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Record of Decision
Operable Unit 1 and Operable Unit 2
Lower Fox River and Green Bay, Wisconsin

Record of Decision
Responsiveness Summary

December 2002

Record of Decision
Operable Unit 1 and Operable Unit 2

Lower Fox River and Green Bay Site
Wisconsin

December 2002

SUPERFUND RECORD OF DECISION (ROD)
for Operable Units I and 2
Wisconsin DNR and U.S. EPA

Lower Fox River
Brown, Outagamie, and Winnebago Counties, Wisconsin,
WID000195481
December 2002

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LIST OF ACRONYMS AND ABBREVIATIONS

API/NCR -	Appleton Papers Inc./NCR Corp.
ARAR -	applicable or relevant and appropriate requirement
AR -	administrative record
AOC -	Administrative Order on Consent or Area of Concern
BTAG -	Biological Technical Assistance Group
BLERA -	Baseline Ecological Risk Assessment
BLRA -	Baseline Human Health and Ecological Risk Assessment
CERCLA -	Comprehensive Environmental Response, Compensation, and Liability Act
cfs -	cubic feet per second
CWA -	Clean Water Act
cy -	cubic yard
CIP -	Community Involvement Plan
CWAC -	Clean Water Action Council
COC -	Chemical of Concern
CT -	central tendency
CTE -	central tendency exposure
CSF -	Cancer Slope Factor
CDI -	Chronic Daily Intake
COPC -	Chemical of Potential Concern
CDF -	Confined Disposal Facility
CAD -	Confined Aquatic Disposal
DDT -	dichlorodiphenyltrichloroethane
DDD -	dichlorodiphenyldichloroethane
DDE -	Dieldrin
DO -	dissolved oxygen
EPA -	Environmental Protection Agency
ESD -	Explanation of Significant Difference
ERA -	Ecological Risk Assessment
FS -	Feasibility Study
FRFOOD -	Fox River Food Chain Model
FRC -	Fox River Coalition
FRG -	Fox River Group
FRDB -	Fox River Data Base
GBRAP -	Green Bay Remedial Action Plan
GBMBS -	Green Bay Mass Balance Study
GFT	Glass Furnace Technology
GLNPO -	Great Lakes National Program Office
HHRA -	Human Health Risk Assessment
HI -	Hazard Index
HQ -	Hazard Quotient
HTTD -	High-temperature Thermal Desorption
IRIS -	Integrated Risk Information System
IC -	institutional control
ISC -	in situ capping
IGP -	Intergovernmental Partnership
kg -	kilogram
LLBdM -	Little Lake Butte des Morts
LMMBS -	Lake Michigan Mass Balance Study
LOAEL -	Lowest Observed Adverse Effects Level
LOAEC -	Lowest Observed Adverse Effects Concentration
MNR -	Monitored Natural Recovery
mg/kg -	milligrams per kilogram
mg/kg/day -	milligrams per kilogram per day
NPL -	National Priorities List
NCP -	National Contingency Plan
NAS -	National Academies of Science
NOAA -	National Oceanographic and Atmospheric Administration

NCR -	National Cash Register Corp.
NRDA -	Natural Resource Damages Assessment
ng/L -	nanograms per liter
NOAEL -	No Observed Adverse Effects Level
NOAEC -	No Observed Adverse Effects Concentration
NPDES -	National Pollutant Discharge Elimination System
NHPA -	National Historic Preservation Act
OU -	Operable Unit
OSWER -	Office of Solid Waste and Emergency Response
PCB -	Polychlorinated Biphenyl
ppm -	parts per million
PRP -	potentially responsible party
POTW -	publicly owned treatment works
ppb -	parts per billion
ppt -	parts per trillion
PAL -	preventive action limit
PEL -	probable exposure limit,
QA -	quality assurance
QA/QC -	quality assurance/quality control
RAL -	Remedial Action Level
RAP -	Remedial Action Plan
RI/FS -	Remedial Investigation/Feasibility Study
ROD -	Record of Decision
RI -	Remedial Investigation
RME -	Reasonable Maximum Exposure
RfD -	Reference Dose
RAO -	Remedial Action Objective
RCRA -	Resource Conservation and Recovery Act
SMU -	Sediment Management Unit
SERA -	Screening Ecological Risk Assessment
SMDP -	Scientific Management Decision Point
SLRA -	Screening Level Risk Assessment
SQT -	Sediment Quality Threshold
SWAC -	Surface Weighted Average Concentration
TAG -	Technical Assistance Grant
TEF -	toxic equivalency factor
TEL -	threshold exposure limit.
TRV -	toxicity reference values
TBC -	to be considered
TSCA -	Toxic Substances Control Act
TMDL -	Total Maximum Daily Load
USACE -	United States Army Corps of Engineers
USFWS -	United States Fish and Wildlife Service
USGS -	United States Geological Survey
UCL -	Upper Confidence Limit
WDNR -	Wisconsin Department of Natural Resources
WLA -	Waste Load Allocation
wLFRM -	whole Lower Fox River Model
WAC -	Wisconsin Administrative Code
WPDES -	Wisconsin Pollutant Discharge Elimination System
WDOT -	Wisconsin Department of Transportation

EXECUTIVE SUMMARY

Record of Decision (ROD) for Operable Units I and 2 Wisconsin DNR & U.S. EPA

The Lower Fox River and Green Bay Site includes an approximately 39-mile stretch of the Lower Fox River as well as the bay of Green Bay. The river portion of the Site extends from the outlet of Lake Winnebago and continues downstream to the mouth of the River at Green Bay, Wisconsin. The Bay portion of the Site includes all of Green Bay from the city of Green Bay to the point where Green Bay enters Lake Michigan. This Record of Decision (ROD) addresses some of the human health and ecological risks posed to people and ecological receptors associated with polychlorinated biphenyls (PCBs) that have been released to the Site. Presently these PCBs reside primarily in the sediments in the River and in the Bay, and this ROD outlines a remedial plan to address a certain portion of PCB contaminated sediments.

The Site has been divided into certain discrete areas (Operable Units or OUs) for ease of management and administration. The River has been divided into Operable Units 1 through 4 and Green Bay constitutes Operable Unit 5. These Operable Units are:

Operable Unit 1 – Little Lake Butte des Morts
Operable Unit 2 – Appleton to Little Rapids
Operable Unit 3 – Little Rapids to De Pere
Operable Unit 4 – De Pere to Green Bay
Operable Unit 5 – Green Bay

This ROD selects a remedial action for Operable Units 1 and 2, and it is anticipated that a second ROD addressing Operable Units 3 through 5 will be issued in the future.

For many years along the Lower Fox River there have been and continue to be located an intense concentration of paper mills. Some of these mills operated de-inking facilities in connection with the recycling of paper. Others manufactured carbonless copy paper. In both the de-inking operations and the manufacturing of carbonless copy paper, these mills handled polychlorinated biphenyls (PCBs), which were used in the emulsion that coated carbonless copy paper. In the de-inking process and in the manufacturing process, PCBs were released from the mills to the River directly or after passing through local water treatment works. PCBs have a tendency to adhere to sediment and they have contaminated the River sediments. In addition, the PCBs and contaminated sediments were carried down river and released into Green Bay.

Presently, it is estimated that Operable Unit 1 contains approximately 4100 pounds of PCBs in 2,200,400 cubic yards of sediment. This ROD provides for the removal by hydraulic dredging 784,000 cubic yards of contaminated sediments from Operable Unit 1. The dredged material will be mechanically “dewatered” and taken to a landfill for permanent disposal. This ROD establishes an “action level” of 1 part per million (ppm) for this cleanup effort. In other words, any sediment found in Operable Unit 1 which has a concentration of PCBs of 1 ppm or greater will be targeted for removal. The goal of the remedial action in Operable Unit 1 is to reach a surface weighted average concentration (SWAC) of less than 0.25 ppm after dredging is completed. This means that the concentration of PCBs averaged over the Operable Unit will not exceed 0.25 ppm when the cleanup is complete. By removing the contaminated sediment, it is presently estimated that Operable Unit 1 will reach a surface weighted average concentration of 0.19 parts per million, well below the goal. By reducing the concentration of PCBs in

Operable Unit 1 to the SWAC level or below will dramatically reduce the human health and ecological risk.

Operable Unit 2, which is about 20 miles in length, contains approximately 240 pounds of PCBs in 339,200 cubic yards (cy) of sediment. A significant portion of the PCBs contained in this Operable Unit has already been removed through the sediment removal demonstration project at Deposit N. The result is that in Operable Unit 2 there remain no significant (i.e., greater than 10,000 cubic yards) contaminated sediment deposits with concentrations of PCBs above the action level. Moreover, it is contemplated that the farthest downstream deposit in Operable Unit 2 (Deposit DD) may be remediated in connection with the remedial action to be undertaken in Operable Unit 3 at a later time. Without active remediation, the SWAC for Operable Unit 2 is only 0.61ppm. Therefore for Operable Unit 2 the ROD selects a remedy of monitored natural recovery (MNR). This remedy does not involve sediment removal. Rather, it consists of a comprehensive monitoring program designed in part to monitor the levels of PCBs in various environmental compartments as the natural recovery processes work. Coupling this MNR with the substantial upstream dredging remedy in Operable Unit 1 should result in reduced human health or ecological risk in Operable Unit 2.

The estimated cost for the remedial action in Operable Unit 1 is $66.2 million and for Operable Unit 2 it is $9.9 million.

Declaration for the Record of Decision (ROD) for Operable Units I and 2 Wisconsin DNR & U.S. EPA

Lower Fox River
Brown, Outagamie, and Winnebago Counties, Wisconsin
WID000195481
December 2002

Part 1: Declaration for the Record of Decision

The Lower Fox River and Green Bay Site ("the Site" or "the Fox River Site") includes an approximately 39 mile section of the Lower Fox River, from Lake Winnebago down river to the mouth of the Fox River and all of Green Bay (approximately 2700 square miles in area). This stretch of the Fox River and Green Bay flows through or borders Brown, Door, Kewaunee, Marinette, Oconto, Outagamie, and Winnebago Counties, in Wisconsin, and, Delta and Menominee Counties in Michigan. The River portion of the Site has been divided into "Operable Units" (OUs) OU 1 through OU 4, and the Green Bay portion of the Site is designated OU 5 for purposes of Site management. The OUs were selected based, at least in part, on stretches of the River that have similar characteristics. They are OU 1 from the Lake Winnebago outlet to Appleton dam; OU 2 from the Appleton dam to Little Rapids dam; OU 3 from Little Rapids dam to the De Pere dam; OU 4 from the De Pere dam to the mouth of the River at Green Bay; and OU 5 Green Bay.

This Record of Decision ("this ROD") addresses the risks to people and ecological receptors associated with polychlorinated biphenyls (PCBs) in OUs 1 and 2; Little Lake Butte des Morts and Appleton to Little Rapids, respectively. PCBs are the primary risk driver, contained in sediment deposits located in the River and the Bay. The implementation of the remedy selected in this ROD will result in reduced risks to humans and ecological receptors living in and near the Site.

With the exception of continuing releases of PCBs from contaminated sediments, it is believed that the original PCB sources are now essentially controlled. PCBs in the River were from historical discharges, primarily related to carbonless copy paper manufacturing and recycling.

STATEMENT OF BASIS AND PURPOSE

In June 1997, the United States Environmental Protection Agency (EPA) announced its intent to list the Fox River and portions of Green Bay on the National Priorities List (NPL), a list of the nation's hazardous waste sites eligible for investigation and cleanup under the federal Superfund program, and formally proposed listing of the Site to the NPL in a *Federal Register* publication on July 28, 1998. By agreement with EPA, the Wisconsin Department of Natural Resources (WDNR) is the "lead agency" with respect to the Site. This decision document was developed by WDNR for OUs 1 and 2 of the Fox River Site, pursuant to WDNR's authority under Ch. 292, Wisconsin Statutes. EPA has concurred and has adopted this ROD for the Fox River Site, as provided for in 40 CFR § 300.515(e).

This ROD was written in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), in a manner not inconsistent with the requirement of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part

300. This decision is based on information contained in the Administrative Record for this Site. This ROD is consistent with the findings of the National Academy of Sciences' (NAS) National Research Council report entitled *A Risk Management Strategy for PCB-Contaminated Sediments* and EPA policy.

ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health, welfare, or the environment from an imminent and substantial endangerment from actual or threatened releases of hazardous substances into the environment.

DESCRIPTION OF THE SELECTED REMEDY

The objectives of the response actions for this Site are to protect public health, welfare and the environment and to comply with applicable federal and state laws. The selected remedy specifies response actions that will address PCB contaminated sediment in the Site's OUs 1 and 2. The WDNR and EPA (Agencies) believe the remedial actions outlined in this ROD, if properly implemented, will result in the cleanup of contaminated sediments in OUs 1 and 2 and will protect human health and the environment. Among the goals for the selected remedy are the removal of fish consumption advisories and the protection of the fish and wildlife that use the Fox River and Green Bay, and to reduce the transport of PCBs from the Fox River to Green Bay.

The major components of the selected remedy include:

- Removal of a total of approximately 784,000 cubic yards (cy) of contaminated sediment containing over 1715 kilograms (kg) or 3770 pounds of PCBs from OU 1 using environmental dredging techniques that minimize adverse environmental impacts. The selected remedy calls for de-watering and stabilizing the dredged sediment and disposing of it off site at existing licensed facilities and/or new facilities yet to be constructed and licensed in the Fox River Valley. In conducting the design of this remedy, WDNR and EPA may utilize vitrification of dredged contaminated sediment, as an alternative to off-site disposal at a licensed facility, if this is determined to be practicable and cost effective.
- The use of natural recovery processes and monitoring for OU 2, with the possible exception of deposit DD. A final decision on deposit DD will be made when the ROD for OU 3 is issued.
- Monitored Natural Recovery (MNR) of the residual PCB contamination remaining in dredged areas and undisturbed areas until the concentrations of PCBs in fish tissue are reduced to an acceptable level. Fish consumption advisories and fishing restrictions will remain in place until acceptable PCB levels are achieved.
- A long term monitoring program (water, sediment and tissue) throughout the OU 1 and 2 to determine the effectiveness of the remedy.

STATUTORY DETERMINATIONS

The selected remedy meets the requirements for remedial actions set forth in Section 121 of CERCLA, 42 USC § 9621. It is protective of human health and the environment, complies with federal and state applicable or relevant and appropriate requirements, and is cost effective. The selected remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. It does not completely satisfy the statutory preference for treatment as a principal element of the remedy, because PCB-contaminated sediment may not be treated prior to disposal.

With respect to the portions of the Fox River addressed in this Record of Decision, some PCB concentrations create a risk in the range of 10^{-3} or more, thus "qualifying" those sediments to be a principal threat waste. The preference for treatment applies to these particular sediments. However, it would be wholly impracticable to closely identify, isolate and treat these principal threat wastes differently than the other PCB sediments identified for removal and disposal. Typical dredging technology that may be employed may not be capable of distinguishing among such fine gradations of PCB concentrations. Nevertheless, at the conclusion of the OU 1 remedy the principal threat wastes will have been removed from OU 1 and deposited in a landfill. In so doing, the mobility of the principal threat wastes will have been greatly reduced.

Because the selected remedy will result in hazardous substances remaining on the Site above levels that allow unlimited use and unrestricted exposure, five-year reviews will be conducted.

DATA CERTIFICATION CHECKLIST

The following information is in the *Decision Summary* section of this ROD. Additional information is in the Administrative Record file for this Site.

- Chemicals of concern and their respective concentrations - Sections 6 and 8
- Baseline risk presented by the chemicals of concern - Section 8
- Cleanup levels established for the chemical of concern and the basis for these levels - Section 13.3
- How source materials constituting principal threats are addressed - Section 12
- Surface water and land use assumptions used in the baseline risk assessments and ROD - Sections 7 and 8
- Potential land and ground water use that will be available at the Site as a result of the Selected Remedy - Section 7
- Estimated capital, operation and maintenance and total present-worth costs; and the time to implement each of the various remedial alternatives - Sections 11 and 13.2
- Key factors that led to selecting the remedy (i.e., best balance of trade-offs with respect to the balancing and modifying criteria) - Sections 11 and 14

12/18/02
Date

Bruce Baker, Deputy Administrator
Water Division
Wisconsin DNR

By signing this ROD, U.S. EPA Regions 5 concurs with the selected remedy.

12/20/02

Date

Wm. E. Muno

William E. Muno, Director
Superfund Division
U.S. EPA – Region 5

SUPERFUND RECORD OF DECISION (ROD)
for Operable Units I and 2
Wisconsin DNR and U.S. EPA

Lower Fox River
Brown, Outagamie, and Winnebago Counties, Wisconsin,
CERCLIS ID: WID000195481
December, 2002

Part 2: Superfund Record of Decision

1. SITE NAME, LOCATION, AND BRIEF DESCRIPTION

1.1 Site Name and Location

The Lower Fox River and Green Bay Site is located in Northeast Wisconsin (in Brown, Door, Marinette, Oconto, Outagamie, Kewaunee, and Winnebago Counties), and the Eastern portion of Upper Peninsula of Michigan, (in Delta and Menominee Counties). The Lower Fox River flows northeast from Lake Winnebago for 39 miles where it discharges into Green Bay. Green Bay is approximately 119 miles long and is an average of 23 miles wide (Figure 1).

The Lower Fox River and Green Bay have been divided into 5 Operable Units (OU) by WDNR and EPA. For purposes of the RI/FS, the River was divided into four River reaches and Green Bay was divided into three major zones on the basis of physical features and information generated in previous investigations. Each of the River reaches has been deemed a separate Operable Unit (OU 1 through OU 4), while all of Green Bay has been designated a single Operable Unit (OU 5). An Operable Unit is a geographical area designated for the purpose of analyzing and implementing remedial actions. OUs are defined on the basis of similar physical and geographic properties and characteristics. The River reaches, Green Bay zones, and corresponding Operable Units are:

1. OU 1 – Little Lake Butte des Morts River reach
2. OU 2 – Appleton to Little Rapids River reach
3. OU 3 – Little Rapids to De Pere River reach
4. OU 4 – De Pere to Green Bay River reach
5. OU 5 – Green Bay

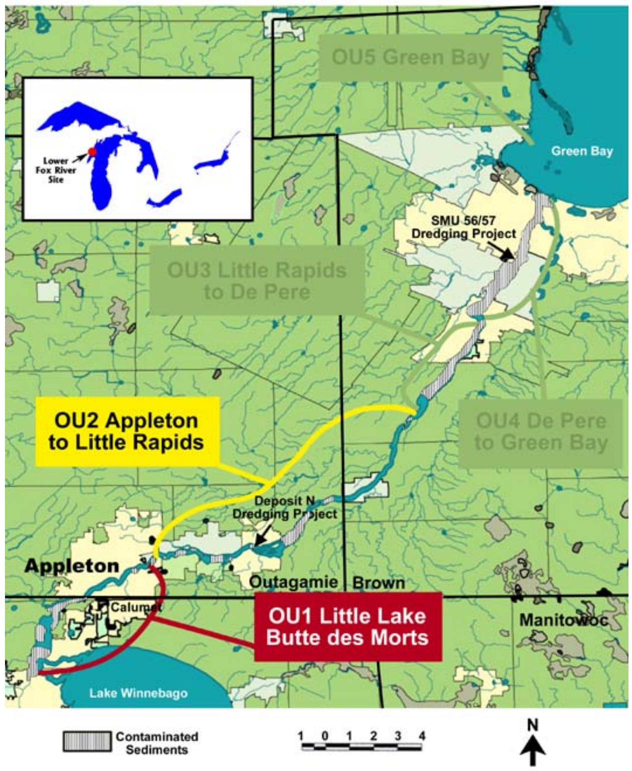
This ROD addresses Operable Units 1 and 2. For OU 1, active remediation (dredging, dewatering, stabilization or vitrification and on-site or off-site disposal) of in-place sediment has been selected. For OU 2, a monitoring program has been selected to evaluate the effectiveness of natural processes that are expected to reduce risk over time. Risk reduction will occur more quickly in OU 1 due to active remediation of that Operable Unit.

