § 300.600]. The NCP interprets the scope of federal natural resource trusteeship to extend to resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled (referred to as “managed or controlled”) by the United States, including “supporting ecosystems” resources [40 C.F.R. § 300.600].

The Secretary of the Interior acts as trustee for natural resources managed or controlled by the Department, including their supporting ecosystems [40 C.F.R. § 300.600(b), (b)(2), and (b)(3)].

Pursuant to the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661 *et seq.*, and the Fish and Wildlife Act, 16 U.S.C. §§ 742a *et seq.*, the United States, in part through DOI, manages and/or controls all surface waters and wetlands regulated under the Federal Water Pollution Control Act, often referred to as the Clean Water Act, or (CWA), including the sediments and banks of such waters and the fish and other aquatic organisms in them. The surface waters and sediments of the Lower Fox River, Green Bay, and Lake Michigan are within the administrative jurisdiction of the United States, and are regulated under the CWA. In addition, pursuant to the Great Lakes Fish and Wildlife Restoration Act, 16 U.S.C. § 941 (Restoration Act), DOI manages and/or controls fish and wildlife resources throughout the Great Lakes and the streams, rivers, lakes, and other bodies of water within the drainage basin of the Great Lakes (Great Lakes System). The water and sediments of the Lower Fox River, Green Bay, and Lake Michigan fall within the Great Lakes System.

The Secretary of Commerce acts as trustee for natural resources managed or controlled by the U.S. Department of Commerce (DOC), including their supporting ecosystems [40 C.F.R. § 300.600(b), (b)(1)]. Pursuant to the Great Lakes Critical Programs Act of 1990, 33 U.S.C. § 1268 (Great Lakes Act), and the Great Lakes Water Quality Agreement of 1978, as amended by the Water Quality Agreement of 1987 (Great Lakes Water Quality Agreement), the United States, in part through DOC, manages or controls the water and sediments of the Great Lakes System. The water and sediments of the Lower Fox River, Green Bay, and Lake Michigan fall within the Great Lakes System.

The Secretary of Commerce also acts as trustee for natural resources managed or controlled by other federal agencies and that are found in, under, or using waters navigable by deep draft vessels, tidally influenced waters, or waters of the contiguous zone, the exclusive economic zone, and the outer continental shelf. Lake Michigan, Green Bay, and a portion of the Lower Fox River below DePere Dam are all waters navigable by deep draft vessels. Therefore, all federally managed or controlled resources that are found in those waters, such as water and sediments that form navigation channels and that are managed, controlled, and maintained by the Army Corps of Engineers, fall within DOC trusteeship. Similarly, the water and sediment of the Great Lakes System are within the administrative jurisdiction of the United States, and are federally managed or controlled pursuant to the Great Lakes Act and the Great Lakes Water Quality Agreement. Therefore, DOC acts as trustee for the water and sediment in the Great Lakes System, including the water and sediment of Lake Michigan, Green Bay, and the Lower Fox River.

The NCP also cites, as examples of DOI and/or DOC trusteeship, the following natural resources and their supporting ecosystems: migratory birds, anadromous fish, and endangered species and marine mammals [40 C.F.R. §§ 300.600(b)(1), (b)(2)]. Numerous migratory birds, anadromous fish, and endangered species, as well as a number of federally stocked fishery resources, have been injured as a result of the release of PCBs into the Lower Fox River, Green Bay, and Lake Michigan (Stratus Consulting Inc., 1999b; Stratus Consulting Inc., 1999c). The supporting ecosystem for these resources includes the water and sediments in the Lower Fox River, Green

Bay, and Lake Michigan. Therefore, DOI and DOC trusteeship includes the water and sediments in the Lower Fox River, Green Bay, and Lake Michigan.

The Secretary of Interior has delegated his authority to act as trustee for fish and wildlife resources and their supporting ecosystem to the Director of the Service [207 DM 6.3(B)]. Similarly, the Secretary of Commerce has delegated his authority to act as trustee to the Administrator of NOAA [DOO 15-10, at § 3.01(mm)]. Pursuant to these delegations, the Service and NOAA have trusteeship for the water and sediment, in addition to the biological resources, that have been injured as a result of the release of PCBs into the Lower Fox River, Green Bay, and Lake Michigan.

CHAPTER 3

INJURY ASSESSMENT APPROACH AND PATHWAY DETERMINATION

The assessment of injuries to surface water resources of the Lower Fox River and Green Bay was conducted consistent with the Department's regulations for conducting NRDA at 43 CFR Part 11. The injury definitions used to determine injuries are presented in Section 3.1, as well as a description of the injury measures used. Section 3.2 provides a pathway determination for surface water resources, which is considered part of the injury determination [43 CFR § 11.61(c)(3)].

3.1 INJURY DEFINITIONS

Injuries to surface water resources are determined using the following injury definitions:

- ▶ Concentrations and duration of hazardous substances in excess of applicable water quality criteria established by Section 304(a)(1) of the Clean Water Act (CWA), or by other federal or state laws or regulations that establish such criteria, in surface water that before the . . . release met the criteria and is a committed use as habitat for aquatic life, water supply, or recreation. The most stringent criterion shall apply when surface water is used for more than one of these purposes [43 CFR § 11.62(b)(1)(iii)].
- ▶ Concentrations and duration of substances sufficient to have caused injury to biological resources when exposed to surface water, suspended sediments, or bed, bank, or shoreline sediments [43 CFR § 11.62(b)(1)(v)].
- ▶ Concentrations of hazardous substances sufficient to cause the sediments to exhibit characteristics identified under or listed pursuant to the Solid Waste Disposal Act [43 CFR § 11.62(b)(iv)].