The remedial action selected herein is to remove and isolate, or otherwise ameliorate the threats to human health and the environment in OU 1 and OU 2 caused by the release of PCBs into the upper part of the Lower Fox River. While the release of PCBs to the environment occurred between 1954 and the late 1970s, the PCB contamination in the sediments continues to act as a source to the water, biota, and air.

1.2 Brief Description

The study area comprises two distinctly different water bodies, the Lower Fox River and Lake Michigan's Green Bay (Figure 1). The Lower Fox River flows northeast approximately 39 miles from Lake Winnebago to the River mouth at the southern end of Green Bay. Green Bay's watershed drains approximately 15,625 square miles. Two-thirds of the Green Bay basin is in Wisconsin; the remaining one-third is in Michigan's Upper Peninsula.

Figure 1 Lower Fox River PCB Contaminated Sediment Deposits and Operable Units



The Lower Fox River is the primary tributary to Green Bay, draining approximately 6,330 miles^2. The River's elevation drops approximately 168 ft between Lake Winnebago and Green Bay. Twelve dams and 17 locks accommodate this elevation change and allow navigation between Lake Winnebago and Green Bay. While the entire Lower Fox River still has a federally authorized navigation channel and is navigable by recreational boats, the Rapide Croche lock is permanently closed to restrict upstream migration of the sea lamprey.

The Lower Fox River is generally less than 1,000 ft wide over much of its length and is up to approximately 20 ft deep in some areas. Where the River widens significantly, the depth generally decreases to less than 10 ft, and, in the case of Little Lake Butte des Morts (LLBdM), water depths range between 2 and 5 ft except in the main channel. The main channel of the River ranges from approximately 6 to 20 ft in depth.

Since 1918, flow in the Lower Fox River has been monitored at the Rapide Croche Dam, midway between Lake Winnebago and the River mouth. Mean annual discharge is approximately 4,237 cubic feet per second (cfs). The recorded maximum daily discharge of 24,000 cfs occurred on April 18, 1952; the minimum daily discharge of 138 cfs occurred on August 2, 1936. Flow in the River between Appleton and the Little Rapids Dam averages 0.78 f/s.

OU 1 is identified primarily as Little Lake Butte des Morts and extends from Lake Winnebago to the Appleton dam for a distance of approximately 6 miles. This reach includes sediment deposits A though H and POG. OU 2 extends from the Appleton dam to Little Rapids dam for a distance of approximately 32 km (20mi). This reach includes sediment deposits I through DD.

1.3 Lead Agency

The Wisconsin Department of Natural Resources (WDNR) is the lead agency for this project. The United States Environmental Protection Agency (EPA), the support agency, has worked jointly with WDNR in the development of this ROD and concurs with the decision described herein.

2. SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 Site History

The Fox River Valley is one of the largest urbanized regions in the state of Wisconsin, with a population of approximately 400,000. The Fox River Valley has a significant concentration of pulp and paper industries, with 20 mills located along or near the Lower Fox River. Other important regional industries include metal working, printing, food and beverages, textiles, leather goods, wood products, and chemicals. In addition to heavy industrial land uses, the region also supports a mixture of agricultural, residential, light industrial, and conservancy uses, as well as wetlands. For investigative purposes, the Site is defined as the 39 river miles of the Lower Fox River and Green Bay to a line that extends between Washington Island, Wisconsin, and the Garden Peninsula of Michigan.

Problems related to water quality have been noted and measured in the Lower Fox River and lower Green Bay almost since the area was settled. Water quality studies were initiated in the early 1900s and have been conducted almost annually since. Between the early 1930s and mid-1970s, the population of desirable fish and other aquatic organisms in the system was poor. Recorded fish kills and the increasing predominance of organisms able to tolerate highly polluted conditions were found throughout the Lower Fox River and lower Green Bay. Few people used the River or lower Green Bay for recreation because of the poor water quality and the lack of a sport fishery. During this same time period, dissolved oxygen levels were often very low (2 milligrams per liter [mg/L] or less). The poor water quality was attributed to many sources such as the effluent discharged from pulp and paper mills and municipal sewage treatment plants.

In large part because of the federal Clean Water Act (1972), over time improved waste treatment systems began operations. As part of this effort, WDNR developed and implemented a Waste Load Allocation system to regulate the discharge of oxygen-demanding pollutants from wastewater treatment plants. Fish and aquatic life in the Lower Fox River and Green Bay have responded dramatically to the improved water quality conditions. Fishery surveys conducted from 1973 to the present indicate a sharp increase in the sport fish population. Species sensitive to water quality, such as lake trout, which were absent since the late 1800s or early 1900s, have been found in the River since 1977. These improvements resulted in a large part from a substantial reduction in organic wastes discharged into the River.

With the return of the sport fishery, human use of the River and Green Bay has also returned. Recognizing concerns about potential health impacts of PCBs in the environment and their bioaccumulative properties, WDNR began routinely monitoring contamination in fish in the early

1970s. Significantly elevated levels of PCBs were detected in all species of fish and all OUs. Measured concentrations of PCBs in fish were (and remain) above levels that have been shown to be harmful to human health. As a result, fish consumption advisories for the Site were first issued in 1976 and 1977 by WDNR and the state of Michigan, respectively. Fish consumption advisories remain in effect today. WDNR has continued to collect data on contaminant concentrations in fish tissue since that time.

PCB Use in the Lower Fox River Valley

The principal source of Polychlorinated Biphenyls (PCBs) in the Lower Fox River and Green Bay is from the manufacture and recycling of carbonless copy paper. The former National Cash Register Company (NCR) is credited with inventing carbonless copy paper. The method used microcapsules of a waxy material to enclose a colorless dye dissolved in PCBs. This material was manufactured as an emulsion and could be coated onto the back of a sheet of paper. A second reactive coating was then applied to the front of a second sheet of paper. When the two sheets were joined, an impact on the front sheet would rupture the capsules and allow the dye to react with the coating on the second sheet, leaving an identical image.

PCB discharges to the Lower Fox River resulted from the production and recycling of carbonless copy paper made with PCB-containing coating emulsions. Manufacturing carbonless paper using the PCB containing emulsion began in the Fox River Valley in 1954 and continued until 1971. The production of carbonless copy paper increased during the 1950s and 1960s and by 1971, approximately 7.5 percent of all office forms were printed on carbonless copy paper. With increased production of carbonless copy paper, PCBs began to appear in many types of paper products made using recycled carbonless copy paper. As documented in an EPA report, nearly all paper products contained detectable levels of PCBs by the late 1960s. During this time period, other Fox River Valley paper mills also began recycling wastepaper laden with PCBs. Evidence of PCBs in paper products includes studies conducted by the Institute of Paper Chemistry to determine the rate at which PCBs migrated from paper container materials to the food products contained in them.

The production of carbonless copy paper was discontinued after 1971 because of increased concern about PCBs in the environment. During the period of use (1954 – 1971) an estimated 13.6 million kg (30 million lbs.) of emulsion were estimated to be used in the production of carbonless copy paper produced in the Fox River Valley. PCBs were released into the Lower Fox River in discharge water from several facilities. By analyzing purchase, manufacturing, and discharge records, conservative estimates have shown that approximately 313,600 kg (690,000 lbs.) of PCBs were released to the Fox River environment during this time. Ninety-eight percent of the total PCBs released into the Lower Fox River had been released by the end of 1971. Ceasing production of carbonless copy paper and the wastewater control measures put in place by the Clean Water Act were effective in eliminating point sources. Non-point sources, such as PCB contaminated groundwater plumes, are not known to exist from any of the potentially responsible parties' sites.

2.2 Actions to Date

To date seven companies have been identified and formally notified by the governmental agencies as potentially responsible parties (PRPs) with respect to the PCB contamination. These companies include Appleton Paper Company, NCR, P.H. Glatfelter Company, Georgia Pacific (formerly Fort James), WTM1 (formerly Wisconsin Tissue), Riverside Paper Co., and U.S. Paper Co. This group is commonly referred to as the Fox River Group (FRG).

EPA's proposed inclusion of the Lower Fox River and Green Bay Site on the National Priorities List (NPL) defines the Site as the Lower Fox River from the outlet of Lake Winnebago to a point in Green Bay 27 miles from the River mouth. That Site is officially called the Fox River NRDA PCB Releases Site in the proposed NPL listing. This Site, for the purpose of the RI/FS and Proposed Plan, includes the 39 miles of the Lower Fox River and all of Green Bay. The federal trustees conducting a Natural Resource Damage Assessment (NRDA) have defined the Site somewhat differently from the proposed listing to include all of Green Bay and nearby areas of Lake Michigan.

With the finding that PCBs released into the Lower Fox River were appearing at harmful levels to human health and the environment, several cooperative efforts were initiated to document residual PCBs in the sediments, and the fate, transport, and risks of PCBs within the Lower Fox River and Green Bay. In 1989/90, following recommendations made in the Green Bay Remedial Action Plan, EPA and WDNR began a comprehensive sampling program of sediment, water, and biota in the Lower Fox River and Green Bay for use in the *Green Bay Mass Balance Study* (GBMBS).

The GBMBS was a pilot project to test the feasibility of using a mass balance approach for assessing the sources and fates of toxic pollutants spreading throughout the food chain. The objectives of the GBMBS were to:

1. Inventory and map PCB mass and contaminated sediment volume;
2. Calculate PCB fluxes into and out of the Lower Fox River and Green Bay by evaluating Lake Winnebago, point sources, landfills, groundwater, atmospheric contributions, and sediment resuspension;
3. Increase understanding of the physical, chemical, and biological processes that affect PCB fluxes;
4. Develop, calibrate, and validate computer models for the River and Bay systems; and,
5. Conduct predictive simulations using computer models to assist in assessing specific management scenarios and selecting specific remedial actions.

The GBMBS confirmed that the primary source (more than 95 percent) of the PCBs moving within the Lower Fox River is the river sediment itself. The contribution of PCBs from wastewater discharges, landfills, groundwater, and the atmosphere is insignificant in comparison to the PCBs originating from the sediment. Furthermore, the GBMBS showed that PCBs released from the sediments were directly linked to the levels of PCBs measured throughout the biological food chain, including fish, birds, and mammals that depend on the River for food.

Inventory and mapping activities showed that PCBs are distributed throughout the entire Lower Fox River. Thirty-five discrete sediment deposits were identified between Lake Winnebago and the De Pere Dam. One relatively large, continuous sediment deposit exists downstream of the De Pere Dam. Water column sampling indicated that the water entering the Lower Fox River from Lake Winnebago contains relatively low PCB concentrations. However, upon exposure to the contaminated river sediment in Little Lake Butte des Morts, water in the River exceeds state water quality standards. During the GBMBS, the lowest water column concentration (5 nanograms per liter [ng/L]) of PCBs measured in any River sample still exceeded the state water quality standard by a factor of more than 1,500. As expected, water column concentrations also increased as River flow increased and PCBs attached to River sediment were resuspended into the water column. These higher flows resulted in PCB concentrations that exceeded standards by a factor of almost 40,000. The GBMBS also documented that more than 60 percent of PCB transport occurs during the relatively short time when River flows are above normal. Movement of PCBs in the water column extends throughout Green Bay, with some PCBs from the Lower Fox River ultimately entering Lake

Michigan proper. The GBMBS also documented that a considerable amount of PCB is lost to the atmosphere from the surface of the water in the River and Bay.

EPA's Great Lakes National Program Office (GLNPO) initiated a similar mass balance study for all of Lake Michigan, the *Lake Michigan Mass Balance Study* (LMMBS). To accomplish the objectives of this study, which were similar to those of the GBMBS but on a larger scale, pollutant loading (including PCBs) from 11 major tributaries flowing into Lake Michigan was measured. The Lake Michigan Tributary Monitoring Program confirmed the magnitude and significance of the Lower Fox River contribution to pollutant loading in Lake Michigan. It is estimated that each day, up to 70 percent of the PCBs entering Lake Michigan via its tributaries are from the Lower Fox River.

In 1993, a group of paper mills approached WDNR to establish a cooperative process for resolving the contaminated sediment issue. The outcome was formation of the Fox River Coalition, a private-public partnership of area businesses, state and local officials, environmentalists, and others committed to improving the quality of the Lower Fox River. The Coalition focused on the technical, financial, and administrative issues that would need to be resolved to achieve a whole River cleanup.

The Coalition's first project was an RI/FS of several sediment deposits upstream of the De Pere Dam. The sediment deposits targeted for the Coalition's RI/FS were selected after all the deposits had been prioritized based on their threat and contribution to the contaminant problems. Previous studies on the River had focused only on the nature and extent of contamination. The Coalition's RI/FS first confirmed the nature and extent of the contamination within each deposit, then evaluated remedial technologies for cleaning up two of the deposits.

The Coalition also undertook a project to more thoroughly inventory and map sediment contamination in the River downstream of the De Pere Dam, collecting sediment cores from 113 locations. The sampling was completed in 1995 with technical and funding assistance from both WDNR and EPA. The resulting data led to a revised estimate of PCB mass and the volume of contaminated sediment in this River reach. The expanded database also made it possible to prioritize areas of sediment contamination, much as had previously been done for areas upstream of the De Pere Dam.

Following completion of the Coalition's RI/FS for the upstream sites, the Coalition selected Deposit N as an appropriate site for a pilot project to evaluate remedial design issues. The primary objectives were to determine requirements for implementing a cleanup project and to generate site-specific information about cleanup costs. Although the Coalition initiated the effort, WDNR, with funding from EPA, was responsible for implementing the Deposit N pilot project.

In 1994, the U.S. Department of the Interior acting through the U.S. Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, the Menominee Indian Tribe of Wisconsin, and the Oneida Tribe of Indians of Wisconsin initiated a Natural Resources Damage Assessment (NRDA) for the Site. The State, federal and Tribal Trustees are working together to determine what is necessary to address natural resource injuries caused to-date by releases of PCBs. This is a separate, but related process to the remediation consideration discussed herein.

In January 1997, the WDNR and the FRG signed an agreement dedicating $10 million to fund demonstration projects on the River and other work to evaluate various methods of restoration. This collaborative effort, however, was not completely successful and did not resolve technical issues as was initially hoped. At about this same time, USFWS issued a formal Notice of Intent to sue the paper companies. In June 1997, the U.S. EPA announced its intent to list the Lower

Fox River and portions of Green Bay on the NPL, a list of the nation's hazardous waste sites eligible for investigation and cleanup under the federal Superfund program. The state indicated its opposition to listing the River as a Superfund site. Federal, state, and tribal officials subsequently signed an agreement on July 11, 1997 to share their resources in developing a comprehensive cleanup and restoration plan for the Lower Fox River and Green Bay. EPA formally proposed listing of the Site to the National Priorities List in the *Federal Register* on July 28, 1998.

In October 1997, the FRG submitted an offer to conduct an RI/FS on the Lower Fox River. An RI/FS is the first step in the federal process initiated by EPA to assess current health risks and evaluate potential remediation methods. Following unsuccessful attempts to negotiate this work activity with the FRG, EPA delegated the lead role for the Site to WDNR and helped craft a scope of work and cooperative agreement with WDNR for completing the RI/FS. WDNR, EPA, USFWS, NOAA, and the Menominee and Oneida Tribes worked in close cooperation to guide, review and issue the RI/FS. Two draft documents were released for public comment (1999, 2001). Comments received from the PRPs, the public, and independent peer review committees were incorporated into the Final RI/FS.

Deposit N

In 1998 and 1999, the WDNR and EPA-GLNPO sponsored a project to remove PCB-contaminated sediment from Deposit N in the Lower Fox River. This project was successful at meeting its primary objective by demonstrating that dredging of PCB-contaminated sediment can be performed in an environmentally safe and cost-effective manner. Other benefits of the project included the opportunity for public outreach and education on the subject of environmental dredging, as well as the actual removal of PCBs from the River system. Deposit N, located near Little Chute and Kimberly, Wisconsin, covered approximately 3 acres and contained about 11,000 cubic yards (cy) of sediment. PCB concentrations were as high as 186 milligrams per kilogram (mg/kg). Of the 11,000 cy in Deposit N, about 65 percent of the volume was targeted for removal.

Approximately 8,200 cy of sediment were removed, generating 6,500 tons of dewatered sediment that contained 112 total pounds of PCBs. The total included about 1,000 cy of sediment from Deposit O, another contaminated sediment deposit adjacent to Deposit N. Monitoring data showed that the River was protected during the dredging and that wastewater discharged back to the River complied with all permit conditions. The project met the design specifications for the removal, such as the volume of sediment removed, sediment tonnage, and allowed thickness of residual sediment. It should be noted that the project's goals were to test and meet the design specifications and focus on PCB mass removal, not to achieve a concentration-based cleanup, i.e., removal of all PCB-contaminated sediment above a certain cleanup level. A cost analysis of this project indicated that a significant portion of the funds was expended in pioneering efforts associated with the first PCB cleanup project on the Lower Fox River, for the winter construction necessary to meet an accelerated schedule, and for late season work in 1998.

Fox River Group Demonstration Project

As part of the January 1997 agreement between the FRG and the State of Wisconsin, the FRG agreed to make available a total of $10 million for a number of projects. One of these was a sediment remediation project for which the objective was to design, implement, and monitor a project downstream of the De Pere Dam. The project was intended to yield important information about large-scale sediment restoration projects in the Lower Fox River. The project, as described in the agreement, had a pre-defined financial limit of $8 million. The FRG and

WDNR agreed on Sediment Management Units 56 and 57 (SMU 56/57) as the project site. Contractors and consultants, under contract to the FRG, designed and implemented the project. Dredging at SMU 56/57 began on August 30, 1999. Dewatered sediment was trucked to a landfill owned and operated by Fort James Corporation (now Georgia Pacific). Because of cold weather and ice, dredging ceased on December 15, 1999, after approximately 31,350 cy of contaminated sediment containing more than 1,400 pounds of PCBs were removed from the River.

At the time this project was halted for the first year, SMU 56/57 had not met the project's dredging objective of removal of 80,000 cy of material. This resulted in unacceptably high concentrations of PCBs in surface sediment in portions of the dredged area. Despite this, the project provided instructive experience concerning hydraulic dredging. Building on the successes of this project, Fort James (now Georgia Pacific) worked cooperatively with WDNR and EPA in the spring of 2000 to complete the SMU 56/57 project. (See description of this enforcement agreement in Section 2.3, below). The sediment volume targeted for removal in 2000 was 50,000 cy. The additional volume of sediment removed from SMU 56/57 in 2000 was 50,316 cy, which was transported to the same Fort James landfill following dewatering. Approximately 670 pounds of PCBs were removed from SMU 56/57 during the 2000 project phase. Overall, the 1999 and 2000 efforts at SMU 56/57 resulted in the removal of approximately 2,070 pounds of PCBs from the River. The 2000 project phase met all goals set forth in the Administrative Order By Consent, and also met or exceeded the project's operational goals for removal rates, dredge slurry solids, filter cake solids, and production rates that were set forth for the original 1999 FRG project.