The first two injury definitions relate to the service of the surface water resource of providing habitat to biological resources. The first injury definition relies on exceedences of relevant water quality criteria that are designed to protect the biological resources that depend on the surface water resource for habitat. The second definition uses actual injuries to the biological resources exposed to the released hazardous substance via the surface water resource for defining injury to the surface water resource. Thus the second definition also is based on the habitat services provided by the surface water resource.

Table 3-1 lists specific regulatory criteria and concentration thresholds that relate to habitat services provided by surface water and that may be used to evaluate injury to surface waters as

**Table 3-1
PCB Criteria (in ng/L)
for Determining Injury to Surface Water**

Source	Protection Endpoint	
	Aquatic Life (chronic)	Piscivorous Wildlife
U.S. EPA CWA § 304 (45 FR 79339)	14	
National Toxics Rule (57 FR 60915)	14	
Michigan Water Quality Standard [Rule 57(2)]	400	
Wisconsin Water Quality Criteria [W.A.C. NR 105.07(1)(b)]		0.12
GLWQG (40 CFR Part 132)		0.12

defined in 43 CFR § 11.62 (b)(1)(iii). Established criteria include PCB concentrations intended to protect aquatic life and wildlife. Pursuant to Section 304 of the CWA, the U.S. EPA has established ambient water quality criteria (AWQC) for the protection of aquatic life. For PCBs, the AWQC is 14 ng/L for chronic exposure. The National Toxics Rule (NTR), which was promulgated by the U.S. EPA pursuant to the CWA, established numeric criteria for 92 priority pollutants, including PCBs [57 FR 60848 *et seq.*]. The NTR adopted the U.S. EPA chronic AWQC for PCBs of 14 ng/L. The State of Michigan chronic water quality standard for the protection of aquatic life is 400 ng/L [Rule 57(2)]. The most restrictive criterion for PCBs is the value of 0.12 ng/L from both the Great Lakes Water Quality Guidance (GLWQG) promulgated by the U.S. EPA [40 CFR Part 132] and the surface water quality for PCBs promulgated by the State of Wisconsin [W.A.C. NR 105.07(1)(b)]. This value was established for the protection of piscivorous wildlife.

No state or federal criteria exist for PCBs in sediment. Modeling methods are available for estimating the sediment concentrations of PCBs that result in injuries to biological resources (Wisconsin Department of Natural Resources, 1993), and these estimated sediment concentrations could be used as injury thresholds for bed sediments. However, the Trustees instead are relying on comparison of surface water concentrations to surface water criteria and the presence of documented injuries to aquatic resources exposed to the surface water resource to determine injuries to the surface water resource.

In addition, bed sediments in the Lower Fox River/Green Bay system are a primary source of PCB contamination in surface water, and the PCB exposure of surface water and biological resources in the system originates with PCBs in the sediment (Stratus Consulting Inc., 1999a).

Therefore, although exceedences of injury thresholds are not being expressly evaluated for bed sediments, the PCB pathway link from bed sediments to surface water and biological resources means that if these resources are injured, bed sediments are injured [43 CFR § 11.62(b)(1)(v)].

The third definition of injury to surface water resources, substance concentrations sufficient to cause the sediments to exhibit characteristics identified under or listed pursuant to the Solid Waste Disposal Act, applies to sediments that exceed the Toxic Substances and Control Act (TSCA) threshold for waste disposal of 50 mg/kg PCBs [40 CFR § 761.60(a)(5)]. However, at this time the Trustees are not determining and quantifying injuries to bed sediment under this definition for the following reasons:

- ▶ The Trustees' determination of injury to the surface water resource of the Lower Fox River/Green Bay environment is focused on the ecological habitat services provided by the surface water resource. This TSCA related injury definition is not directly applicable to the habitat service of the surface water resource.
- ▶ This injury definition relates primarily to disposal requirements of sediments contaminated with PCB. The Trustees anticipate that sediment remediation and removal will be addressed by the ongoing remedial investigation/feasibility study for the site being conducted by the State of Wisconsin and the U.S. EPA.

Therefore, injuries to the surface water resource of the Lower Fox River/Green Bay environment are determined using the first two injury definitions given above: exceedences of applicable state or federal water criteria or standards [43 CFR § 11.62(b)(1)(iii)] or injury to biological resources exposed to PCBs in the surface water resource [43 CFR § 11.62(b)(1)(v)]. Injuries according to the first definition are determined by comparing measured concentrations of PCBs in Lower Fox River and Green Bay surface water to the most stringent applicable state or federal water quality criteria, which is the value of 0.12 ng/L for the U.S. EPA's GLWQG and the State of Wisconsin's surface water quality standard for PCBs [W.A.C. NR 105.07(1)(b)]. Injuries according to the second definition (causing injury to biological resources) are assessed by referring to the fish injury determination conducted by the Trustees (Stratus Consulting Inc., 1999c).

3.2 SUMMARY OF PATHWAY DETERMINATION

In a Trustee report previously released to the public, Stratus Consulting Inc. (1999a) presented a PCB pathway determination for surface water resources of the Lower Fox River and Green Bay. The report, which was prepared as part of the Lower Fox River/Green Bay NRDA, documents and describes how surface water is the primary transport pathway for PCBs in the system. This section provides a summary of that pathway determination for surface water resources. Pathway determination is a component of the injury assessment process in that it establishes the relationship between the injured resource and the hazardous substances released [43 CFR

§11.61(c)(3)]. Specifically, the Stratus Consulting Inc. (1999a) report demonstrated the following:

1. *Paper manufacturing and processing facilities released large quantities of PCBs into the Lower Fox River.*

R A review of historical facility records, industrial processes and waste disposal practices, and PCB concentrations in paper products and waste documents that paper company facilities along the Lower Fox River released approximately 300,000 kg of PCBs into the Lower Fox River.