In February 1999, WDNR released a draft RI/FS for public review and comment. The draft RI/FS was released to solicit public comment early in the planning process, to better evaluate public acceptance, and to assist WDNR and U.S. EPA in selecting a cleanup alternative having the greatest public acceptance. Comments were received from other governmental agencies, the public, environmental groups, and private sector corporations. These comments were used to revise and refine the scope of work that led to the RI/FS and Proposed Remedial Action Plan (PRAP) released for public comment in October 2001.

2.3 Enforcement Activities

The work described above on SMU 56/57 was conducted from July to November 2000, under an Administrative Order By Consent (Docket No. V-W-00-C-596), that was entered into by Fort James, EPA, and the State of Wisconsin. Under its terms, Fort James funded and managed the project in 2000 with oversight from both WDNR and EPA.

An interim Consent Decree settlement was reached with Appleton Papers/NCR (API/NCR), with the Court entering the Decree on December 10, 2001. Under this agreement, API/NCR agrees to provide $10 million a year for both remediation and restoration work (under the NRD process), with projects determined by the Intergovernmental Partnership. In return, the Intergovernmental Partnership agree to not order API/NCR to do remediation or restoration work on the River for the 4-year life of the agreement.

3. COMMUNITY PARTICIPATION

3.1 Public Participation

The community/public participation activities to support selection of the remedy were conducted in accordance with CERCLA § 117 and the NCP § 300.430(f)(3).

More than 100 people were interviewed in late 1998 and early 1999 to develop the Site's community involvement plan (CIP). Residents, tribal members, elected officials, business organizations, local health staff, and environmental groups from the affected communities discussed their concerns and those discussions are included in the CIP. In addition, an extensive profile of each municipality and reservation, as well as history of the River, was completed for the CIP. The CIP was placed in the information repositories for the Site in 2001.

The information repositories are located at the Appleton Public Library; Oshkosh Public Library; Brown County Library in Green Bay; Door County Library in Sturgeon Bay; and Oneida Community Library. Five additional locations, at the Kaukauna, Little Chute, Neenah, De Pere and Wrightstown Public Libraries, still maintain a fact sheet file, although they are no longer information repositories.

EPA awarded a $50,000 Technical Assistance Grant to the Clean Water Action Council (CWAC) in 1999 and another $50,000 grant was provided in 2001. The council has used its TAG to inform the community about the Lower Fox River investigations. To fulfill its obligations, CWAC developed a web site, printed flyers and bumper stickers, paid for newspaper ads and paid technical advisors to review EPA and WDNR-generated documents.

WDNR and EPA held numerous public meetings and availability sessions beginning in summer 1997 to explain how and why the Site was proposed for the Superfund NPL. In February 1999, a draft RI/FS (which did not identify a specific selected remedy) was released with a 45-day public comment period, which was extended an additional 60 days. Prior to and after the release of the draft RI/FS, WDNR and EPA provided for extensive community and public participation, and kept residents, local government officials, environmental organizations and other interest groups apprised of the steps of the process. Well-attended public meetings, small group discussions, meetings and presentations for local officials, and informal open houses continued through 2001.

The public meetings and proposed plan availability were announced to the public at a press conference on October 5, 2001, and received extensive coverage through TV, radio and newspapers news stories. The draft RI/FS and proposed plan were formally presented at public meetings held on October 29, 2001 in Appleton and October 30, 2001 in Green Bay. Additionally, WDNR and EPA mailed meeting reminders and proposed plan summaries to the 10,000 name Fox River mailing list. Press releases pertaining to the proposed plan, comment period, and public meetings were sent to newspapers and TV and radio stations throughout the Fox Valley. Display ads announcing the proposed plan, comment period and public meetings were also placed in Green Bay and Appleton newspapers. The presentations and question and answer sessions at the public meetings, and all public comments taken at the meetings, were recorded and transcribed. The written transcripts of the public meetings are available in the information repositories, the administrative record and on the WDNR Lower Fox River web page.

More than 20 public meetings and availability sessions have been held regarding the project. Cleanup and restoration activities, the status of pilot projects, fish consumption advisories, and the February 1999 draft RI/FS released by WDNR have been among the topics on which these meetings focused. Additionally, over 15 small group and one-on-one interview sessions have been held. Project staff have also made more than 60 presentations to interested organizations and groups. In addition, WDNR, EPA and their intergovernmental partners publish a bimonthly newsletter, the *Fox River Current*, which is mailed to over 10,000 addresses. To date, 23 issues of the *Fox River Current* have been published.

Copies of the various supporting reports and the proposed plan were made available to the public during a public comment period that began on October 5, 2001 and concluded on January 22, 2002. Approximately 4,800 written comments were received via letter, fax and e-mail. A copy of the Responsiveness Summary for these comments is attached to this ROD. Originally, the comment period was for 60 days, ending on December 7, 2001. The announcement of the extension until January 22 was published through newspaper advertisements and news releases on October 25, 2001. Newspaper advertisements were placed in the Green Bay Press Gazette and the Appleton Post Crescent announcing the availability of the plan and its supporting documents, and a brief summary of the plan in the information repositories. The proposed plan, the RI/FS and other supporting documents containing information upon which the proposed alternative was based were also made available on the Internet at www.dnr.state.us/org/water/wm/lowerfox/index.html and at the EPA Region 5 web site. All documents were also available as part of the Administrative Record housed at WDNR offices in Madison, Wisconsin and Green Bay, Wisconsin and at the EPA Region 5 office in Chicago, Illinois.

4. SCOPE AND ROLE OF RESPONSE ACTION

As with many Superfund sites, the problems at the Lower Fox River and Green Bay Site are complex. As a result, WDNR and EPA organized the Site into five OUs described in Section 1.1, above.

The Proposed Plan, issued October 2001, recommended a cleanup plan for all five Operable Units at the Site. However, at this time, WDNR and EPA are issuing a ROD for the Fox River OUs 1 and 2 only. WDNR and EPA expect to issue a ROD for OUs 3, 4 and 5 at a later date.

The reasons for issuing a ROD at this time for only OUs 1 and 2, and not for OUs 3, 4 and 5, are as follows:

- OU 1 and 2 represent a smaller portion of the area within the Fox River where remediation is necessary. These two Operable Units represent approximately 6.5 percent of the PCB mass and 18 percent of the sediment volume in the Lower Fox River. Consequently, these two Operable Units represent a more manageable project than conducting all of the remediation at one time.
- Provide a phased approach to the remedial work. Work on upstream areas, OUs 1-2 can start before the downstream areas, OUs 3, 4, and 5. This is consistent with the EPA policy Memorandum by Marianne Horinko, "OSWER Directive 8258.6-08, Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites," dated February 12, 2002. Principles described in this memorandum include, "Control Sources Early," and "Use an Iterative Approach in a Risk Based Framework." Additionally, the NCP states at 300 CFR Section 430(a)(1)(ii):

  > "*Program Management Principles.* EPA generally should consider the following general principles of program management during the remedial process:
  >
  > Sites should generally be remediated in Operable Units when....phased analysis and response is necessary or appropriate given the size or complexity of the site...."
- Planning for OUs 3, 4, and 5 may benefit from knowledge gained on the OUs 1 and 2 project.

The primary objective of this response action is to address the risks to human health and the environment due to PCBs in the in-place sediments of OUs 1 and 2 in the Lower Fox River. PCB concentrations remain elevated in Fox River sediments, in the water column and in the fish. Removal of the PCB-contaminated sediments will result in reduced PCB concentrations in fish tissue, thereby accelerating the reduction in future human health and ecological risks. In addition, by addressing the sediments, the remediation will control a source of PCBs to the water column, which contributes to fish tissue concentrations and transports PCBs into downstream reaches of the River, Green Bay, and eventually to Lake Michigan.

5. PEER REVIEW

To ensure the credibility of the scientific work conducted during the Remedial Investigation/Feasibility Study (RI/FS), EPA conducted both forms of peer involvement: peer input and peer review. Peer input was conducted through internal Agency reviews, and reviews by other agencies and Tribes. Peer review was also conducted, in accordance with EPA guidance outlined in the Peer Review Handbook (dated December 1998, updated December 2000). The peer review was conducted by independent experts who were unaffiliated with EPA, WDNR, the FRG or other Site stakeholders, and was undertaken on some of the major scientific aspects that form the basis for this decision.

Two separate EPA-sponsored peer review panels were convened. The review process consisted of each panel conducting an independent review by three panel members, with technical and administrative support by an EPA-contractor. The EPA contractor was responsible for convening the panels, consistent with the “charge” given by EPA for the panel review. This peer review was undertaken without influence by EPA, WDNR, the FRG or other interested parties. This was to provide an independent analysis and comment on key documents and issues related to development of a proposed remedy. Specifically, the panels were asked to evaluate:

- Adequacy of data considered in the 1999 Draft Lower Fox River Remedial Investigation, relative to quality and quantity (RI Panel), and
- Natural recovery and environmental transformation, i.e., biological breakdown of PCBs (FS Panel). Natural recovery was defined by the panel as naturally occurring physical, chemical, or biological processes that reduce the risks associated with contaminants in sediments over time.

Each peer review panel was asked to address specific questions (i.e., the “charge”) regarding the report being reviewed, including key controversial issues identified by EPA. The RI and FS panels issued reports October 7, 1999, and September 28, 1999, respectively.

The following summarizes the major findings of each of the panels:

- Data are adequate to determine the distribution of contaminants (i.e., it can be decided where cleanups should take place), if all data sources are considered (i.e., the RI does not provide a complete record).
- Data from all available sources are adequate to support identification and selection of a remedy for those technologies (e.g., dredging and capping) that have been used on a large scale at other, similar sites. Data are insufficient for developing in situ bio-technologies that may be applicable to the Site.
- Substantial improvements or additions to the existing data set are not indicated.

- The Draft FS should more fully evaluate natural recovery of sediments as a remedial alternative in comparison with other remedial options.
- The technical basis of the natural recovery analysis needs to be described in more detail to permit a review of the methodology used and to assess confidence in natural recovery predictions.

In the 2001 draft RI and FS and the Proposed Plan, WDNR and EPA considered the recommendations by the peer review panels, and on that basis made modifications to draft documents upon which the proposed plan was based.

In addition to EPA-sponsored peer reviews, the FRG sponsored peer reviews that were technically consistent with EPA peer review policy, although they may not have conformed to all aspects of the peer review process and documentation. These reviews consisted of the following analysis for the Fox River:

- Fate and transport and bio-uptake modeling evaluations by WDNR and the FRG;
- Human Health Risk Assessments by WDNR and the FRG
- Ecological Risk Assessments by WDNR and the FRG.

Recommendations by both EPA-sponsored peer reviews as well as those by the FRG were considered and incorporated into the 2001draft RI/FS, which was a significant part of the basis for the Proposed Plan.

6. SITE CHARACTERISTICS

6.1 Conceptual Site Model

The conceptual site model for the Fox River PCBs Site describes the source to receptor succession in simple terms and identifies the major contamination sources, contaminant release mechanisms, secondary sources, pathways and receptors of concern (see Figures 2 and 3). Figures 2 and 3 show both human and ecological site models. The design of field investigations and human and ecological risk assessments reflect the basic components of the conceptual site model.

In the conceptual site model, historical PCB releases were from paper manufacturing and recycling facilities that discharged into the Fox River. Although current releases are insignificant, historical releases were from discharge of wastewater containing PCBs. Contaminated sediment “hotspots” contribute to the overall PCB load in the Fox River and Green Bay.

Once introduced into the River, the PCBs adhere to sediments, with some fraction being carried in the water column. Physical, chemical and biological release mechanisms allow PCBs in the sediment to become available for redistribution and a source of PCB contamination to the water column. The sediments will continue to release contamination to the water column and biota, through aquatic and benthic food chains, as well as other not easily modeled processes such as boat scour, ice rafting, and bioturbation, unless they are managed or remediated in some manner. In addition, scour from water flowing over sediments during high flow events will continue to redistribute sediments and re-expose contaminants.

Because the River is a dynamic system with varying energy regimes, generally PCB-laden sediments are not sequestered or stable. Some PCB-contaminated sediment is buried by deposition of cleaner sediments at times, but in other places and at other times contaminants are redistributed. This redistribution may be local or more regional depending on the energy of flow events and/or physical type or size of the sediment particles. The redistributed sediments release contamination to the water column and high flow events (e.g., floods) further increase the bioavailability of contaminants to organisms in the water column. Although scour during high flow events is an important release mechanism PCBs in the surface water are also routinely observed during periods of lower flows (see Section 6.2.3, "Water Column," below). The conceptual site model shows that the fish ingestion pathway is a completed exposure route for the Site. Receptors include humans (e.g., anglers and their families), piscivorous (i.e., fish eating) fish, piscivorous birds (including threatened and endangered species) and mammals. Additional information on the human and ecological receptor populations is provided in the risk section (Section 8) of this document.

Figure 2 Human Health Site Conceptual Model

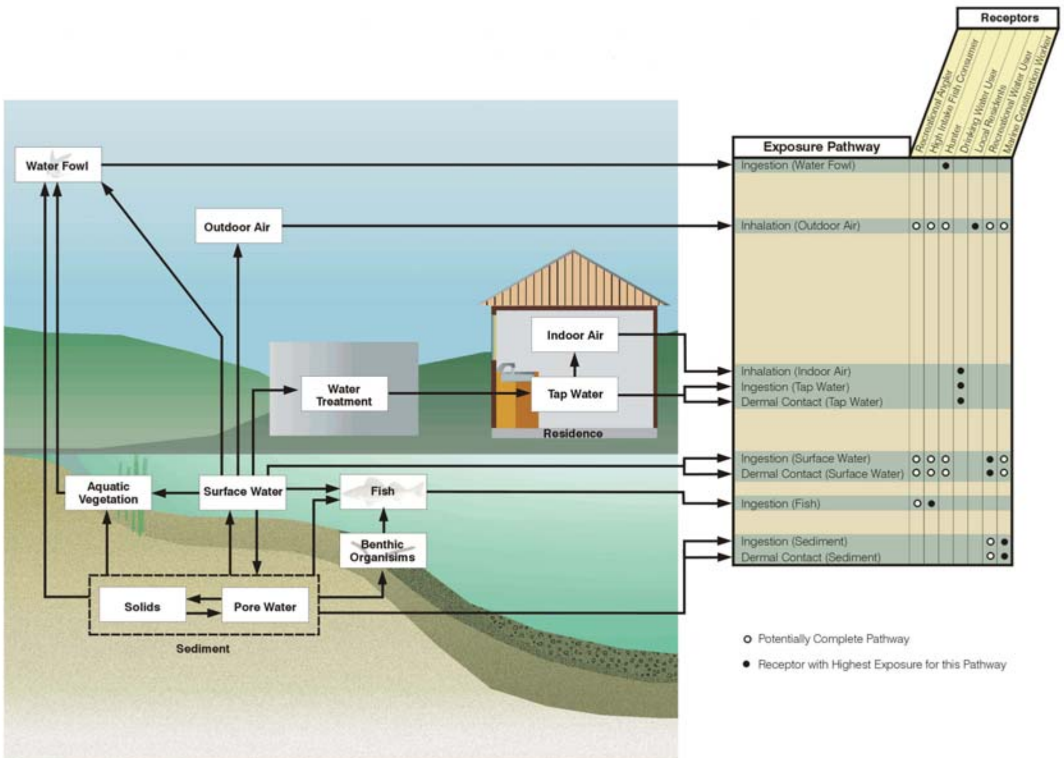
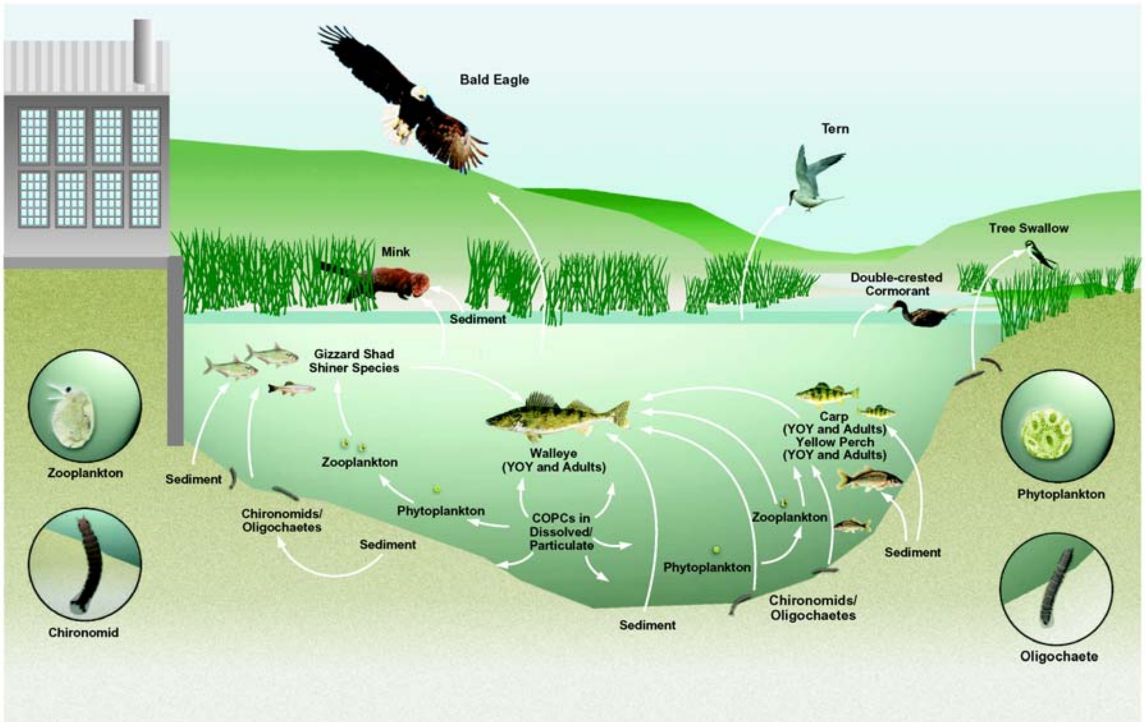


Figure 3 Ecological Site Conceptual Model



6.2 Results of the Remedial Investigation

6.2.1 Site Overview

The Lower Fox River is a large freshwater river that has been contaminated with PCBs for nearly 50 years. The contaminated portions of the Lower Fox River include variations in hydrology and river bed geology, which create complex environmental setting with varying levels of PCB contamination.

6.2.2 Summary of Sampling Results

WDNR's RI/FS evaluated data from numerous prior investigations conducted since 1971. These data have been incorporated into a single Fox River Database, available at WDNR's Lower Fox River Web page. The data received as part of the comments on the proposed plan have been added to the database. The current database contains in excess of 500,000 analytical records captured from every major substantial data collection activity since 1989 up until the time the proposed plan was released and covers analysis of sediment, water, air, and biota (e.g., fish and wildlife tissues).

6.2.3 Nature of Contamination

Contaminants representing the primary risk driver studied in the RI/FS are, by definition, polychlorinated biphenyls. PCBs consist of a group of 209 distinct chemical compounds, known as congeners, that contain one to ten chlorine atoms attached to a biphenyl molecule, with the generic formula of $C12H_{(10-x)}Cl_x$, where x is an integer from one to ten. Homologue groups are identified based on the number of chlorine atoms present. For example, monochlorobiphenyls contain one chlorine atom, dichlorobiphenyls contain two chlorine atoms, and trichlorobiphenyls contain three chlorine atoms. Some PCB congeners are structurally and toxicologically similar to dioxin (sometimes called dioxin-like PCBs).

Commercially manufactured PCBs consisted of complex mixtures of congeners, known under various trade names. These PCBs were marketed under the general trade name "Aroclors." About 140 to 150 different congeners have been identified in the various commercial Aroclors, with about 60 to 90 different congeners present in each individual Aroclor.

The polychlorinated biphenyls (PCBs) used in the production of carbonless copy paper by paper manufacturing facilities on the Fox River from 1954 to 1971, consisted largely of the Aroclor identified as "1242." Carbonless copy paper produced during this time contained approximately 3.4 percent PCBs by weight.

Other contaminants of potential concern (e.g., mercury, lead, arsenic, dieldrin, DDT/DDE/DDD, furan, and dioxin) are also present, but are not significant risk drivers due to relatively low concentrations.

Sources

Twenty paper mills are located along the portion of the Fox River included in the Site. Among that group of companies, six engaged in the production or de-inking of carbonless copy paper containing PCBs. As a result of those processes, these mills discharged PCBs to the Lower Fox River. It is estimated that the wastewater discharged by the paper mills either directly or indirectly (through publicly owned treatment works) into the Fox River released an estimated 690,000 pounds of PCBs into the Lower Fox River.

Contaminated Media

Sediment

Much of the volume of PCBs discharged into the Lower Fox River in the past has already been transported throughout the system and is now concentrated in sediment within specific areas. In general, the upper three River reaches can be characterized as having discrete soft sediment deposits within inter deposit areas that have little or no soft sediment. In contrast, the last River reach from De Pere to Green Bay is essentially one large, continuous soft sediment deposit. Because there were several points of PCB discharge along the entire length of the Lower Fox River, PCB concentrations and mass distributions are highly variable. Table 1 summarizes the distribution of PCBs within OU 1 and OU 2 sediments.

Table 1 PCB Distribution in the Lower Fox River OUs 1 and 2

River Reaches	Sediment Volume (cy)	PCB Mass (kg)	PCB Mass in Top 100 cm (%)
OU 1- Little Lake Butte des Morts	2,200,400	1,849	98%
OU 2 - Appleton to Little Rapids	339,200	109	100%

Transport of PCBs in Fox River

Contaminant fate and transport in the Lower Fox River and Green Bay are largely a function of deposition, suspension, and redeposition of the Chemicals of Concern (COC) that are bound to sediment particles. The organic COCs (PCBs, pesticides) exhibit strong affinities for organic material in the sediment. The ultimate fate and transport of these organic compounds depends significantly on the rate of flow and water velocities through the River and Bay. More sediment becomes suspended and transported downstream during high-flow events like storms and spring snowmelt. High-flow events occur approximately 15 to 20 percent of the time, but can transport more than 50 to 60 percent of the PCB mass that moves annually. In any event, less than 1 kilogram/year enters Little Lake Butte des Morts from Lake Winnebago and 40 kilograms (88 pounds)/year are resuspended and transported from Little Lake Butte des Morts to OU 2

(Little Rapids Reach). An estimated 64 kilograms (141 pounds)/year migrate from OU 2 downstream. This estimate does not consider removal of the Deposit N or for possible actions for Deposit DD. Other modes of contaminant transport, such as volatilization, atmospheric deposition, and point source discharges, are negligible when compared to sediment resuspension.

Changes in Sediment Bed Elevation

The Lower Fox River is an alluvial river that exhibits significant changes in bed elevations over time in response to changing volumes of flow during annual, seasonal, and storm events, changes in sediment load, and changes in its base level, which is determined by Lake Michigan. Sediment in the riverbed is dynamic and does not function as discrete layers. River sediment movement is in marked contrast to the sediment dynamics found in a large quiescent body of water, such as deep lakes, or the deeper portions of Green Bay. Scouring of the sediment bed plays a significant role in the quantity of sediment and contaminants transported through the River system. In response to comments received from the FRG on the 1999 draft RI/FS to the effect that less than one inch of sediment would be resuspended from the riverbed as a result of a 100-year storm event, WDNR and EPA investigated changes in sediment bed elevation for the De Pere to Green Bay River reach (OU 4). This work is partially relevant to OU 1 and OU 2, but is informative regarding movement of Fox River sediments generally. This work (see Technical Memo 2g of the Model Documentation Report) was completed by a group called the FRG/WDNR Model Evaluation Workgroup as part of the 1997 agreement between the FRG and WDNR. Additional evaluation by EPA was consistent with changes documented in Technical Memo 2g.

Results of these analyses indicate that sediment bed elevation changes occur in the Lower Fox River over both short- and long-term time frames. Changes in sediment bed elevation were observed both across the channel and downstream profiles. These changes show little continuity. Since River flows have not significantly changed in recent years, the complexity of these sediment bed elevation changes reflects the prevailing hydrologic and sediment conditions that occurred over a 22-year period from 1977 through 2000. The wide range of discharges and sediment loads continuously reshapes the Lower Fox River sediment bed. Short-term (e.g., annual and sub-annual) changes in average net sediment bed elevations range from a decrease or scour of over 11 inches to an increase or deposition of over 14 inches. Long-term (e.g., over several years) changes in average net elevations range from a decrease of more than 39 inches to an increase of nearly 17 inches. The changes documented are well supported by U.S. Army Corps of Engineers (USACE) sediment volume calculations from pre- and post-dredge sediment bed elevation surveys, as well as by results of a U.S. Geological Survey (USGS) analysis of bed surveys performed at intermediate time scales (e.g., 8 months to 45 months).

Surveys of the River bottom, conducted by several different groups, show significant changes in sediment bed elevation. On average, sediment bed elevation data from throughout the De Pere to Green Bay reach suggest that this River reach is a net depositional zone. However, when examined at a finer scale, the data show areas of sediment scour up to 14 ft. It should be noted that during the survey period, there were no large storm events of a 10-year or greater magnitude. It is unknown what the scour would be during larger events.

For OUs 1 and 2, PCBs are often high in surficial sediments. This is indicative that higher concentrations of PCBs continue to be exposed or re-exposed.

The Potential for Natural Biodegradation of PCBs

Responding to comments received from the EPA's peer review panel concerning natural recovery, the viability of natural degradation as a potential remedial action for the sediment-bound PCBs in the Lower Fox River and Green Bay was evaluated. Two basic processes, both anaerobic (without oxygen) and aerobic (in the presence of oxygen) degradation, must occur to completely decompose PCBs. Based on evidence in the literature, anaerobic PCB degradation was demonstrated to have occurred under field conditions at almost all the sites studied. However, a reduction in PCB concentrations through anaerobic processes is site-dependent. In the Lower Fox River, University of Wisconsin researchers found only a 10 percent reduction that could be attributed to anaerobic degradation processes in deposits with average PCB concentrations greater than 30 mg/kg. More importantly, no PCB reductions resulting from anaerobic processes could be accounted for in deposits with average concentrations less than 30 mg/kg.

Other active treatment options might possibly promote dechlorination of the sediment, making the PCBs more amenable to biological destruction. However, a pilot-scale experiment conducted at the Sheboygan River, another site with PCB-contaminated sediment, yielded inconclusive results regarding the viability of enhanced biodegradation. In that study, PCB-contaminated sediment was removed from the River and placed into a specially engineered treatment facility. The sediment was seeded with microorganisms and nutrients and the sediment was manipulated between aerobic and anaerobic conditions to optimize biological degradation. Even under these conditions, the data were insufficient to conclude that PCB decomposition was enhanced.

Effects of Time

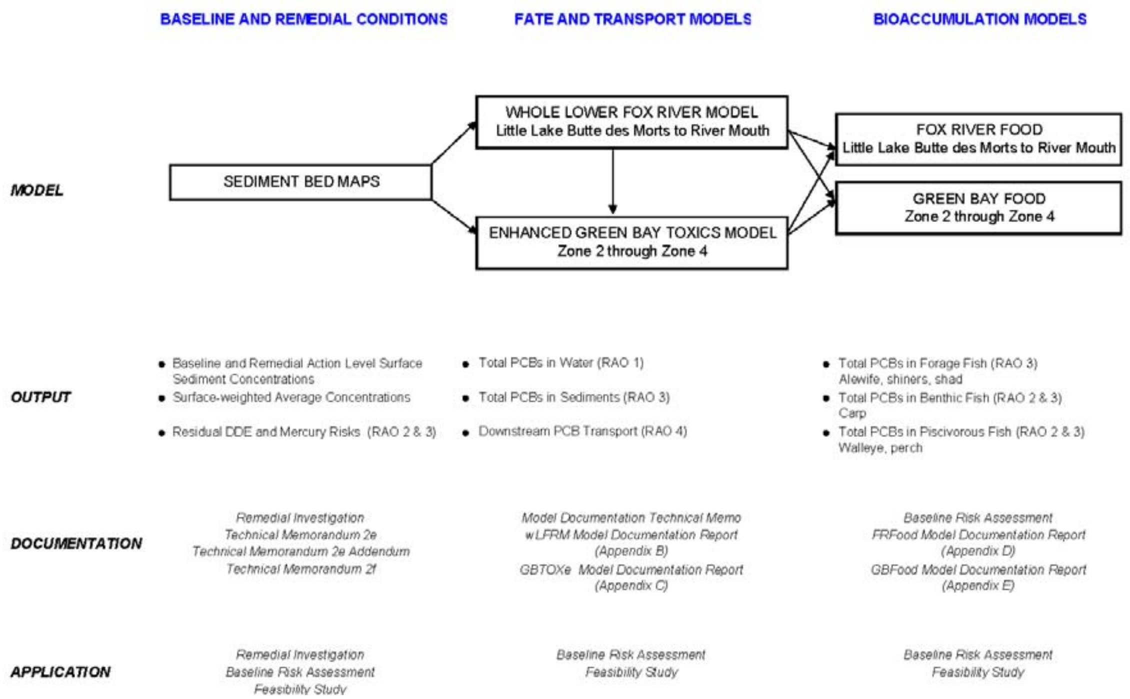
The Fox River Database includes sediment and water test results for tissue samples collected since 1971. During the 1970s, after PCB use in the manufacturing of carbonless copy paper had ceased, PCB concentrations in fish tissue showed significantly declining concentrations. Since the mid-1980s, however, changes in PCB levels in fish have slowed, remained constant, or, in some cases, increased.

Trends in PCB concentrations in the surface layer (i.e., top four inches) of River sediment are not consistent, but concentrations generally appear to be decreasing over time as more PCB mass is transported downstream. However, the time trends showed that concentrations in the subsurface sediments do not appear to be declining. This indicates that a considerable amount of PCB mass remains within the sediments of the Lower Fox River. Any changes made to the current lock and dam configuration on the River could result in increased scour and resuspension of those underlying sediments, which could in turn result in increases in fish tissue concentrations. In addition, soil eroded from the watershed mixes with and may further dilute PCB concentrations in the sediment.

Modeling Effort for the Lower Fox River

Four interrelated models were used in the RI/FS to simulate the fate and transport of PCBs in the Lower Fox River and Green Bay (Figure 4). They are mathematical representations of the transport and transfer of PCBs between the sediment, the water, and uptake into the River and Bay food webs. The models are intended not only to provide information on the fate and transport of PCBs in an unremediated River system, but also to compare the potential remedial alternatives in the FS. The models tend to estimate concentrations lower than the concentrations actually observed in the River. The relative differences predicted by the model are considered to be reliable.

Figure 4 Relationship of Models Used for Risk Projections in the Lower Fox River and Green Bay



The modeling effort included:

- Bed mapping of the Lower Fox River to define sediment thickness, sediment physical properties (such as total organic carbon and bulk density), and total PCB concentrations;
- Use of the whole Lower Fox River Model (wLFRM) to simulate the movement of PCBs in the water column and sediment of the Lower Fox River from Little Lake Butte des Morts to the mouth of the River at Green Bay; and,
- Use of the Fox River Food Chain Model (FRFOOD) to simulate the uptake and accumulation of PCBs in the aquatic food chain in the Lower Fox River using model results from wLFRM.

Bed mapping provided the foundation for the modeling inputs. Total PCB concentrations in surface sediment for the baseline and action levels serve as inputs to wLFRM . This model projects total PCB concentrations in water and sediment. The output from this model is in turn used in the bioaccumulation model, FRFood, to project whole fish tissue concentrations of PCBs (Figure 4). The output from all of the models is then compared to the remedial action levels specified in the FS. This information is used in the FS to estimate the length of time it would take for a receptor to achieve the acceptable fish tissue concentration in response to a given action level.

Taken together, these models provide a method for evaluating the long-term effects of different remedial alternatives and different action levels on PCB concentrations in water, sediment, and aquatic biota in the Lower Fox River. The models are then used to predict PCB concentrations in the aquatic environment over a 100-year period under different remedial alternatives and action levels. The modeling results are discussed in the FS, and a more detailed discussion on modeling can be found in the Model Documentation Report. A complete copy of that report is available on the WDNR's Lower Fox River Web page.

<u>Water Column</u>
The dominant current PCB source to the water column is sediments. Average River surface water total concentrations are 54.6 parts per trillion (ppt), with particulates and dissolved concentrations, 40.0 ppt and 14.6 ppt, respectively. There are significant seasonal variations, particularly when the water temperature drops below 40^{o} F. For example during the winter months of December 1994 and February 1995, total PCB concentrations dropped to about 10 percent of the average concentration. Average Green Bay concentrations range from 18.5 ppt for zone 2 to non-detect in zone 4.

<u>Fish and Other Biota</u>
PCB concentrations in fish are a result of the fish's exposure to PCBs in water and surface sediment, through an aquatic food chain and/or a benthic food chain, respectively. WDNR continues to collect and analyze fish tissue data from locations in the Fox River and Green Bay.

A wide variety of fish and other species have been collected and analyzed for the Fox River and Green Bay from 1971 to present. Generally, concentrations in biota have been declining, although the rate of decline varies depending upon the location and time.

<u>Air</u>
PCBs can enter the air via volatilization from PCB-contaminated water and soil although volatilization of PCBs is generally considered to be limited. Air monitoring during the 1999 SMU 56/57 dredging project demonstrated that even under "worst case" conditions (i.e., when sediments are excavated and exposed to the air) that volatilization of PCBs do not pose a significant risk to humans or wildlife.

6.2.4 Geochemistry and Modeling Conclusions

In the RI/FS, EPA evaluated PCB contamination at the Site using a number of tools. These tools include geochemical analyses of the water and sediment, "time trends" (i.e., statistical) analyses, and analysis of biological monitoring data, and synthesis of the data by the application of a set of complex mathematical (i.e., computer) models. PCB physical/chemical transport and fate and PCB bioaccumulation models were applied to predict future levels of PCBs in the Fox River and Green Bay sediment, water and fish.

7. CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

As one of Wisconsin's great rivers, the Lower Fox River has played and will continue to play a major role in the history, culture, and economy of the area. The Fox River has played an important role in defining regional history and culture. Current and reasonably anticipated future land use and surface water use are described below.

7.1 Current and Reasonably Anticipated Future Land Use

Current land use includes a variety of residential, commercial, agricultural, and industrial activities. Use of the River and lands surrounding the River are projected to remain the same. At this time, no changes in future land use are known, nor are any new uses expected. Table 2 below summarizes current land use for OUs 1 and 2.

Table 2 Predominant Land Use by Operable Unit

Operable Unit	Predominant Land Use
1 - Little Lake Butte des Morts	Residential, industrial, and commercial
2 - Appleton to Little Rapids	Residential, industrial, commercial, and agricultural

Other uses of the River include parks, woodlands, and recreational. OUs 1 and 2 pass through Winnebago, Outagamie and Brown Counties.

7.2 Surface Water Uses

- *Industrial and commercial purposes:* Uses include generation of electrical power and industrial/commercial purposes.
- *Residential/Domestic:* Due to historic problems in the Lower Fox River, the main surface water sources for human consumption for the areas surrounding OU 1 and 2 is Lake Winnebago and groundwater (i.e., not the Fox River).
- *Recreation:* The Fox River supports a variety of water-based recreational activities including sport fishing, waterfowl hunting, swimming and boating. Boating (both power and non-power) is available on the River, particularly in Little Lake Butte des Morts. Tourism is popular and important to the local economy.
- *Ecological Resources:* The Fox River and Green Bay support many species of birds (e.g., tree swallow, Forsters and Common Tern, Double-crested Cormorants, Bald Eagles) fish (Rainbow Smelt, Alewife, Gizzard Shad, Shiner, Yellow Perch, Carp, Brown Trout and Walleye), and mammals (e.g., mink), including sixteen (16) species of State or federally listed Threatened or Endangered species.

The Lower Fox River provides diverse habitats for all trophic levels of the River and Bay ecosystem. Plants, plankton, aquatic invertebrates, fish, amphibians, reptiles, birds and mammals use the Fox River for feeding, reproduction and shelter. In addition to the aquatic communities associated with the River, animals living in wetlands, floodplains and upland communities are also dependent on the River.

Both federal and state freshwater wetlands exist in the Fox River region, providing valuable habitat.

8. SUMMARY OF SITE RISKS

Baseline human health and ecological risk assessments were conducted to evaluate the potential for current and future impacts of site-related contaminants on receptors visiting, utilizing or inhabiting the Fox River and Green Bay in the Baseline Human Health and Ecological Risk Assessment (BLRA). The BLRA for the Lower Fox River and Green Bay was prepared as a companion document to the RI/FS and was finalized in December 2002.

In the portion of the report covering Human Health Risk Assessment (HHRA), cancer risks and non-cancer health hazards were evaluated for the Lower Fox River and Green Bay. In the Ecological Risk Assessment (ERA) portion of the report, ecological risks were evaluated for Lower Fox River and Green Bay. The BLRA supports the selected remedy.

The BLRA concludes that:

- Human health and ecological receptors are at risk in each Operable Unit.
- Fish consumption is the exposure pathway representing the greatest level of risk for human and ecological receptors, other than the direct risks posed to benthic invertebrates via direct exposure to contaminated sediments.
- The primary contaminant of concern is PCBs.

8.1 Identification of Chemicals of Concern

The Site includes the contaminated sediment found within the Lower Fox River and Green Bay. A Screening Level Risk Assessment (SLRA) was conducted to evaluate which chemicals in the system pose the greatest degree of risk to people and animals. Identified Chemicals of Concern (COCs) include PCBs, dioxins/furans, the pesticide DDT and its metabolites (DDD and DDE), the pesticide dieldrin, and arsenic, lead, and mercury.