2. *The Fox River is the dominant source of PCBs to Green Bay.*

R The Green Bay Mass Balance Study (GBMBS), which is a multiyear, multimillion dollar effort conducted by several government agencies to model PCB fate and transport in the Lower Fox River/Green Bay system, estimates that in 1989, the Fox River was the source of 92% of the PCBs that entered Green Bay from all tributary or atmospheric sources.

R The spatial pattern of PCBs in Green Bay sediment, surface water, and fish is consistent with the Fox River being the primary source of PCBs to Green Bay.

R Detailed analysis of sediment congener patterns shows that PCBs in the inner and outer bays of Green Bay have congener patterns more similar to Fox River patterns than to northern Lake Michigan patterns. Changes observed in the congener patterns throughout the bay are consistent with environmental weathering of the Aroclor 1242 released from Fox River paper company facilities.

3. *Surface water is the primary pathway by which PCBs are transported in the Lower Fox River/Green Bay system.*

R Measurements of PCBs in surface water (as both dissolved and suspended phases) document the movement of PCBs in the surface water column.

R The GBMBS models demonstrate that advective transport in surface water (i.e., movement with water currents) is the primary PCB transport pathway in the system.

4. *Fox River PCBs are transported throughout Green Bay.*

R Water circulates from the inner bay to the outer bay, carrying suspended sediment and PCBs with it.

- R Outer bay sediment, water, and fish are contaminated with PCBs.
- R The PCB congener patterns in inner and outer bay sediments are consistent with the Fox River being the source of outer bay PCBs.

5. *Fish and birds in Green Bay are exposed to PCBs in surface water and sediment via the food chain pathway.*

- R A PCB bioaccumulation model, developed as part of the GBMBS, models food chain PCB uptake for several fish species, including gizzard shad, alewife, rainbow smelt, brown trout, and walleye. For all species, both surface water and dietary items are PCB exposure routes. Most of the accumulated PCBs come from the diet, particularly for walleye and brown trout.

6. *PCB concentrations in Green Bay have declined since the 1970s, but remain high because of the environmental persistence and continued environmental release of PCBs.*

- R PCB concentrations in Green Bay sediment increased in the 1960s and 1970s, coinciding with Fox River paper company PCB releases.
- R PCB concentrations in Green Bay fish have declined since the 1970s, coinciding with reductions in direct PCB releases to the Fox River.
- R PCB concentrations in Green Bay fish have declined much more slowly than the decline in direct PCB releases from paper companies into the Fox River, demonstrating that PCBs are persistent in the environment and continue to be re-released and transported within the system.

7. *PCBs are transported from Green Bay into Lake Michigan.*

- R A large exchange of water takes place between Green Bay and Lake Michigan, providing a PCB transport mechanism.
 - R PCBs in water have been measured at higher concentrations in outer Green Bay than in northern Lake Michigan, indicating a concentration gradient from the bay to the lake.
 - R The GBMBS models estimate a net movement of approximately 122 kg of PCBs from the bay to the lake via surface water advection in 1989. Additionally, the models estimate a net exchange of 158 kg from the water column to the air in
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1989, and the prevailing southwesterly winds would tend to carry these volatilized PCBs toward Lake Michigan.

- R Congener patterns are consistent with the transport and weathering of PCBs from Green Bay to Lake Michigan.
- R A simple mass balance approach indicates that the ultimate fate of much of the PCBs released from Fox River paper company facilities is transported out of the Fox River/Green Bay system to Lake Michigan.

The pathway determination analysis concludes that the surface water/sediment pathway transports PCBs released from Fox River paper company facilities to exposed natural resources in the Lower Fox River/Green Bay environment. The report demonstrates that surface water and sediment in the Lower Fox River downstream of the paper company facilities and in Green Bay have been exposed to PCBs at concentrations sufficient to cause injury to biological resources. Therefore, the analysis conclusions in the pathway report which was prepared consistent with 43 CFR Part II can be used to establish that the water and sediment have been injured, pursuant to the injury definition at 43 CFR § 11.62(b)(1)(v).

CHAPTER 4

COMPARISON OF SURFACE WATER PCB CONCENTRATIONS WITH INJURY THRESHOLDS

This chapter presents a comparison of PCB concentrations measured in surface water of the Lower Fox River and Green Bay with injury thresholds and demonstrates that PCB concentrations throughout the river and bay exceed the thresholds.

4.1 SURFACE WATER DATA SOURCES

Three sources of PCB concentration data in surface water were used for the comparison to injury thresholds:

1. Data collected from the Lower Fox River and Green Bay in 1989-1990 as part of the GBMBS. The GBMBS included collection and analysis of hundreds of water samples for PCBs from throughout the Lower Fox River and Green Bay during different times of the year. This dataset is the most spatially comprehensive dataset available on PCBs in surface water in the area. The dataset we used was downloaded from the Wisconsin Department of Natural Resource's Fox River database website (<http://www.ecochem.net/FoxRiverDatabaseWeb/default.asp>). The Green Bay data used were downloaded in July 1999, and the Lower Fox River data were downloaded in October 1999.
 2. Data collected from the mouth of the Lower Fox River in 1994-1995 as part of the Lake Michigan Mass Balance Study (LMMBS). The LMMBS is a multiyear, multiagency mass balance study of PCBs in Lake Michigan (U.S. EPA, 1996). As part of the study, approximately 42 surface water samples were collected at different times from the mouth of the Lower Fox River throughout 1994-1995 to monitor PCB concentrations and loadings into the bay. The dataset we used was downloaded from the Wisconsin Department of Natural Resource's Fox River database website (<http://www.ecochem.net/FoxRiverDatabaseWeb/default.asp>) in October 1999.
 3. Data collected from multiple locations in the Lower Fox River in 1998 by Blasland, Bouck & Lee (BBL) for the Fox River Group of paper companies. Surface water samples were collected from six locations in the Lower Fox River at several different times in 1998. The database we used was provided to the Wisconsin Department of Natural Resources by the
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Fox River Group (R. Paulson, Wisconsin Department of Natural Resources, personal communication, 1999).