8.2 Human Health Risk Assessment

8.2.1 Summary of Site Risks

The site-specific HHRA evaluated both cancer risks and non-cancer health hazards from exposure to PCBs in the Fox River and Green Bay, as documented in the Remedial Investigation and Feasibility Study (RI/FS). This discussion emphasizes cancer risks and non-cancer health hazards due to PCBs in the Fox River and Green Bay that exceed EPA's goals for protection. For cancer, regulatory decisions are made ranging from risk levels of one in a million (10^{-6}) to one in 10,000 (10^{-4}). A one in a 100,000 cancer risk level is commonly used in federal and state regulatory decisions. For non-cancer, a hazard index (HI) of 1 is the most frequent basis for risk management decisions. Cancer risks and non-cancer hazard indices in Green Bay were calculated to be generally similar to the Fox River. The cancer risk and non-cancer hazard indices in the Fox River and Green Bay are above EPA's levels of concern for fish consumption. Consistent with Superfund policy and guidance, the Human Health Risk Assessment (HHRA) is a baseline risk assessment and therefore assumes no actions (i.e., remediation) to control or mitigate hazardous substance releases and no institutional controls, such as the fish consumption advisories and fishing restrictions that are currently in place, which are intended to control exposure to hazardous substances. Cancer risks and non-cancer hazard indices were calculated based on an estimate of the reasonable maximum exposure (RME) expected to occur under current and future conditions at the Site. The RME is defined as an upper end exposure that is reasonably expected to occur at a Site. EPA also estimated cancer risks and non-cancer hazard indices based on central tendency (CT), or average, exposures at the Site. For both the RME and CT exposures, average contaminant (e.g., PCBs) levels in fish were exceeded. The following discussion summarizes the HHRA with respect to the basic steps of the Superfund HHRA process: 1) Data Collection and Analysis, 2) Exposure Assessment, 3) Toxicity Assessment and 4) Risk Characterization.

8.2.2 Data Collection and Analysis

The HHRA utilizes documents relating to the nature and extent of PCB contamination at the Site developed as part of the RI/FS. These RI/FS documents provide both current and projected future concentrations of PCBs in air, fish, sediments and river water. To calculate cancer risks and non-cancer hazard indices, the information on concentrations in these media (Tables 3 and 4) are combined with other information on exposure (see Section 8.2.3) and toxicity (see Section 8.2.4).

Table 3 Summary of PCB Data and Medium-Specific Human Exposure Point Concentrations for OU 1

Exposure Point	Chemical of Concern		Concentration Detected		Frequency of Detection	Exposure Point Concentration (ppm)	Statistical Measure
			Min.	Max.			
Sediments	Total PCBs		0.002 ppm	222.7 ppm*	539/661	3.70	mean
Surface Water Direct Contact	Total PCBs	particulate	0.13 ng/L	40.16 ng/L	34/41	1.66E-05	mean
		dissolved	1.4 ng/L	19 ng/L	40/46	1.11E-05	
Fish Tissue (Walleye)	Total PCBs		0.0989 ppm	3.8 ppm	11/13	1.16	mean

ng/L - nannograms/Liter
ppm - parts per million
**data submitted with comments from the responsible parties included data from LLBdM in excess of 360 ppm PCB.*

Data sources:
Concentrations and detections for surface water -- RI Tables, 5-1, 5-16 and RA Table 6-14.
Point of exposures -- RA Table 5-31, 6-8.

Table 4 Summary of PCB Data and Medium-Specific Human Exposure Point Concentrations for OU 2

Exposure Point	Chemical of Concern		Concentration Detected		Frequency of Detection	Exposure Point Concentration (ppm)	Statistical Measure
			Min.	Max.			
Sediments	Total PCBs		0 ppm	77.44 4 ppm	188/263	1.40	mean
Surface Water Direct Contact	Total PCBs	particulate	0.01 ng/L	52.17 ng/L	34/41	1.19E-05	mean
		dissolved	0.026 ng/L	18.86 ng/L	84/85	4.84E-06	
Fish Tissue (Walleye)	Total PCBs		1.431 ppm	3.90 ppm	4/4	2.74	mean

ng/L - nannograms/Liter
ppm - parts per million

Data sources:
Concentrations and detections for surface water -- RI Tables, 5-1, 5-16 and RA Table 6-14.

Fish at the Site have been collected by the WDNR for approximately 35 years, with fish advisories in effect since 1976. Fish samples have been analyzed for PCBs (both total PCBs and selected congeners), Dioxins/furans (specifically, 2,3,7,8-TCDD and 2,3,7,8-TCDF), DDT (dichlorodiphenyltrichloroethane), a pesticide, and its metabolites (DDD and DDE) Dieldrin (pesticide), arsenic, lead and mercury. These non-PCB contaminants were found to present substantially less risk compared to PCBs. Additionally, some of the other contaminants identified in sediment have similar fate and transport properties, and are generally found with PCBs. For this reason, a remedy that effectively addresses PCB exposure will also address the other COCs (with lesser toxicities) in the sediment.

The conceptual site model identifies potential receptors for COCs and exposure pathways. As discussed above, determination of PCB exposure provides a sound basis for characterizing significant human health risks at the Site. Estimates of the exposures allow a quantitative risk evaluation. This was done for fish, sediment, drinking/river water, and air. Most Site risks were determined to relate to fish consumption, with only minimal risk associated with other potential exposures (e.g., inhalation, direct contact). Thus the discussion below focuses on risks and exposures related to fish consumption.

Specifically, these quantitative risk calculations from fish consumption were based on wet-weight PCB concentrations in fish fillets, as generated by WDNR's bioaccumulation models, Fox River Food (FRFOOD) and Green Bay Food (GBFOOD). The fillet represents the portion of the fish most commonly consumed. The fish exposures were derived by weighting the model output by reported angler preference for species consumption (i.e., weighting the modeled PCB concentrations in fish to reflect the species caught and consumed by anglers) and by averaging over location within the study area.

8.2.3 Exposure Assessment

The exposure assessment evaluates exposure pathways by which people are or can be exposed to the contaminants of concern in different media (e.g., fish, water, and sediment). Factors relating to the exposure assessment include, but are not limited to, the concentrations that people are or can be exposed to and the potential frequency and duration of exposure.

Conceptual Site Model
Human exposure to PCBs through consumption of fish presented the greatest risk. Other human exposure pathways such as inhalation, drinking contaminated water or direct exposure presented no significant risk. The human health conceptual site model is shown in Figure 2.

Exposed Populations
Recreational and high intake (i.e., subsistence) fish consumers are the most likely population to have significant PCB exposures. Populations that may have portions of their members engaged in subsistence fishing include Native Americans~~,~~ and Hmong (Laotians). Sensitive populations that were qualitatively evaluated include highly exposed (i.e., subsistence) anglers and their families as well as infants of mothers who ingest fish that are exposed *in utero* and/or through consumption of breast milk. With respect to subsistence or highly exposed angler populations in Wisconsin, review of the literature suggests that these populations are likely to be adequately represented in the HHRA. With respect to infants (less than one year old), exposure to PCBs *in utero* and via ingestion of breast milk are known exposure routes that pose risks to fetal development in the infant. Several ongoing studies are determining if it is possible to develop quantitative relationships between fetal/infant PCB exposure and developmental effects. Standard EPA default factors were used for angler body weight [e.g., 72 (kilograms (kgs) for an adult].

Fish Ingestion Rate
Several fish consumption surveys were used to evaluate fish intake rates for both recreational and high intake fish consumers. Specific studies included: West (1989, 1993) conducted in Michigan; Fiore (1989) conducted in Wisconsin; Hutchinson and Kraft conducted in Wisconsin (1994) and Hutchinson (1999) conducted in Wisconsin. The RME fish ingestion rate was determined to be 59 grams per day from the West studies while 81 grams was determined for high intake fishes, using the findings from Hutchinson and Kraft (1994).

Exposure Duration
Values of 30 years for Central Tendency Exposure (CTE) and 50 years for the RME scenario were established based on EPA published estimates of the years persons live in the Lower Fox River and Green Bay area.

PCB Cooking Loss
PCB losses during cooking were assumed to be 50 percent, based on studies reported in the literature. Potential PCB loss mechanisms include removing skin and fat, draining cooking fluids from the fish and grilling to allow oil to drip away from the fish.

Probabilistic Analysis
In addition to the point estimate (i.e., deterministic) analyses, a probabilistic analysis was performed to provide a range of estimates of the cancer risks and non-cancer health hazards associated with the fish ingestion pathway. The probabilistic analysis helps to evaluate variability in exposure parameters (e.g., differences within a population's fish ingestion rates, number of years anglers are exposed, body weight, etc.) and uncertainty (i.e., lack of complete knowledge about specific variables). The deterministic risk analyses using point estimates to generate RME exposures and risks was found to compare favorably to findings from the probabilistic approach.

8.2.4 Toxicity

The toxicity assessment determines the types of adverse health effects associated with PCB exposures and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). Potential health effects for PCBs include the risk of developing cancer over a lifetime. Other non-cancer health effects, such as changes in the normal functions of organs within the body (e.g., changes in the effectiveness of the immune system), are also associated with PCB exposure. Some of the 209 PCB congeners are considered to be structurally and mechanistically similar to dioxin and exert dioxin-like effects.

Sources of Toxicity Information.
The HHRA used the current consensus toxicity values for PCBs from EPA's Integrated Risk Information System (IRIS) in evaluating the cancer risk and non-cancer health effects of PCBs. IRIS provides the primary database of chemical-specific toxicity information used in Superfund risk assessments. More recent toxicity data are provided in Appendix D of the BLRA. These data do not change EPA's use of IRIS values. For the dioxin-like PCBs, the HHRA used toxicity information for dioxin (2,3,7,8-TCDD) provided in EPA's 1997 Health Effects Assessment Summary Tables.

Cancer
EPA has determined that PCBs cause cancer in animals and probably cause cancer in humans (B2 classification or likely to cause cancer in humans). EPA's cancer slope factors (CSFs) for PCBs represent plausible upper bound estimates, which means that EPA is reasonably confident that the actual cancer risks will not exceed the estimated risks calculated using the

CSFs. For fish ingestion, the pathway determined to be of greatest concern, CSFs of 2 (mg/kg day)$^{-1}$ and 1 (mg/kg-day)$^{-1}$ were used for the RME and CT (average) exposure, respectively. For dermal and inhalation exposures, a CSF of 2 (mg/kg-day)$^{-1}$ was used with a dermal absorption fraction of 14 percent, consistent with the IRIS chemical file. For inhalation, a CSF of 0.4 (mg/kg-day)$^{-1}$ was used. For the dioxin-like PCBs, the CSF for 2,3,7,8-TCDD of 150,000 (mg/kg-day) was used.

<u>Non-Cancer Health Effects</u>
Serious non-cancer health effects have been observed in animals exposed to PCBs. Studies of Rhesus monkeys exposed through ingestion of PCBs (i.e., Aroclors 1016 and 1254) indicate a reduced ability to fight infection and reduced birth weight in offspring exposed *in utero*. Studies of non-cancer health effects, including neurobehavioral effects observed in children of mothers who consume PCB-contaminated fish were summarized in the baseline risk assessment and, are being evaluated by EPA as part of the Agency's IRIS process. The toxicity assessment is an evaluation of the chronic (e.g., 7 years or more) adverse health effects from exposure to PCBs. The chronic Reference Dose (RfD) represents an estimate (with uncertainty spanning an order of magnitude or greater) of a daily exposure level for the human population, including sensitive populations (e.g., children), which is likely to be without an appreciable risk of deleterious effects during a lifetime. Chemical exposures exceeding the RfD do not predict specific disease. For the fish ingestion pathway, the oral RfD for Aroclor 1254 of 2 x 10^{-5} mg/kg-day was used for the RME and CT (average) exposures, because the congener analysis of fish samples more closely resembled Aroclor 1254 rather than 1016. For the sediment and water ingestion pathways, the oral RfD for Aroclor 1016 of 7 x 10^{-5} mg/kg-day was used because analyses of sediment and water samples most closely resemble Aroclor 1016. For the dermal contact pathway, dermal RfDs were extrapolated from the oral RfD for Aroclor 1016.

8.2.5 Risk Characterization

This final step in the HHRA combines the exposure and toxicity information to provide a quantitative assessment of site risks. Exposures are evaluated based on the potential risk for developing cancer and the potential for non-cancer health hazards.

8.2.6 Cancer Risks

Cancer risk is expressed as a probability. For example, a 10^{-4} cancer risk means a one in 10,000 excess cancer risk, or an increased risk of an individual developing cancer of one in 10,000 as a result of exposure to site contaminants under the conditions used in the Exposure Assessment. Under Superfund, acceptable exposures RME cancer risk must be defined with the range of 10^{-4} to 10^{-6} (corresponding to a one in 10,000 to a one in 1,000,000 excess cancer risk). Excess lifetime cancer risk is calculated from the following equation:

$$\text{Risk} = \text{CDI} \times \text{CSF}$$

where: Risk = a unit less probability (e.g., 1 x 10^{-3} of an individual developing cancer)

CDI = Chronic Daily Intake averaged over 70 years (mg/kg-day)
CSF = Cancer Slope Factor, expressed as (mg/kg-day)$^{-1}$

At this Site, cancer risks to the RME individual associated with ingestion of fish are above EPA's generally acceptable levels, as shown below in Tables 5 and 6. In addition, cancer risks to the average (CT) individual associated with ingestion of fish are above EPA's goal for protection. Tables 5 and 6 below summarize key cancer risks from Tables 5-82 and 5-86 from the Human Health Risk Assessment for the Site. Cancer risks from exposure to dioxin-like PCBs were comparable to the cancer risks from the non-dioxin-like PCBs presented below for fish ingestion.

Table 5 Cancer Risk from Fish Ingestion – Summary for OU 1

Pathway	RME Cancer Risk	CT (Average) Cancer Risk
Recreational Angler		
All Fish	5.2×10^{-4} (5.2 in 100,000)	7.8×10^{-5} (7.8 in 100,000)
Walleye	1.5×10^{-4} (1.5 in 10,000)	2.2×10^{-5} (2.2 in 100,000)
High Intake (i.e., Subsistence) Angler		
All Fish	7.2×10^{-4} (7.2 in 10,000)	1.1×10^{-4} (1.1 in 10,000)
Walleye	2.0×10^{-4} (2.0 in 10,000)	3.2×10^{-5} (3.2 in 100,000)

Table 6 Cancer Risk from Fish Ingestion – Summary for OU 2

Pathway	RME Cancer Risk	CT (Average) Cancer Risk
Recreational Angler		
All Fish	4.9×10^{-4} (4.9 in 10,000)	7.4×10^{-5} (7.4 in 100,000)
Walleye	1.6×10^{-4} (1.6 in 10,000)	2.4×10^{-5} (2.4 in 100,000)
High Intake (i.e., Subsistence Angler)		
All Fish	6.8×10^{-4} (6.8 in 10,000)	1.1×10^{-4} (1.1 in 10,000)
Walleye	2.3×10^{-4} (2.3 in 10,000)	3.5×10^{-5} (3.5 in 100,000)

8.2.7 Non-Cancer Health Hazards

The potential for non-cancer health effects is evaluated by comparing an exposure level over a specified time period (e.g., 7 years) with Reference Dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a Hazard Quotient (HQ). An HQ less than 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non-carcinogenic effects from that chemical are unlikely. A Hazard Index (HI) represents the sum of the individual exposure levels for different chemicals and different media (e.g., fish, water, sediment) compared to their corresponding RfDs (i.e., HI is the sum of HQs for an individual). The key concept of a non-cancer HI is that a threshold level (measured as an HI of 1) exists below which non-cancer health effects are not expected to occur. Under the federal Superfund program, EPA's goal for protection for non-cancer health hazards is an HI equal or less than 1 for the RME individual.

The HQ is calculated as follows:

$$\text{Non-cancer HQ} = \text{CDI/RfD}$$

where: CDI = Chronic daily intake (mg/kg-day)
RfD = Reference dose (mg/kg-day)

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic).

At this Site, all non-cancer RME hazard indices from the consumption of PCBs in fish are above EPA's generally acceptable levels, as shown below (see also Table 6). Risk to children is particularly elevated. Tables 7 and 8 below summarize key non-cancer risks from Tables 5-84, 5-85, from the Human Health Risk Assessment for the Site. In addition, non-cancer hazard indices to the average (CT) individual are above EPA's generally acceptable levels. Non-cancer hazard indices for dioxin-like PCBs were not evaluated quantitatively due to EPA's ongoing evaluation of dioxin toxicity.

Table 7 Non-Cancer Health Hazard from Fish Ingestion – Summary for OU 1

Pathway	RME Non-Cancer HI	CT (Average) Non-Cancer HI
Recreational Angler		
All Fish	20	5
Walleye	5.5	1.4
High Intake (i.e., subsistence) Angler		
All Fish	27	7
Walleye	8	2
High Intake Recreational Child		
All Fish	47	12
Walleye	13	3
High Intake Subsistence Child		
All Fish	65	17
Walleye	19	5

Table 8 Non-Cancer Health Hazard from Fish Ingestion – Summary for OU 2

Pathway	RME Non-Cancer HI	CT (Average) Non-Cancer HI
Recreational Angler	84	21
High Intake (i.e., subsistence) Angler	115	30

8.2.8 Probabilistic Analysis

In addition to the deterministic calculations discussed above, EPA calculated risks for ingestion of fish in the Fox River and Green Bay using a probabilistic analysis, consistent with EPA guidance on probabilistic risk assessments (EPA, 1999). This analysis supports and complements the point estimates of risks and hazard indices calculated in evaluations of exposure to PCBs in fish.

Deterministic RME estimates of risk and hazard index provided in the probabilistic evaluation are generally consistent within the 90^{th} to 95^{th} percentiles of the respective probability distributions of risk and hazard indices. This is consistent with the interpretation provided by EPA (EPA, 1999) of the RME as a plausible high-end risk or hazard index for the exposed population.

Deterministic CTE estimates of risk and hazard index are generally close to the means of probability distributions of risk and hazard index. This is consistent with the interpretation of the CTE as the average risk or hazard index for the exposed population.

8.2.9 Uncertainty

The process of evaluating human health cancer risks and non-cancer hazard indices involves multiple steps. Inherent in each step of the process are uncertainties that ultimately affect the final cancer risks and non-cancer hazard indices. Important sources of uncertainty in the HHRA are discussed below:

The use of a bioaccumulation model to generate future concentrations of PCBs in fish if no action occurs were used in the HHRA calculations. WDNR minimized this uncertainty to the extent possible by developing a bioaccumulation model specifically for the Fox River Fox River and Green Bay (i.e., "FRFOOD" and "GBFOOD", respectively), calibrating the model to the extensive database for the Fox River and Green Bay. Additionally the model was revised based on a peer review sponsored by the Fox River Group. Based on the model calibration (i.e., the ability of the fish bioaccumulation model to capture the historical observed lipid-normalized PCB measurements in fish), and the feedback received from the peer review, the model uncertainty is not sufficient to change the overall conclusion of the HHRA that cancer risks and non-cancer hazard indices due to ingestion of fish are above acceptable levels.

Time Trends

Although concentrations in fish may be decreasing over time for some fish species in OU 1 and OU 2 these trends were not consistent with all species. In addition, trends in the surficial sediment layer are not consistent and concentrations in deeper sediments are not decreasing. Additionally, events that may scour sediments may cause declining trends currently observed to either slow or reverse.

Fish Ingestion Rate

This uncertainty in the fish ingestion rate was minimized by relying on a number of surveys. These included Michigan angler surveys for recreational anglers by West *et al.*, 1989 and 1993, and a Wisconsin angler survey by Fiore, 1989. For high intake fish consumers, surveys by West *et al.*, 1993, Peterson, 1994 and Hutchison and Kraft, 1994, Hutchison, 1994, and Hutchison, 1999 were also considered. In addition, the sensitivity/uncertainty analysis conducted for the probabilistic analysis showed that, despite the use of different fish, the overall conclusion of the HHRA -- that cancer risks and non-cancer hazard indices due to ingestion of fish are above levels of concern, essentially remains the same.