In both the GBMBS and LMMBS, PCBs were measured as individual congeners. We estimated total PCB concentration in each sample by summing the concentrations of individual congeners, using a value of 0 for any undetected congeners. In the BBL study, PCBs were measured as Aroclors, and Aroclor 1242 was the only Aroclor detected in any of the samples. Therefore, in samples where no PCBs were detected, we used the detection limit for Aroclor 1242 analysis in the sample as the PCB detection limit. In all three of these databases, PCBs were measured in dissolved (i.e., passing through a certain size filter) and particulate phases. We used both dissolved and total (dissolved + particulate) PCB concentrations for comparison to injury thresholds. Results for duplicate samples were averaged.

As described in Section 3.1, the injury threshold for comparison to the measured PCB concentrations is the value of 0.12 ng/L for the U.S. EPA's GLWQG and the State of Wisconsin's surface water quality standard for PCBs [W.A.C. NR 105.07(1)(b)].

4.2 LOWER FOX RIVER

Measured surface water PCB concentrations in the Lower Fox River are compared with the 0.12 ng/L injury threshold in Figure 4-1 (1989-1990 GBMBS data), Figure 4-2 (1994-1995 LMMBS data), and Figure 4-3 (1998 BBL data). The figures show the distribution of PCB concentrations measured at each location or sampling reach as the percentage of samples (on the x-axis) that exceed a given PCB concentration (on the y-axis). The three figures show that dissolved and total PCB concentrations measured in every sample from every Lower Fox River location in all three studies exceed the 0.12 ng/L injury threshold. In fact, the lowest concentrations measured in the studies (shown as the value at the 100th percentile, which is the value at or exceeded by 100% of the samples) are consistently an order of magnitude higher than the injury threshold.

4.3 GREEN BAY

From May 1989 through April 1990, surface water samples were collected at 27 locations in the bay over seven sampling periods as part of the GBMBS (Figure 4-4) (DePinto et al., 1994). The sampling periods were May 1989, June 1989, July 1989, September 1989, October 1989, February 1990, and April 1990. The data, which are presented in Table 4-1 for total PCBs and Table 4-2 for dissolved PCBs, show that every measurement of total PCBs and nearly every measurement of dissolved PCBs in Green Bay exceeded the injury threshold of 0.12 ng/L. The highest PCB concentrations measured were close to the mouth of the Lower Fox River, and

Figure 4-1
Distribution of 1989-1990 Total and Dissolved PCB Concentrations Measured in the Lower Fox River Compared with the 0.12 ng/L Injury Threshold.

The x-axis (labeled percentile) is the percent of samples at or exceeding the given PCB concentration shown on the y-axis. GBMBS data downloaded from <http://www.ecochem.net/FoxRiverDatabaseWeb/default.asp> in October 1999.

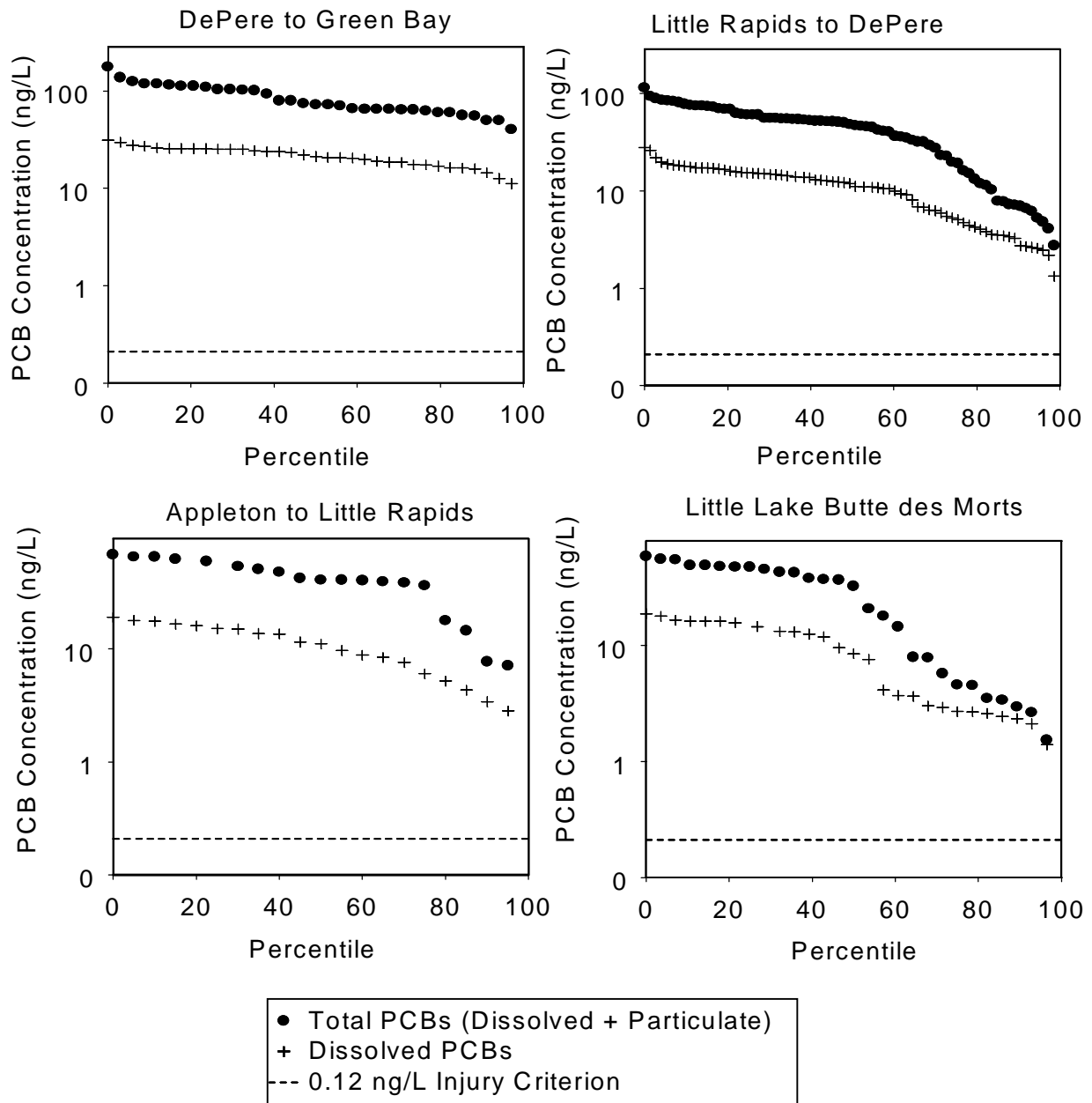


Figure 4-2
Distribution of 1994-1995 Total and Dissolved PCB Concentrations Measured in the Lower Fox River Compared with the 0.12 ng/L Injury Threshold.

The x-axis (labeled percentile) is the percent of samples