PCB Toxicity

EPA describes the uncertainty in the cancer toxicity values as extending in both directions (i.e., contributing to possible underestimation or overestimation of cancer slope factors (CSF)). However, the CSFs were developed to represent plausible upper bound estimates, which means that EPA is reasonably confident that the actual cancer risk will not exceed the estimated risk calculated using the CSF. The CSFs used in the HHRA were externally peer reviewed and supported by the panel of expert scientists and are the most current values recommended by EPA in IRIS. Non-cancer toxicity values also have uncertainty. The current oral RfDs for Aroclor 1016 and 1254, which were used in the HHRA, have uncertainty factors of 100 and 300, respectively in order to provide for protection of public health. The RfD for Aroclor 1016 was externally peer-reviewed and supported by the panel of scientists. The RfD for Aroclor 1254 was developed using the same methodology as Aroclor 1016 and was internally peer-reviewed. Since these RfDs were developed, a number of recent national and international studies have reported possible associations between developmental and neurotoxic effects in children from prenatal or postnatal exposures to PCBs. In light of these new studies, the current RfDs are currently being evaluated as part of the IRIS process. It would be inappropriate to prejudge the results of the IRIS evaluation at this time.

PCB Body Burden
The fact that any previous exposures (either background or past consumption of PCB-contaminated fish) may still be reflected in an individual's body burden today is an additional source of uncertainty and may result in an underestimate of non-cancer hazard indices and cancer risks.

PCB Bioaccumulation Modeling
The use of a bioaccumulation model to generate estimations of future concentrations of PCBs in fish if no action occurs were used in the HHRA calculations. WDNR minimized this uncertainty to the extent possible by developing a bioaccumulation model specifically for the Fox River and Green Bay (i.e., FRFOOD and GBFOOD, respectively), calibrating the model to the extensive database for the Fox River and Green Bay. Additionally the model was revised based on a peer review sponsored by the Fox River Group. Based on the model calibration (i.e., the ability of the fish bioaccumulation model to capture the historical observed lipid-normalized PCB measurements in fish), and the feedback received from the peer review, the model uncertainty is not sufficient to change the overall conclusion of the HHRA that cancer risks and non-cancer hazard indices due to ingestion of fish are above acceptable levels.

8.3 Ecological Risk Assessment

The Lower Fox River and Green Bay provide habitat function for a variety of invertebrates, fish, birds, and mammals that inhabit or use this watershed for foraging, reproducing, rearing young and other life cycle requirements. The Lower Fox River basin and Green Bay varies considerably in its potential to provide and support different kinds of wildlife habitat and this variability affects the wildlife diversity and populations. The BLRA focuses primarily on aquatic, or aquatic-dependent species. Aquatic habitats within the area are wetland (e.g., Lower Fox River and Southern Green Bay), and riverine (e.g., Lower Fox River).

The significant groups of wildlife found within these habitats include the following:

- Both pelagic and benthic aquatic invertebrate species form the primary prey in the food webs of the River and Bay. Species of oligochaetes and chironomids (e.g., worms and midges) are typically most abundant and are found throughout the Lower Fox River and Green Bay. Amphipods, crayfish, snails, and mussels are also present in the River and Bay. Zebra mussels, an exotic species, are present throughout Green Bay and the River.
- Fish of the region include salmon/trout; game fish, including walleye, yellow perch, and northern pike; and pelagic and benthic non-game fish. A discussion of the significant fish species within the study area is presented later in this section.
- Birds of the region include raptors, gulls/terns, diving birds, migratory waterfowl, passerines, shorebirds, and wading birds. A listing of the significant bird species within the study area is presented later in this section. These animals are found nesting, feeding, and living in both terrestrial and aquatic habitat environments.
- Mammals of the region include large and small game animals that generally live in open or wooded habitat, as well as fur-bearing animals that may forage or live within or near aquatic environments. The small and large game animals include rabbits, squirrels, and deer. The fur-bearing animals include beaver, red fox, mink, raccoon, muskrat, and otter. Additionally, bats feed on insects in the vicinity of Lake Winnebago and near the communities along the Fox River. Few of the mammals will be discussed in detail within this document. Mink are the principal species discussed in the BLRA.

- Reptiles and amphibians, including snakes, turtles, frogs, and toads are present in the region (Exponent, 1998). Typically, the frogs and turtles confine themselves to the wetland and near shore areas while several snake species and toads are found in association with both terrestrial and aquatic habitats. Frogs and toads that dwell in wetlands or near shore areas are fed upon by wading birds of the region.

Through the mid-1970s the population levels of fish species, such as walleye and perch, were low within the Lower Fox River and southern Green Bay ecosystems. Contaminants, along with low dissolved oxygen (DO) conditions brought about by uncontrolled and untreated wastewater dumped into the River, were believed to be a contributing factor causing low population levels. Principal species found within the system were those that could tolerate these conditions, especially bullhead and carp.

With the institution of water quality controls in the mid-1970s, contaminants and DO conditions improved. The WDNR undertook a program to reintroduce walleye into the River and Bay through a stocking program beginning in 1973. That program was very successful; self-sustaining populations of walleye now exist within the River and Bay. Recent electro-fishing catch data for walleye from De Pere dam to the mouth of the Lower Fox River are shown on Figure 2-15 of the BLRA.

In addition to walleye, a number of other species were reestablished in the Lower Fox River and Green Bay, including white and yellow perch, alewife, shad, bass, and other species. Historical anecdotal data from the Oneida tribe and more recent creel survey data from the WDNR indicate that Duck Creek and Suamico tributaries to southern Green Bay were used by numerous fish species (Nelson, 1998).

The WDNR has completed extensive fish surveys in the Lower Fox River and inner Green Bay. However, due to the numerous factors that may effect fish populations, simply reviewing and comparing the population survey results from various years is not valid. Year-to-year fish populations do not necessarily indicate whether conditions within the River/Bay are degraded or improving because other environmental, physical, or biological factors may be impacting select fish species at any given time. Selected fish surveys for the Lower Fox River have been reviewed to provide data on the types of fish present within the system at given points in time. However, no in-depth analysis of whether these population surveys indicate declining or improving conditions is included. No Green Bay fish surveys are included in this discussion. Rather, the personal observations from WDNR and MDNR personnel familiar with both the commercial and sport fisheries of Green Bay are used.

8.3.1 Screening Ecological Risk Assessment

The Screening Ecological Risk Assessment (SERA) for the Lower Fox River and Green Bay focused on the potential for ecological risks associated with chemicals in sediments, surface waters, and biota. The SERA was conducted using conservative exposure and effects scenarios in an effort to identify which of the over 300 contaminants previously identified potentially posed risks to ecological receptors. Data from 16 separate comprehensive studies conducted on the Fox River and Green Bay by state, federal, university, and private parties were used to assess risk. The objective of the screening was to identify a smaller list of contaminants that would be carried through to the baseline risk assessment.

As defined in the Superfund Risk Assessment Guidance (EPA, 1997a), following the completion of the SERA, a Scientific Management Decision Point (SMDP) was necessary to review the results of the SERA. The technical team of risk managers and risk assessors, collectively referred to as the Biological Technical Assistance Group (BTAG), were assembled during the SERA process to specifically address SMDPs and provide technical review.

The SMDP was formalized in a memo from WDNR dated August 3, 1998 (Appendix A - RA). The memo identified and justified which chemicals should be carried forward into the RA, based on the potential for either human health or ecological risk. Of the 75 chemicals that were above screening level risk criteria, only those with the most potential for adverse risk were carried forward as BLRA contaminants of potential concern (COPCs).

The retained COPCs include: PCBs (expressed as total and PCB coplanar congeners), dioxin and furan congeners, DDT and its metabolites DDE, and DDD, dieldrin, arsenic, lead, and mercury. Sediment HQs were greatest for PCBs based on both human heath and ecological risk-based screening levels.

8.3.2 Baseline Ecological Risk Assessment

The overall ecological goals of the Baseline Risk Assessment (BLRA) for the Lower Fox River and Green Bay were to:

- Examine how the contaminants of potential concern (COPCs) carried forward from the Screening Level Risk Assessment (SLRA) (RETEC, 1998b) move from the sediment and water into ecological receptors within the Lower Fox River and Green Bay.
- Quantify the current (or baseline) ecological risk associated with the COPCs.
- Distinguish those COPCs, which pose the greatest potential for risk to the environment and should be carried forward as contaminants of concern (COCs) in the FS.
- Determine which exposure pathways lead to the greatest risks.
- Support the selection of a remedy, which eliminates, reduces, and/or controls identified risks by calculating sediment quality thresholds (SQTs).

Consistent with Superfund policy and guidance, the BLRA is a baseline risk assessment and, therefore, assumes no actions (remediation) to control or mitigate hazardous substance releases. The following discussion summarizes the BLRA with respect to the four basic steps of the Superfund Ecological Risk Assessment process: 1) Problem Formulation, 2) Exposure Assessment, 3) Effects Assessment, and 4) Risk Characterization.

Problem Formulation

Chemicals of Concern
PCBs were carried forward in the BLRA as the primary COPC because SLRA-calculated sediment hazard quotients (HQs) ranged from 1,514 to 5,872, generally several orders of magnitude greater than HQs for other COPCs. Although 2,3,7,8-TCDD is the most toxic dioxin congener, all structurally related dioxin and furan congeners were evaluated for toxicity based on the toxicity equivalency method, further described in Section 6.3.2 of the BLRA. The dioxin and furan congeners that will be evaluated are those that have been measured in Site media and those that have toxic equivalency factors (TEFs). The only PCB congeners that were evaluated for dioxin-like toxicity are those that most structurally resemble dioxin and have the greatest potential for bioaccumulation: congeners 77, 81, 105, 118, 126, and 169, as further discussed in Section 6.3.3 of the BLRA.

The electronic Fox River Database (FRDB) currently contains more than 500,000 records representing contaminant data from sediment, water, and tissue data. Total PCBs are the most frequently found analyte in the database. 1989 was used as a cut-off date for inclusion of data for the evaluation of risk for several reasons: 1) the contribution of these data towards assessing risk was considered to be less advantageous than the greater accuracy obtained by evaluating risk based on more current data; 2) no data collected prior to 1989 were validated, and 3) although data collected in 1989 were not validated, the total number of samples collected in this year is more than 30 percent of all samples collected.

<u>Complete Exposure Pathways</u>
Currently, the principal source for COPCs is the contaminated sediment deposits found throughout the system. The principal transport mechanism is sediment resuspension, with transport occurring by downstream currents in the Lower Fox River, and by discrete resuspension transport and deposition events within Green Bay (WDNR, 1998b, 1998c). The fate of these contaminants, following their release into the water column, depends on the chemical properties of the contaminant, abiotic factors within the receiving environment (e.g., organic carbon in sediments, pH, surface water hardness), and interaction with the biotic environment. This interaction can result in degradation, transformation, or bioconcentration of the contaminant. The fate of a contaminant is not fixed, and the degree of contaminant exchange between surface water, sediment, sediment pore water, and biota varies.

Aquatic organisms can be exposed to COPCs through the water column, through ingesting sediments, and through consumption of contaminated prey. Water column organisms are exposed to dissolved and particulate-based COPCs through respiration, ingestion and direct contact. Benthic invertebrates are exposed through direct contact and ingestion of contaminated sediments. Benthic fish, carnivorous birds and carnivorous mammals can incidentally ingest sediments during feeding on prey species. All of the COPCs have the potential to biomagnify up the food chain except for lead and arsenic, which can bioconcentrate. Therefore, benthic invertebrates, fish, birds and mammals are all exposed to COPCs by consuming contaminated food.

PCBs in the environment are stable and persistent; cycling rather than degradation represents the predominant fate. PCBs are highly lipophilic and, therefore, more readily bind to sediments or accumulate in tissues rather than remain in the water column. Aquatic organisms can be exposed to PCBs through the water column, through ingesting sediments, and through consuming prey. For invertebrates, both aquatic and benthic, exposure to PCBs through contact with the water column or pore water contributes significantly to the total body burden of total PCBs. For most species, however, particularly those at high trophic levels, prey consumption is likely the primary route of exposure. Biological uptake of PCBs by aquatic organisms appears to be species-specific. Rates of accumulation vary depending on species, age, sex, and size. Generally, when equally exposed, fish accumulate two to three times more PCBs than aquatic invertebrates.

Bioaccumulation of non-polar organic compounds occurs as a result of uptake by a receptor, followed by partitioning of the compounds into the receptor's organic carbon compartment-the lipids. Once chemicals are accumulated within an organism's lipid fraction, biomagnification may occur when organisms at lower trophic levels are preyed upon by receptors higher in the food chain. The net result is an aggregate increase in tissue body burdens of the chemicals at higher trophic levels.

Animals and plants living in or near the River, such as invertebrates, fish, amphibians, and water-dependent reptiles, birds, and mammals, are or can be exposed to PCBs directly and/or indirectly through the food chain. Ecological exposure to PCBs is primarily an issue of bioaccumulation through the food chain rather than direct toxicity, because PCBs bioaccumulate in the environment by bioconcentrating (i.e., being absorbed from water and accumulated in tissue to levels greater than those found in surrounding water) and biomagnifying (i.e., increasing in tissue concentrations as they go up the food chain through two or more trophic levels). As a result, the ecological risk assessment emphasizes indirect exposure at various levels of the food chain to address PCB-related risks at higher trophic levels. The ecological conceptual model is provided in Figure 3.

Assessment Endpoints

Appropriate selection and definition of assessment endpoints, which focus the risk assessment design and analysis, are critical to the utility of risk assessment. It is not practical, nor possible, to directly evaluate risks to all of the individual components of the ecosystem at the Site. Assessment endpoints were selected for the risk assessment based on particular components of the ecosystem that could be adversely affected by the contaminants present. Eight assessment endpoints were developed to evaluate the risk of contaminants in the Lower Fox River and Green Bay. They include the functioning of water column and benthic invertebrate populations, benthic and pelagic fish survival and reproduction, insectivorous, piscivorous, and carnivorous bird survival and reproduction, and piscivorous mammal survival and reproduction. By evaluating and protecting these assessment endpoints, it is assumed that this ecosystem as a whole would also be protected.

Conceptual Model

The biological conceptual model identifies where contaminant interactions with biota can occur, describes the uptake of Site contaminants into the biological system (in this case, the water and sediments of the Lower Fox River and Green Bay), and diagrams key receptor contaminant exposure pathways. Due to the large area being assessed for risk, more than one conceptual model was necessary. The Lower Fox River, from the mouth of Lake Winnebago to the De Pere dam, was evaluated using the same conceptual model (Figure 3).

Measurement Endpoints

Risk questions are assessed using measurement endpoints. Types of measurement endpoints used in the risk assessment process fall generally into four categories: 1) comparison of estimated or measured exposure levels of COPCs to levels known to cause adverse effects, 2) bioassay testing of site and reference media, 3) in-situ toxicity testing of Site and reference media, and 4) comparison of observed effects on-site with those observed at a reference site. Measurement endpoints selected for assessment endpoint evaluation in this risk assessment consistently fell in to the first category of measurement endpoints and are presented in Table 6-2 from BLRA. Only existing data were evaluated as part of this assessment. As such, the measurement endpoints were fashioned around the existing data. Where the data did not already exist to fulfill the measurement endpoint, it was modeled based on the existing data.

Exposure Assessment

The exposure assessment includes a quantitative evaluation of contaminant release, migration, and fate; characterization of exposure parameters; and measurement or estimation of exposure point concentrations. Complete exposure pathways and exposure parameters (e.g., body weight, prey ingestion rate, home range) used to calculate the concentrations or dietary doses to which the receptors of concern may be exposed were obtained from EPA references, the scientific literature and directly from researchers. In the FRDB, data were generally lacking for piscivorous and carnivorous birds, and no data were available for piscivorous mammals, therefore, ecological modeling was used to estimate COPC exposure to these receptors.

Description of Groups of Key Species
Invertebrate communities constitute a vast portion of the basis of the food chain in aquatic ecosystems. Since invertebrates process organic material and are prey items for other invertebrates, fish, and birds, they are important in nutrient and energy transfer in an aquatic ecosystem. Alterations in invertebrate functions may consequently affect nutrient and energy transfer, and bird and fish populations. Also, COPCs in invertebrates may be passed along through the food chain. Therefore, upper trophic levels can be affected not only by reduced prey abundance, but also by trophic transfer of accumulated contaminants in invertebrate prey. Examples of important benthic invertebrates in the Lower Fox River system include chironomids (e.g., midges) and oligochaetes (e.g., segmented worms).

Fish have many roles in the aquatic ecosystem, including the transfer of nutrients and energy, and are prey for mammals, birds, and predatory fish. In fact, several predators rely solely, or primarily, on fish for survival. Fish typically constitute a large proportion of the biomass in aquatic systems. Additionally, fish have social and economic value; impaired fish communities would adversely affect commercial and recreational fishing. Benthic fish are those fish that live in contact with and forage for food directly in the sediments. As such, they represent a unique exposure pathway because of their foraging behavior (i.e., high exposure to sediments) and prey items (i.e., predominately benthic invertebrates). Examples of benthic fish in the Lower Fox River include carp, catfish, and bullhead. Pelagial fish are those species that live and feed principally in the water column (as opposed to being in direct contact with sediment). Pelagial fish represent many trophic levels with prey items predominately in the water column (e.g., zooplankton and other fish). Examples of important pelagial fish in the Lower Fox River include shiners, shad, alewife, perch, and walleye. Pelagial fish important to Green Bay include the same species as are found in the River, in addition to lake trout and other salmonids in the upper Bay.

Bird populations, in general, present one of the most significant biological components of the River/Bay system and occupy several trophic levels. Given the potential for some contaminants to biomagnify, birds, as upper trophic level receptors, may concentrate, and be affected by, contaminants in their tissues to a greater degree than lower trophic level species. In addition to their ecological importance, birds are socially valued because of recreational activities and aquatic aesthetics. Insectivorous birds rely predominately on insects (e.g., benthic invertebrates) for food. Examples of insectivorous birds in the Lower Fox River and Green Bay region include swallows and blackbirds. Piscivorous birds rely primarily on fish for food. Of the bird populations present at the Site, piscivorous birds represent a high trophic level and, therefore, are more at risk than insectivores from contaminants transferred through the food chain. Examples of piscivorous birds on the Lower Fox River and Green Bay include cormorants and terns. Carnivorous birds were selected for evaluation because of their diverse forage, which can include consumption of fish, piscivorous birds, or even small mammals. Examples of carnivorous birds on the Lower Fox River and Green Bay include eagles, osprey, and other raptors.

Piscivorous mammals represent the upper trophic level of the riverine corridor ecosystem and, therefore, are potentially highly exposed to contaminants that bioaccumulate or biomagnify. Piscivorous mammals rely primarily on fish as food, but may also consume amphibians, invertebrates, crayfish, clams, and mussels. The foraging behavior of these mammals represents a pathway through which energy is transferred from the aquatic to terrestrial ecosystem. Mink are piscivorous mammals found in the Lower Fox River and Green Bay area.

A number of different animals have been or are currently on the Wisconsin, Michigan, or Federal Endangered and Threatened Species lists. Listed animals which have historically been found in the vicinity of the Lower Fox River or Green Bay include: osprey, common tern, Forsters tern, Caspian tern, and great egret (Matteson *et al*., 1998). The osprey, common tern, and Forsters tern have nested along the Lower Fox River as well as at upstream locations in Lake Winnebago, Little Lake Butte des Morts, and Lake Poygan. Osprey have been sighted near Kaukauna and have attempted to nest in the vicinity of Combined locks, while terns have been observed farther upstream. Additionally, Caspian tern and great egret have nested on some of the islands located in Green Bay. Very few nesting pairs have been observed over the past few years and recovery of these populations is slow (Matteson *et al.*, 1998).

In addition to these birds, the WDNR reported a bed of clams or mussels, which may be threatened. The sediment bed, which these clams/mussels inhabit, is approximately 6 meters (20 feet) wide and 30.5 meters (100 feet) long and is located near the mouth of Mud Creek in the Lower Fox River (Szymanski, 1998, 2000).

As mentioned above, populations of both eagles and the double crested cormorants have recovered to the point where both birds have been removed from the Wisconsin endangered species list. Other populations, specifically, wild mink and otter, have been found to be declining around the Lower Fox River and Green Bay, yet they are not currently listed by state or federal agencies. The endangered and threatened fish and birds of the region were listed on Tables 2-11 and 2-12 of the BLRA. The endangered and threatened mammals of the region are listed in Table 2-14 of the BLRA.

Derivation of Exposure Point Concentrations

<u>All COPCs</u>

Tables 9 through 13 show the exposure point concentrations for chemicals where risk was indicated. For calculation of exposure values, one-half of the sample quantitation limit was used for undetected values (EPA, 1991b). The 95 percent UCL of the mean is the value that a mean, calculated repeatedly from subsamples of the data population, will not exceed 95 percent of the time. Therefore, there is a 95 percent probability that the true mean of the population does not exceed the 95 percent UCL. The 95 percent UCL was calculated from the sample values depending on whether the data were normally, log-normally, or not normally distributed. When the data distribution fit neither a normal nor log-normal distribution pattern, the 95 percent UCL selected was the greater of the two calculated 95 percent UCLs (normal and log-normal). In cases where data was limited, or where the variability in the data was high, the calculated 95 percent UCL can exceed the maximum detected concentration. The RME is defined as the lesser of the calculated 95 percent UCL, or the maximum detected value.

As an estimate of risk, both the arithmetic mean concentration and the RME concentration are used as exposure point concentrations. The RME is an estimate of the highest average exposure expected to occur at a Site. The intent of the RME is to provide an estimate of exposure that is above average, yet still within the range of most exposures. The RME thus provides a degree of protectiveness that encompasses the individual receptors that have a higher likelihood of exposure.

Table 9 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Water Column Invertebrates

Scenario Time Frame:	**Current**
Medium:	**Water**
Exposure Medium:	**Surface water**

Exposure Point	Chemical of Concern	Concentration Detected (ng/l)		Frequency of Detection	Exposure Point Concentration (ng/l)	Statistical Measure
		Min.	Max.			
Surface Water (OU 1)	Mercury (unfiltered)	0.2	7140	5/6	7140	max
					2237	mean
	Total PCBs (filtered)	1.4	19	40/46	15.3	95% UCL
					11.1	mean
	Total PCBs (unfiltered)	na	na	0/6		
	Total PCBs (particulates)	0.1	40.2	34/41	40.2	max
Surface water (OU 2)	Total PCBs (particulate)	0.01	52.2	82/86	52.2	max
					11.9	mean
					16.6	mean

na = not applicable

Table 10 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Benthic Invertebrates

Scenario Time Frame:	**Current**
Medium:	**Sediment**
Exposure Medium:	**Sediment**

Exposure Point	Chemical of Concern	Concentration Detected		Frequency of Detection	Exposure Point Concentration	Statistical Measure
		Min	Max			
Sediments (OU 1)	Lead (mg/kg)	3.8	522	27/27	172	mean
					522	max
	Mercury (mg/kg)	0.2	3.3	71/86	1.4	95 %UCL
					1	mean
	2,3,7,8-TCDD (µg/kg)	1.80e-03	5.40e-03	4/5	4.30e-03	95% UCL
					2.50e-03	mean
	Total PCBs (µg/kg)	25	130,000		22,848	95% UCL
					10,724	mean
	DDD (µg/kg)	4.7	19	4/23	19	max
					17.8	mean
	DDT (µg/kg)	13	50	2/20	50	max
Sediments (OU 2)	Lead (mg/kg)	44	130	10/10	88.9	95% UCL
					75.6	mean
	Mercury (mg/kg)	0.2	2.1	10/10	1.7	95% UCL
					0.8	mean
	Total PCBs (µg/kg)	3.50e +01	7.42e+04	122/131	1.53e+04	95% UCL
					6.75e+03	mean

Table 11 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Fish

Scenario Time Frame:	**Current**					
Medium:	**Fish**					
Exposure Medium:	**Fish**					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
OU 1						
whole fish tissue (carp)	PCBs (µg/kg)	245	11,400	30/30	2957	95% UCL
					1992	mean
whole fish tissue (gizzard shad)	PCBs (µg/kg)	54	530	4/4	530	max
					296	mean
whole fish tissue (golden shiner)	PCBs (µg/kg)	845	1140	2/2	1140	max
					993	mean
whole fish tissue (yellow perch)	PCBs (µg/kg)	363	na	1/1	363	max
whole fish tissue (walleye)	PCBs (µg/kg)	98.9	3800	11/13	3800	max
					1159	mean
OU 2						
whole fish tissue (carp)	PCBs (µg/kg)	160	6600	12/12	3606	95% UCL
					2581	mean
whole fish tissue (yellow perch)	PCBs (µg/kg)	425	1298	4/4	1219	95% UCL
					779	mean
whole fish tissue (walleye)	PCBs (µg/kg)	1431	3900	4/4	3900	max
					2737	mean

na = not applicable

Table 12 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds

Scenario Time Frame:	**Current**
Medium:	**Prey Items**
Exposure Medium:	**Prey Items**

Exposure Point	Chemical of Concern	Concentration Detected		Frequency of Detection	Exposure Point Concentration	Statistical Measure
		Min	Max			
OU 1						
Tree swallow egg	PCBs (µg/kg)	1790	4030	5/5	3732	95% UCL
					2924	mean
Tree swallow whole body	PCBs (µg/kg)	79	7400	24/24	5254	95% UCL
					2135	mean
Common tern ingestion	mercury (µg/kg)	na	na	na	1.5	mean
					1.6	RME
	mercury (µg/kg -BW/day)	na	na	na	12.5	mean
					13.1	RME
	total PCBs (µg/day)	na	na	na	17.4	mean
					31.2	RME
	total PCBs (µg/kg-BW/day)	na	na	na	145	mean
					260	RME
Forster's tern ingestion	mercury (µg/kg)	na	na	na	1.8	mean
					1.9	RME
	mercury (µg/kg-BW/day)	na	na	na	11.5	mean
					12.1	RME
	total PCBs (µg/kg)	na	na	na	21.2	mean
					37.9	RME
	total PCBs (µg/kg-BW/day)	na	na	na	134	mean
					240	RME
Double Crested Cormorant ingestion	mercury (µg/kg)	na	na	na	8.1	mean
					8.6	RME

Table 12 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds

Scenario Time Frame:	**Current**					
Medium:	**Prey Items**					
Exposure Medium:	**Prey Items**					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
	mercury (µg/kg-BW/day)	na	na	na	4.8	mean
					5.1	RME
	total PCBs (µg/kg)	na	na	na	94.1	mean
					168	RME
	total PCBs (µg/kg-BW)	na	na	na	56	mean
					100	RME
bald eagle	total PCBs (µg/kg)	na	na	na	963	mean
					1647	RME
	total PCBs (µg/kg-BW)	na	na	na	207	mean
					354	RME
OU 2						
common tern ingestion	mercury (µg/kg)	na	na	na	1.5	mean
					1.5	RME
	mercury (µg/kg-BW/day)	na	na	na	12.3	mean
					12.3	RME
	total PCBs (µg/kg)	na	na	na	45.8	mean
					71.6	RME
	total PCBs (µg/kg-BW/day)	na	na	na	382	mean
					597	RME
Forster's tern ingestion	mercury (µg/kg)	na	na	na	1.8	mean
					1.8	RME
	mercury (µg/kg-BW/day)	na	na	na	11.3	mean
					11.3	RME
	total PCBs (µg/kg)	na	na	na	55.6	mean
					87	RME

Table 12 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Birds

Scenario Time Frame:	**Current**					
Medium:	**Prey Items**					
Exposure Medium:	**Prey Items**					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
	total PCBs (µg/kg-BW/day)	na	na	na	352	mean
					551	RME
double crested cormorant	mercury (µg/kg)	na	na	na	8	mean
					8	RME
	mercury (µg/kg-BW/day)	na	na	na	4.7	mean
					4.7	RME
	total PCBs (µg/kg)	na	na	na	249	mean
					388	RME
	total PCBs (µg/kg-BW/day)	na	na	na	148	mean
					231	RME
bald eagle ingestion	mercury (µg/kg)	na	na	na	40	mean
					67.4	RME
	mercury (µg/kg-BW/day)	na	na	na	8.6	mean
					14.5	RME
	total PCBs (µg/kg)	na	na	na	1376	mean
					1930	RME
	total PCBs (µg/kg-BW/day)	na	na	na	296	mean
					415	RME
bald eagle egg	total PCBs (µg/kg)	na	36000	1/1	36000	max

na = not applicable

RME = reasonable maximum exposure

BW = body weight

Table 13 Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations for Mammals

Scenario Time Frame:	**Current**					
Medium:	**Prey items**					
Exposure Medium:	**Prey items**					
Exposure Point	**Chemical of Concern**	**Concentration Detected**		**Frequency of Detection**	**Exposure Point Concentration**	**Statistical Measure**
		Min	**Max**			
Mammal ingestion (OU 1)	total PCBs (µg/day)	na	na	na	348	mean
					544	RME
	total PCBs (µg/kg-BW/day)	na	na	na	435	mean
					680	RME
Mammal ingestion (OU 2)	total PCBs (µg/day)	na	na	na	422	mean
					613	RME
	total PCBs (µg/kg-BW/day)	na	na	na	527	mean
					766	RME

na = not applicable

RME = reasonable maximum exposure

BW = body weight

PCB-Specific Exposure Point Concentrations

Water

Filtered and particulate concentrations of PCBs were detected in all River reaches and Green Bay zones and these concentrations were summed to estimated total water concentrations of total PCBs. Estimated mean, 95 percent UCL, and maximum total PCB concentrations in water are presented on Figure 6-6 of the BLRA. Estimated mean total PCB concentrations were greatest in Green Bay Zone 1 (60.9 μg/L) and represented an increase of 2.2 times over the estimated mean total PCB concentrations in Little Lake Butte des Morts (27.6 μg/L).

Sediment

Total PCBs were detected frequently in all River reaches and Green Bay zones. Measured concentrations are reported in three different ways: non-interpolated, interpolated (I_0), and interpolated (I_d) for all of the River reaches, but, as discussed in Section 6.4.1 of the BLRA, I_0 concentrations are not presented for zones 2, 3A, 3B, or 4 of Green Bay. In contrast to metals, PCB concentrations generally decreased moving down the River and into the Bay. The mean total PCB concentration ranged from 82.9 μg/kg (Green Bay Zone 4) to 10,724 μg/kg (Little Lake Butte des Morts). Mean, 95 percent UCL, and maximum concentrations of PCBs are presented on Figure 6-8 of the BLRA.

Fish

Total PCBs were detected frequently in all River reaches and Green Bay zones. The range of detection frequency was 85 to 100 percent. The mean total PCB concentration ranged from 79.8 μg/kg (yellow perch from Green Bay Zone 4) to 6,637 μg/kg (carp from Green Bay zones 1 and 2). Mean, 95 percent UCL, and maximum total PCB concentrations in yellow perch, carp, and walleye are presented on Figure 6-11 of the BLRA. Mean, 95 percent UCL, and maximum total PCB concentrations in forage fish species (gizzard shad, alewife, shiner species, and rainbow smelt) are presented on Figure 6-12 of the BLRA.

Birds

Where they were analyzed, total PCBs were detected at a frequency of 100 percent, except for Green Bay Zone 3B where they were detected at a frequency of 95 percent. The mean total PCB concentration ranged from 2,135 μg/kg (whole tree swallow from Little Lake Butte des Morts) to 11,026 μg/kg (whole double-crested cormorants from Green Bay Zone 2). Measured total PCB concentrations in birds are presented on Figure 6-15 of the BLRA. As indicated by this figure, the area where the most bird species were sampled was Green Bay Zone 2. This area also contained the highest concentrations of total PCBs, found in double-crested cormorants.

Mammals

LLBdM: The mean estimated exposure concentration for total PCBs (N), total PCBs (I_0), and total PCBs (I_d) were 435, 397, and 400 μg/kg-BW/day, respectively.
Appleton-LR: The mean estimated exposure concentration for total PCBs (N), total PCBs (I_0), and total PCBs (I_d) were 527, 494, and 501 μg/kg-BW/day, respectively.

Summary of Field Studies

Within the Lower Fox River and Green Bay system, there have been numerous field studies on a variety of different species. Many of the species studied were also evaluated in the BLRA as receptor species that represented the assessment endpoints in the BLRA. While not specifically included in the risk characterization, the studies are presented in BLRA Section 6.5.4 to provide the risk managers with an integrated tool for decision-making.

Effects Assessment

Toxic effects of all COPCs were evaluated in the BLERA. Section 6.3 of the BLRA provides details of the effects of all the COPCs on the assessment endpoints. The rest of the discussion below focuses on effects of PCBs only.

PCBs have been shown to cause lethal and sub-lethal reproductive, developmental, immunological and biochemical effects. The risk assessment limited its focus to adverse impacts on survival, growth and reproduction. The ecological effects assessment includes literature reviews, field studies and toxicity tests that correlate concentrations of PCBs to effects on ecological receptors. Toxic equivalency factors, based on the toxicity of dioxin, have been developed for the dioxin-like PCB congeners. The effects of PCBs on Great Lakes fish and wildlife have been extensively documented. PCB-induced reproductive impairment has been demonstrated for several fish species (Mac, 1988; Ankley *et al.*, 1991; Walker and Peterson, 1991; Walker *et al.*, 1991a, 1991b; Williams and Giesy, 1992), a number of insectivorous and piscivorous birds (Kubiak *et al.*, 1989; Gilbertson *et al.*, 1991; Tillitt *et al.*, 1992) and mink (Aulerich *et al.*, 1973, Aulerich and Ringer, 1977; Bleavins *et al.*, 1980; Wren, 1991; Giesy *et al.*, 1994c; Heaton *et al.*, 1995a, 1995b; Tillitt *et al.*, 1996).

Derivation of TRVs

In order to derive toxicity reference values (TRVs), a comprehensive literature search was performed for all COPCs. A variety of databases were searched for literature references containing toxicological information. Some of these literature sources included Biological Abstracts, Applied Ecology Abstracts, Chemical Abstract Services, Medline, Toxline, BIOSIS, ENVIROLINE, Current Contents, Integrated Risk Information System (IRIS), the Aquatic Information Retrieval Database (AQUIRE) maintained by the EPA, and the Environmental Residue Effects Database (ERED) maintained by the EPA and U.S. Army Corps of Engineers. The TRVs selected for this assessment were discussed with and agreed upon by BTAG members. Importantly, the consensus on the TRVs are for site-specific use only and are not intended to be used at other sites (Table 6-5 of the BLRA).

TRVs were used to estimate the potential for ecological risk at the Site. The selected TRVs were either Lowest Observed Adverse Effects Levels (LOAELs) and/or No Observed Adverse Effects Levels (NOAELs) from laboratory and/or field based studies reported in the scientific literature. LOAELs are the lowest values at which adverse effects have been observed, and NOAELs are the highest values at which adverse effects were not observed.

The PCB and dioxin-like PCB congener TRVs for fish, birds and mammals are based on effects on survival, growth, and reproduction of fish and wildlife species in the Fox River. Reproductive effects (e.g., egg maturation, egg hatchability and survival of juveniles) were generally the most sensitive endpoints for animals exposed to PCBs.

Risk Characterization

<u>Hazard Quotient Calculations</u>
Risk characterization for each assessment endpoint was based upon the calculated HQs and, as available, population or field study data. Hazard quotients calculated based on literature values, provide one line of evidence for characterizing ecological effects. Field studies were evaluated, where appropriate, as a supplement to the risk evaluation, particularly when the contamination has a historical basis (EPA, 1994b, 1997a).

While HQs and other lines of evidence (i.e., field studies and other data types) cannot be quantitatively combined, each can inform risk managers on the presence of risk and how these risks may be reduced. Therefore, this risk characterization process did not result in the distillation of a single conclusive statement regarding overall risk to each assessment endpoint. Consideration of the magnitude of uncertainty, discussed in Section 6.6 of the BLRA, is also a key component of the risk interpretation process.

For this risk assessment it was agreed by BTAG that degree of risk would be determined based on three categories: "no" risk was concluded when both the NOAEC and LOAEC HQs evaluated were less than 1.0, "potential" risk was concluded when the NOAEC HQ exceeded 1.0 but the LOAEC HQ was less than 1.0, and risk ("yes") was concluded when both the NOAEC and LOAEC HQs evaluated were greater than 1.0. When constituents were analyzed but not detected, it was concluded that no risk existed.

OU 1 - Little Lake Butte des Morts Summary. In summary, the results suggest that only measured or estimated concentrations of total PCBs are at sufficient levels to cause risk to benthic invertebrates, and piscivorous mammals. Potential risks from total PCBs are indicated for water column invertebrates, benthic and pelagic fish, and insectivorous, piscivorous, and carnivorous birds. Measured or estimated concentrations of mercury are found to be at sufficient concentrations to cause or potentially cause risk to water column and benthic invertebrates, and piscivorous birds. Concentrations of 2,3,7,8-TCDD, DDD, and DDT are only sufficient to be of risk to benthic invertebrates. Sediment concentrations of elevated PCBs are widespread and persistent throughout the reach. Concentrations of arsenic, dieldrin, and all o,p'- isomers of DDT and its metabolites are not found to pose risk to any assessment endpoint.

OU 2 - Appleton to Little Rapids Summary. In summary, the results taken in total suggest that measured or estimated concentrations of total PCBs are at sufficient levels to cause risk to benthic invertebrates, carnivorous birds, and piscivorous mammals. Potential risks are indicated for all other receptors except insectivorous birds, for which there are no data. Measured or estimated concentrations of mercury were found to be at sufficient concentrations to cause risk to benthic invertebrates, piscivorous birds, and carnivorous birds. Concentrations of lead are only of risk to benthic invertebrates. Concentrations of all chlorinated pesticides are not found to pose risk to any assessment endpoint. Surface sediment concentrations of elevated PCBs indicate reach-wide effects, but are likely limited to specific deposits.

Major Findings

A summary of the risk to each assessment endpoint in each reach and zone is presented in Table 6-134 of the BLRA. OU 1 and OU 2 are discussed below and summarized in Table 14. Risk assessment summaries will be provided for OU 3, OU 4 and OU 5 in subsequent RODs.

The principle findings of the ecological risk assessment are:

- Total PCBs cause, or potentially cause risk to all identified receptors. The exception is insectivorous birds where the weight of evidence suggests that these receptors are not at risk from PCB concentrations. Not all receptors at risk or potentially at risk from PCBs are at risk in all River reaches or Bay zones.
- Mercury poses a risk in all River reaches and zones, but not to all receptors. Mercury was not identified as a risk for benthic fish, insectivorous birds, or piscivorous mammals.
- DDT or its metabolites poses a risk to benthic invertebrates in OU 1 (i.e., Little Lake Butte des Morts Reach).