at or exceeding the given PCB concentration shown on the y-axis. LMMBS data downloaded from <http://www.ecochem.net/FoxRiverDatabaseWeb/default.asp> in October 1999.

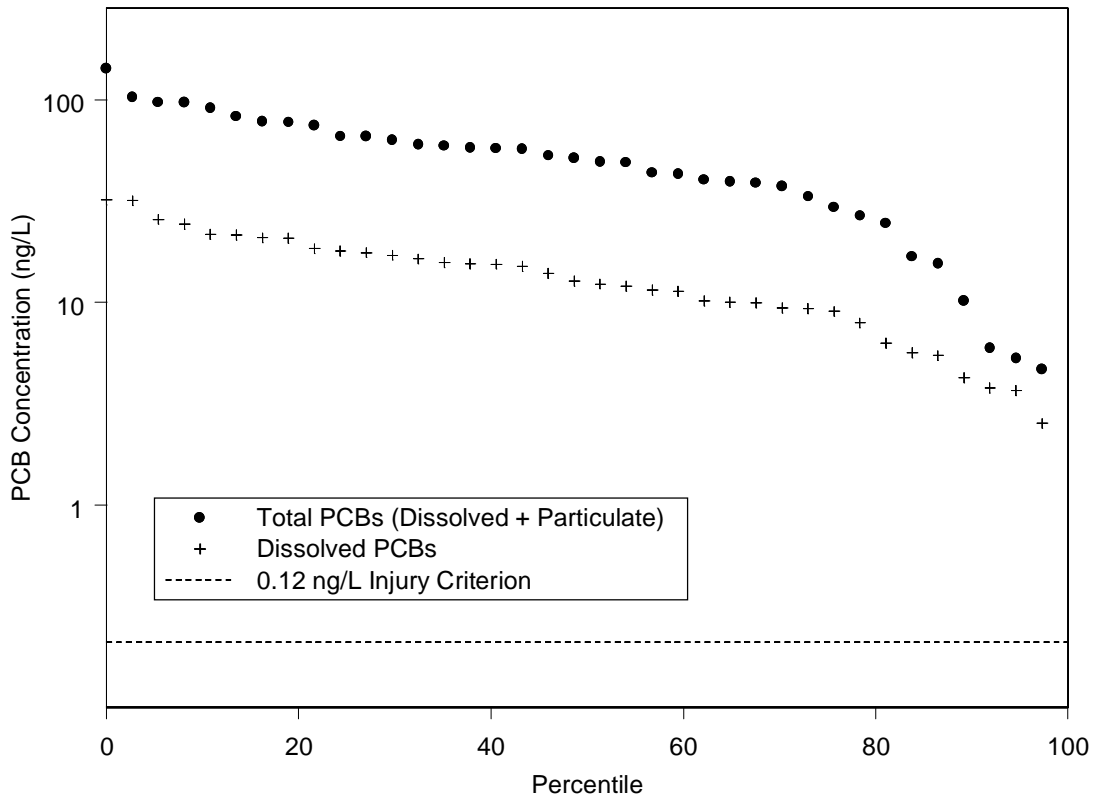
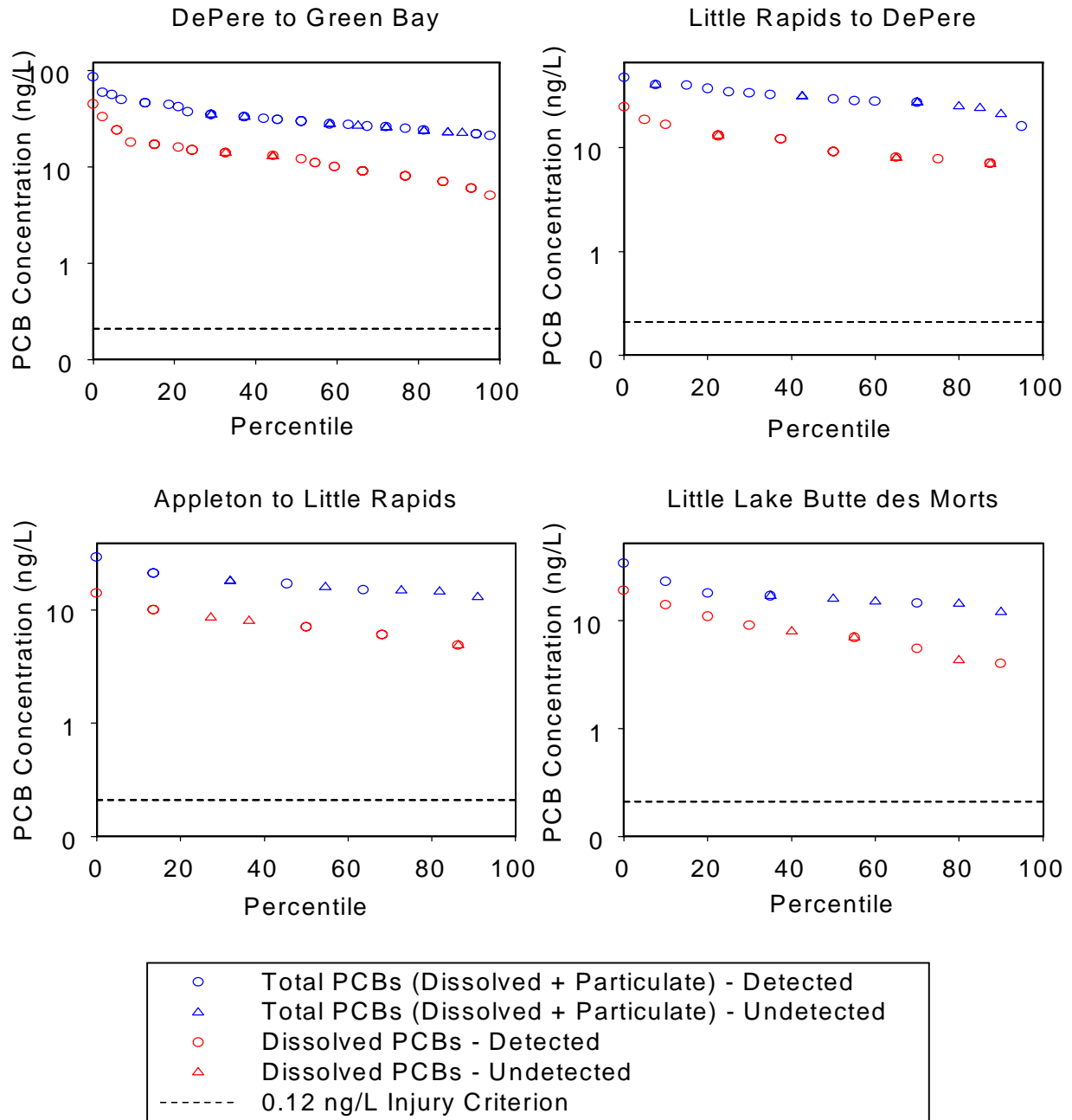


Figure 4-3

Distribution of 1998 Total and Dissolved PCB Concentrations Measured in the Lower Fox River Compared with the 0.12 ng/L Injury Threshold. The x-axis (labeled percentile) is the percent of samples at or exceeding the given PCB concentration shown on the y-axis. Undetected values are plotted at the detection limit. Fox River Group paper company data (R. Paulson, Wisconsin Department of Natural Resources, personal communication, 1999).



concentrations declined with increasing distance from the river mouth (Stratus Consulting Inc., 1999a). This decreasing gradient of PCBs away from the Fox River mouth is indicative of the Fox River being the dominant source of PCBs to Green Bay (Stratus Consulting Inc., 1999a).

4.4 CONCLUSIONS

Measured PCB concentrations in the surface water of the Lower Fox River and Green Bay consistently exceed the injury threshold of 0.12 ng/L, the U.S. EPA's GLWQG value and the State of Wisconsin's surface water quality standard [W.A.C. NR 105.07(1)(b)]. Concentrations in nearly every sample in both dissolved and total phases exceed the threshold, in many cases by several orders of magnitude.

Figure 4-4
Surface Water Sampling Locations in the GBMBS, 1989 to 1990

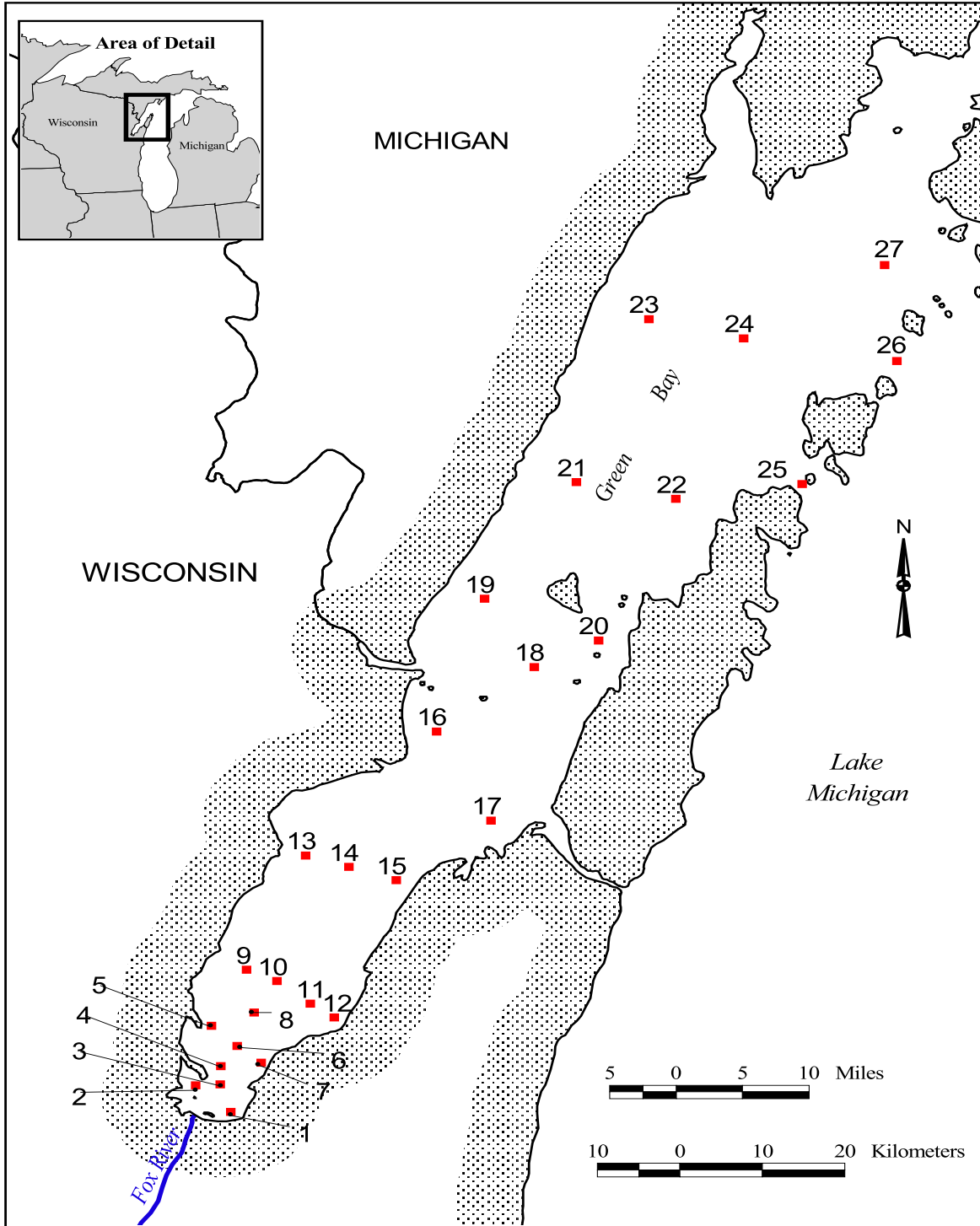


Table 4-1
1989-1990 GBMBS Total PCBs in Surface Water (ng/L)

Station ^a	May 1989	June 1989	July 1989	Sept. 1989	Oct. 1989	Feb. 1990	April 1990
1	-	26.0	24.9	40.4	47.8	8.7	103
2	11.7	31.5	28.5	23.2	31.5	10.6	102
3	43.3	27.0	15.1	24.7	44.2	7.45	9.38
4	9.31	21.5	6.84	11.0	10.4	9.09	5.75
5	5.74	8.98	5.84	11.8	6.20	3.51	4.37
6	4.67	10.2	14.2	13.9	9.79	7.92	6.92
7	30.3	19.6	23.1	9.67	24.0	13.5	18.2
8	8.56	4.63	12.0	7.99	20.7	5.01	7.04
9	3.39	3.94	4.57	6.39	5.58	4.18	3.68
10	4.30	4.89	11.2	4.67	15.2	4.97	2.79
11	6.87	7.22	8.80	6.37	12.5	5.79	4.72
12	17.7	13.0	13.1	10.4	7.32	6.39	7.17
13	6.22	2.97	2.96	3.10	3.93	3.09	3.65
14	3.57	2.08	3.34	1.57	9.25	3.21	2.59
15	5.42	7.28	1.96	1.60	9.16	3.51	5.95
16	2.82	1.16	1.31	1.24	2.19	2.24	1.80
17	6.40	5.94	1.46	1.08	3.65	3.93	4.30
18	3.35	1.31	1.34	1.06	3.66	1.73	1.43
19	1.77	0.91	1.11	0.98	2.80	1.67	1.52
20	-	1.08	1.19	0.80	1.90	1.58	0.61
21	-	0.92	0.50	0.74	2.06	-	0.75
22	2.32	0.99	0.46	0.88	1.48	1.35	0.96
23	2.77	0.72	0.64	0.61	1.08	-	0.87
24	1.40	0.83	0.80	0.81	1.04	-	0.85
25	1.25	0.76	0.69	0.98	1.40	-	0.67
26	3.11	1.16	0.65	0.71	1.10	-	0.70
27	1.95	0.98	0.82	0.64	1.36	-	0.74

a. See Figure 4-4 for station locations.

-: No measurement taken.

Source: GBMBS data from the Wisconsin Department of Natural Resources sponsored database at <http://www.ecochem.net/FoxRiverDatabaseWeb/default.asp>, downloaded July 1999.

Table 4-2
1989-1990 GBMBS Dissolved PCBs in Surface Water (ng/L)

Station ^a	May 1989	June 1989	July 1989	Sept. 1989	Oct. 1989	Feb. 1990	April 1990
1	-	7.37	10.26	6.93	5.51	5.31	9.86
2	8.59	7.99	6.20	6.55	7.16	3.94	2.22
3	2.31	4.25	3.04	3.00	1.84	4.17	1.25
4	1.27	1.69	2.32	2.85	1.31	2.24	1.00
5	1.52	2.43	4.94	3.74	2.14	4.56	1.31
6	5.76	4.03	7.09	3.13	3.80	6.02	3.47
7	1.89	1.65	4.02	2.67	3.74	2.77	1.44
8	1.36	1.26	1.75	2.31	1.20	2.25	0.81
9	1.77	1.94	4.22	1.85	3.09	3.18	0.72
10	2.40	2.57	3.92	2.16	3.01	3.87	0.91
11	4.26	3.47	5.55	2.69	2.35	4.36	1.16
12	2.24	1.19	1.38	1.31	1.39	1.96	0.81
13	1.70	1.05	1.47	1.14	2.75	2.37	0.74
14	2.05	2.17	1.17	0.91	2.15	2.22	1.33
15	1.46	0.65	0.79	0.81	1.07	1.50	0.66
16	2.38	1.75	1.46	0.66	1.18	2.22	1.08
17	1.67	0.77	0.80	0.70	1.29	1.31	0.52
18	0.77	0.56	0.76	0.58	1.14	1.17	0.50
19	0.00	0.59	0.78	0.55	0.71	0.97	0.61
20	-	0.55	0.50	0.52	0.83	0.00	0.35
21	-	0.57	0.21	0.62	0.89	-	0.56
22	0.70	0.45	0.39	0.43	0.65	0.00	0.41
23	0.83	0.54	0.51	0.53	0.67	-	0.52
24	0.81	0.49	0.43	0.72	0.88	-	0.38
25	0.73	0.82	0.41	0.57	0.73	-	0.45
26	0.95	0.80	0.48	0.48	0.62	-	0.42
27	0.00	0.00	0.00	0.00	0.00	-	0.00

a. See Figure 4-4 for station locations.

-: No measurement taken.

Source: GBMBS data from the Wisconsin Department of Natural Resources sponsored database at <http://www.ecochem.net/FoxRiverDatabaseWeb/default.asp>, downloaded July 1999.

CHAPTER 5

INJURY DETERMINATION AND CONCLUSIONS

Injuries to surface water resources are determined using the following injury definitions:

- ▶ Concentrations and duration of hazardous substances in excess of applicable water quality criteria established by Section 304(a)(1) of the CWA, or by other federal or state laws or regulations that establish such criteria, in surface water that before the . . . release met the criteria and is a committed use as habitat for aquatic life, water supply, or recreation. The most stringent criterion shall apply when surface water is used for more than one of these purposes [43 CFR § 11.62(b)(1)(iii)].
- ▶ Concentrations and duration of substances sufficient to have caused injury to biological resources when exposed to surface water, suspended sediments, or bed, bank, or shoreline sediments [43 CFR § 11.62(b)(1)(v)].

Both of these injury definitions relate to the service of the surface water resource providing supporting habitat to biological resources. The first injury definition relies on exceedences of relevant water quality criteria that are designed to protect the biological resources that depend on the surface water resource for habitat. The second definition uses actual injuries to the biological resources exposed to the released hazardous substance via the surface water resource for defining injury to the surface water resource.

Surface Water Criteria Exceedences

Chapter 4 demonstrates that PCB concentrations in surface water throughout the Lower Fox River and Green Bay exceed the injury threshold of 0.12 ng/L, the GLWQG value promulgated by the U.S. EPA [40 CFR Part 132] and the State of Wisconsin surface water quality for PCBs [W.A.C. NR 105.07(1)(b)] for the protection of piscivorous wildlife. Exceedences occur in every sample collected in the Lower Fox River and Green Bay included in the injury assessment. In addition to exceedences of the relevant criteria, the definition of this injury includes the following two components [43 CFR § 11.62(b)(1)(iii)]:

- ▶ The surface water resource is a committed use as a habitat for aquatic life, water supply, or recreation.
 - ▶ The surface water resource met the injury criteria prior to the hazardous substance release being assessed.
-

Both of these components of the injury definition are met in the Lower Fox River and Green Bay surface water resource. A “committed use” is defined in the Department’s regulations as “a current public use; or a planned public use of a natural resource . . .” [43 CFR §11.14(h)]. The presence of the recreational and commercial fishery (Stratus Consulting Inc., 1999d) and the cultural services provided by aquatic biota to the Oneida and Menominee tribes (Stratus Consulting Inc., 1999c) are clear examples of the public use of the Lower Fox River and Green Bay surface water resources as a habitat for aquatic life.

No surface water data are available prior to the PCB releases from Lower Fox River paper company facilities. PCB releases from the Lower Fox River paper company facilities resulted from their production or use of carbonless copy paper that contained PCBs (Wisconsin Department of Natural Resources, 1999). Experimentation with carbonless copy paper began in Lower Fox River paper company facilities in 1950, and commercial production began in 1954 (Wisconsin Department of Natural Resources, 1999). PCB loadings to the environment from all industrial and commercial sources at this time were much lower than those that occurred in the 1960s and 1970s (U.S. EPA, 1976). Furthermore, given that PCBs do not occur naturally in the environment (Erickson, 1997), it is highly likely that prior to the PCB releases from paper company facilities, PCB concentrations in surface water resources of the Lower Fox River and Green Bay did not exceed the injury criteria.

Therefore, the surface water resource of the Lower Fox River and Green Bay is injured because of PCB concentrations in excess of injury thresholds. The injury occurs throughout the river and bay.

Causing Injury to Biological Resources

Fish in the Lower Fox River and Green Bay are injured as a result of their exposure to PCBs in the surface water (Stratus Consulting Inc., 1999c). The injuries include the existence of fish consumption advisories for numerous fish species throughout the area because of PCBs, and fish tissue PCB concentrations in excess of the Food and Drug Administration’s tolerance level for PCBs (Stratus Consulting Inc., 1999c). In addition, walleye in the Lower Fox River downstream of DePere Dam and in Green Bay are injured because of increased incidences of liver tumors and pre-tumors compared with reference area fish.

Therefore, the surface water resource of the Lower Fox River and Green Bay is injured because concentrations are sufficient to cause injury to fish exposed to PCBs in the surface water. The injury occurs throughout the river and bay.

Conclusions

The surface water resource of the Lower Fox River and Green Bay is essential in providing habitat to aquatic biota, including fish. The humans and wildlife that use or depend on the fishery

resource thus also are dependent on the habitat services provided by surface water. The surface water resource of the Lower Fox River and Green Bay is injured as a result of PCB releases from Lower Fox River paper companies. As a result of the injury, the habitat services provided by the surface water resource are impaired.

CHAPTER 6

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