Table 14 Ecological Risk Summary

OU	Water Column Invertebrates		Benthic Invertebrates		Benthic Fish		Pelagic Fish		Insectivorous Bird		Piscivorous Bird		Carnivorous Bird		Piscivorous Mammal	
1	● ☼	Mercury PCBs	●	PCBs, lead, mercury, DDD,DDT, 2,3,7,8TCDD	☼	PCBs	☼	PCBs	☼	PCBs	☼	mercury, PCBs	☼	PCBs	●	PCBs
2	☼	PCBs	●	lead, mercury, PCBs	☼	PCBs	☼	PCBs		NA	☼	mercury, PCBs	● ☼	PCBs, mercury	●	PCBs

Notes:

NA = no data available

Risk conclusions based on HQs

= No risk

● = Risk

☼ = Potential Risk

Risk Conclusions based on weight of evidence

= Site specific receptor data suggest that there is no risk

= Because of the Federal listing of the bald eagle as threatened, it is concluded that potential risk is actual risk

<u>Uncertainty</u>

The goal of this uncertainty analysis is to both qualitatively, and quantitatively to the degree possible, define the degree of confidence that exists with the estimations of effects from exposure to hazardous chemicals in toxic amounts. Bounding the certainty of risk estimates is a developing science. EPA's Superfund Ecological Risk Assessment Guidance (EPA, 1997a) and the Guidelines for Ecological Risk Assessment (EPA, 1998b) provide general instructions on what should be addressed in an uncertainty analysis.

<u>Conceptual Site Model</u>

Qualitatively, there is a high degree of certainty that factors (such as fate and distribution, downstream transport, biological uptake, effects on field populations, habitat and life histories of important fish, birds, and mammals within the River and Bay) are well understood and adequately characterized in the conceptual site model. There remains, however, some uncertainty as to whether the receptors identified within the conceptual site model adequately represent the ecosystem and other species potentially at risk within the Lower Fox River. The selection of the important receptor species was done in consultation with biologists both within the WDNR and the USFWS. In addition, input on the receptor species was given by biologists and resource managers within EPA, NOAA, and the Oneida and Menominee Nations through the USEPA Biological and Technical Assistance Group (BTAG) process. However, despite this, there remains a class of organisms and a threatened species that was not addressed in this BLRA. Reptile and amphibian species were not evaluated for risk because there are no data within the FRDB to evaluate this receptor group, and there are no uptake models to estimate risk for frogs or other amphibians. For the fish species sturgeon, listed as a threatened species in Michigan, but not in Wisconsin, there are also too few data points within the FRDB to evaluate potential risks.

<u>Data</u>

The FRDB represents numerous separate data collection efforts with over 500,000 discrete data records of air, water, sediments, and tissue, from throughout the Lower Fox River and Green Bay. A rigorous evaluation of the quality of the data was undertaken, and only data for which at least partial QA packages could be reviewed were placed into the FRDB. Of the studies between 1971 and 1991, only partial packages could be reviewed, and so those data were used as supporting evidence within the BLRA. There have been several studies completed on the Fox River in the 1990s. All studies conducted after 1992 have fully validated data packages. Given the temporal and spatial density of the data within the Lower Fox River, there are good reasons to assume that the overall quality of the data is high, and thus the related degree of data uncertainty is low. There were no significant biases or gaps observed within the sediment, fish, or bird sample data.

Another data gap within the BLRA is that there are limited measurements of metals and the organochlorine pesticides in the surface water. However, this impacts only the ability to assess risks to pelagic invertebrate communities, and the remaining assessment endpoints could be addressed through the other media (e.g., bird tissues) for which data were judged adequate. Finally, there are relatively too few data on all PCB congeners for all media within the Lower Fox River and Green Bay to make conclusive assessments or predictions of risk. While the FRDB contains numerous congener-specific data points, until relatively recently all of the dioxin-like congeners have not been adequately assessed. For example, while PCB congener 169 has been detected in the fish and birds of the River and Bay, there have been too few measurements taken in sediments or water.

<u>Temporal</u>

A time trends analysis was undertaken to specifically address the question of losses or gains in PCB concentrations over time in sediments and fish. For sediments, a large fraction of analyses provided little useful information for projecting future trends because of the lack of statistical significance and the wide confidence limits observed. This is especially true for sediments below the top 4 inches; changes in the sediment PCB concentrations cannot be distinguished from zero-or no change. Generally over time, however, the surface sediment concentrations (i.e., top 10 cm) of PCBs have been steadily decreasing, but the rate of change in surface sediments is both reach- and deposit-specific. The change averages an annual decrease of 15 percent, but ranges from an increase of 17 percent to a decrease of 43 percent. Given these conditions, the sediment data used may over- or under-evaluate the risks dependent upon how much older data were used in the point estimates or interpolated bed maps.

Like sediment PCB concentrations, fish tissue PCB concentrations showed a significant but slow rate of change throughout the Lower Fox River and Green Bay. In all of the reaches of the River and in Zone 2, there were steep declines in fish tissue PCB concentrations from the 1970s, but with significant breakpoints in declines beginning around 1980. After the breakpoint, depending upon the fish species, the additional apparent declines were either not significantly different from zero, or were relatively low (i.e., 5 to 7 percent annually). In addition, there are some increases in fish tissue PCB concentrations. Walleye in Little Lake Butte des Morts show a non-significant increase of 22 percent per year since 1987. Likewise, gizzard shad in Zone 2 show a non-significant increase of 6 percent per year into 1999. These data, taken collectively, suggest that since the breakpoint for tissue declines occurred in the early 1980s and the changes in fish tissue concentrations were no greater than 4 to 7 percent annually, aggregating fish tissue from 1989 does not likely result in any significant biasing of the risk estimations. At worst, the tissue point estimates might overestimate risks by 50 percent (i.e., average of 5 percent per year over 10 years), but given that at least some fish tissue concentrations increased, it is reasonable to suggest that some risks were underestimated by at least an equivalent amount.

<u>Spatial Variability</u>

Uncertainty in the spatial variability refers principally to where sediment samples were collected from within the Lower Fox River and Green Bay. Within the River, most sampling efforts are concentrated in areas where there were thick sediment deposits (e.g., A, POG, N, GG/HH, and the SMUs below De Pere). There were no systematic sampling efforts to define PCB concentrations throughout the River. Within the Bay, systematic grid sampling was employed, but the spatial uncertainty is higher because of the large distance between sampling points. Sediment concentrations used in the risk assessment were based on both non-interpolated and interpolated concentration estimation methods so that the differences in risk estimates could be compared. The calculations demonstrate that in general, using the interpolated sediment yields a lower estimation of sediment-based risk than use of the non-interpolated data.

Toxic Exposure

Point estimates of exposure concentrations were compared in the BLRA to point estimates of toxicity in the literature to yield the hazard quotients. While the rationale used to select the most representative value from the literature was presented in Section 6.3, there remain uncertainties associated with effects concentrations above or below the selected TRV, selection of TRVs from one species and applying to another, interpretation between NOAECs and LOAECs based on application of uncertainty factors, or application of different sets of toxicity equivalent factors from the literature. For PCBs, risk estimation uncertainty was reduced by determining risk potential on a total PCB basis and a PCB congener basis for receptors where both exposure and effects data were available (i.e., fish and birds).

Alternative Exposure Points

The principle exposure point concentration used for risk evaluation in the BLRA was the RME (i.e., the lower of either the 95 percent UCL or the maximum concentration) for all media and receptors evaluated. In order to determine the degree to which risk may have been under or overestimated, 90th percentile concentrations were estimated and evaluated for risk for two representative species; walleye and double crested cormorants.

For walleye, results of this comparison indicated that risk evaluation of the 90th percentile concentrations would result in only two changes to the risk conclusions. Hazard quotients for the total PCB NOAEL for walleye in Green Bay Zone 1 increase from 10 to 14 using the 90th percentile. The risk determination for walleye from total PCBs would change from “potential risk” to “likely risk” in Green Bay zones 1 and 2, and risk from mercury in Green Bay Zone 4 would change from “no risk” to “potential risk”. The net conclusions of the ecological risk assessment for piscivorous fish would be negligibly affected by using the 90th percentile.

For double-crested cormorants, risk evaluation of the 90th percentile concentrations would result in only one change to the risk conclusions. Risk to double-crested cormorants from p,p'-DDE would change from “potential risk” to “likely risk” in Green Bay Zone 3B. Because of the limited 90th percentile data in fish appropriate as prey for double-crested cormorants, dietary concentrations could not be modeled. However, use of the 90th percentile would not appreciably affect the risk determinations for piscivorous birds.

Population Data

As noted previously, while population level endpoints can be an appropriate tool to assess risk, the population data discussed in the BLRA were not collected specifically for risk assessment. There is some uncertainty introduced given the potential for other confounding environmental factors that may affect the absence or abundance of receptors within the Lower Fox River and Green Bay. These can include such things as immigration, emigration, food availability, habitat suitability and availability, species competition, predation, and weather. For example, while the risk assessment concludes that PCBs are at sufficient concentrations to affect mink reproduction within the River and Bay, Section 2 documented that there is limited habitat for mink, especially along the River. While contaminant conditions exist that potentially would jeopardize mink health along the River corridor, the absence of mink due to absence of habitat must be considered.

Likewise, the apparent increase in populations of walleye and cormorants suggest little or no current risks to these species. Increases in walleye populations have occurred since the 1980s, and are directly linked to improvement in water quality and habitat in the Lower Fox River, and not necessarily to decreases in contaminants. Evidence that some risks persist is evidenced in the apparent presence of pre-cancerous lesions. Cormorant population increases may be related to decreases in contaminant concentrations, but are also likely tied to increases in available prey (fish). Like walleye, sublethal conditions appear to persist within the cormorant population. Given a shift in food or habitat conditions, those risks could be potentially of greater concern.

<u>Quantitative Analysis</u>
Only the data for benthic infauna for the Lower Fox River were thought to be amenable to a quantitative analysis. This analysis involved *using* of a range of toxicity values as listed in the literature rather than the single point estimate for toxicity that was used in the main body of the BLRA. This re-analysis was done for each River reach and Green Bay zone.

- LLBdM: There is a high probability (70 to 80 percent) that PCBs are widely distributed throughout the reach at sufficiently high concentrations to moderately effect benthic infaunal populations, and at least a 40 to 50 percent probability of encountering PCB concentrations associated with extreme effects.
- Appleton-LR: For this reach, the probability of infaunal organisms encountering levels of PCBs associated with toxic effects is low (5 to 10 percent).

<u>Concluding Statement</u>
The evaluation of uncertainties did not change the general conclusions drawn from the BLRA, which are that:

- Fish consumption by other fish, birds and mammals is the exposure pathway that represents the greatest level of risk for receptors (other than direct risk to benthic invertebrates).

The primary COC is PCBs, and other COCs carried forward for remedial evaluation and long-term monitoring are mercury and DDE.

8.4 Derivation of SQTs

Sediment Quality Thresholds (SQTs) are sediment concentrations that have been linked to a specific magnitude of risk. SQTs were developed for each pathway and receptor identified as important in the BLRA by the response agencies of the Lower Fox River and Green Bay (e.g., sport fishing consumption, bald eagles). The SQTs themselves are not cleanup criteria, but were used to evaluate levels of PCBs in the Feasibility Study. The final selection of the remedial action levels is a policy decision left to the response agencies.

SQTs were estimated for PCBs with the assumption that a remedy that reduces PCB exposure would also address the other co-located COCs. Risk-based concentrations in fish for human and ecological receptors were determined based on:

- Human health cancer risk levels of 10^{-4}, 10^{-5}, and 10^{-6}, and a noncancer hazard index of 1.0 for risk in recreational anglers and high-intake fish consumers
- The NOAECs and LOAECs for species of benthic invertebrates, fish, birds, and riverine mammals found in the River and Bay.

8.5 Basis for Action

The excess cancer risk and non-cancer health hazards associated with human ingestion of fish, as well as the ecological risks associated with ingestion of fish by birds, fish and mammals, are above acceptable levels under baseline conditions. The response action selected in this ROD is necessary to protect the public health or welfare and the environment from actual releases of hazardous substances into the environment.

9. REMEDIAL ACTION OBJECTIVES

Consistent with the NCP and RI/FS Guidance, WDNR and EPA developed remedial action objectives (RAOs) for the protection of human health and the environment. The RAOs specify the contaminants and media of concern, exposure routes and potential receptors, and an acceptable concentration limit or range for each contaminant for each of the various media, exposure routes and receptors. RAOs were then used to establish specific Remedial Action Levels (RAL) for the Site. Action Levels were established after review of both the preliminary chemical-specific ARARs and risk-based concentrations and serve to focus the development of alternatives or remedial technologies that can achieve the remedial goals. Although this ROD only addresses remediation of OUs 1 and 2, the RAOs were developed for the entire Lower Fox River and Green Bay and are therefore discussed here. Additional activities as they relate to these RAOs for OUs 3 through 5 will be discussed in a subsequent ROD or RODs.

The FS brought together the four major components used to evaluate risk, remedial goals, and alternative technologies in its analysis of remedial options. These components are briefly described below, then discussed in more detail on the following pages.

- **Remedial Action Objectives.** RAOs are site-specific goals for the protection of human and ecological health. Five RAOs were developed; all five apply to the River, while RAOs 1, 2, 3, and 5 apply to Green Bay.
- **Remedial Action Levels.** A range of action levels were considered for the River and Bay; action levels were chosen based in part on Sediment Quality Thresholds (SQTs), which link risk in humans, birds, mammals, and fish with safe threshold concentrations of PCBs in sediment. The SQTs were developed in the human health and ecological risk assessments.
- **Operable Units.** The four reaches (OU 1 through OU 4) and Green Bay (OU 5) were identified based on geographical similarities for the purpose of analyzing remedial actions.
- **Remedial Alternatives.** Following a screening process detailed in the FS, six remedial alternatives (A-F) were retained for the Lower Fox River and seven (A-G) were retained for Green Bay.

For each River reach, six possible remedial alternatives were applied to each of five possible action levels and evaluated against each of five remedial action objectives. For each Green Bay zone, seven possible remedial alternatives were applied to each of three possible action levels and evaluated against each of four remedial action objectives. The steps in this process are described in more detail below. Cost estimates were also prepared for each combination of River reach/Bay zone, remedial alternative, and action level.

9.1 Remedial Action Objectives

RAOs address the protection of human health and protection of the environment. The following five RAOs have been established for the Fox River and Green Bay Site.

- **RAO 1. Achieve, to the extent practicable, surface water quality criteria throughout the Lower Fox River and Green Bay.** This RAO is intended to reduce PCB concentration in surface water as quickly as possible. The current water quality criteria for PCBs are 0.003 ng/L for the protection of human health and 0.012 ng/L for the protection of wild and domestic animals. Water quality criteria incorporate all routes of exposure assuming the maximum amount is ingested daily over a person's lifetime.
- **RAO 2. Protect humans who consume fish from exposure to COCs that exceed protective levels.** This RAO is intended to protect human health by targeting removal of fish consumption advisories as quickly as possible. DNR and EPA defined the expectation for the protection of human health as the likelihood for recreational anglers and high-intake fish consumers to consume fish within 10 years and 30 years, respectively, at an acceptable level of risk or without restrictions following completion of a remedy.
- **RAO 3. Protect ecological receptors from exposure to COCs above protective levels.** RAO3 is intended to protect ecological receptors like invertebrates, birds, fish, and mammals. DNR and EPA defined the ecological expectation as the likelihood of achieving safe ecological thresholds for fish-eating birds and mammals within 30 years following remedy completion. Although the FS did not identify a specific time frame for evaluating ecological protection, the 30-year figure was used as a measurement tool.
- **RAO 4. Reduce transport of PCBs from the Lower Fox River into Green Bay and Lake Michigan.** The objective of this RAO is to reduce the transport of PCBs from the River into Green Bay and Lake Michigan as quickly as possible. DNR and EPA defined the transport expectation as a reduction in loading to Green Bay and Lake Michigan to levels comparable to the loading from other Lake Michigan tributaries. This RAO applies only to River reaches.
- **RAO 5. Minimize the downstream movement of PCBs during implementation of the remedy.** A remedy is to be completed within 10 years.

No numeric cleanup standards have been promulgated by the federal government or the State of Wisconsin for PCB-contaminated sediment. Therefore, site-specific RAOs to protect human and ecological health were developed based on available information and standards, such as applicable or relevant and appropriate requirements (ARARs), to be considered non-promulgated guidelines (TBC), and risk-based levels established using the human and ecological RAs. The following RAOs were established for the Site:

Remedial Action Levels - PCB remedial action levels were developed based on the Sediment Quality Thresholds (SQTs) derived in the RA for the Lower Fox River and Green Bay. SQTs are estimated concentrations that link risk in humans, birds, mammals, and fish with safe threshold concentrations of PCBs in sediment. The PCB RALs considered are 0.125, 0.25, 0.5, 1.0, and 5.0 parts per million (ppm) for the Lower Fox River and 0.5, 1.0, and 5.0 ppm for Green Bay.

A range of RALs was considered in order to balance the feasibility as determined by implementability, effectiveness, duration, and cost of removing PCB-contaminated sediment down to each action level against the residual risk to human and ecological receptors after remediation. For each River reach or Bay zone, all of the sediment with PCB concentrations greater than the selected RAL is to be remediated. One of the outcomes of applying a specific RAL to a suite of active remedial alternatives is the recognition that Monitored Natural Recovery (MNR) may also be a component of the remedy. This was considered because when sediment is removed to a specific action level, some sediment with PCB concentrations above the SQTs will likely be left in place. MNR can also be a stand-alone remedy if it is determined to achieve sufficient protection within a reasonable time frame. As a result, each action level and each remedial alternative has an MNR component.

9.2 Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121(d) of CERCLA requires that Superfund remedial actions meet ARARs. In addition to applicable requirements, the ARARs analysis that was conducted considered criteria, and relevant and appropriate standards that were useful in evaluating remedial alternatives. These non-promulgated guidelines and criteria are known as To Be Considered (TBCs). In contrast to ARARs, which are promulgated cleanup standards, standards of control, and other substantive environmental protection requirements, criteria or limitations; TBCs are guidelines and other criteria that have not been promulgated.

Location-specific ARARs establish restrictions on the management of waste or hazardous substances in specific protected locations, such as wetlands, floodplains, historic places, and sensitive habitats.

Action-specific ARARs are technology-based or activity-based requirements or limitations on actions taken with respect to remediation. These requirements are triggered by particular remedial activities that are selected to accomplish the remedial objectives. The action-specific ARARs indicate the way in which the selected alternative must be implemented as well as specify levels for discharge. See table 4-2 of the FS. Chemical specific ARARs are health- or risk-based numerical values or methodologies that establish concentration or discharge limits, or a basis for calculating such limits, for particular substances, pollutants or contaminants.

In addition to the water quality criteria, substantive requirements of National Pollutant Discharge Elimination System (NPDES), as implemented under Wisconsin administrative rules, would also be applicable to wastewaters that are planned to be discharged to the Fox River, which will require treatment. These wastewaters include liquids generated during construction activities such as dewatering liquids, excavation area liquids, and liquids generated during construction of any on-site consolidation area. Discharges to Publicly Owned Treatment Works (POTWs) may be pursued as an alternative discharge location. However, such discharges must also comply with limitations to ensure acceptable discharge from the POTW after treatment. The specific discharge levels will be determined during the design stage in coordination with WDNR.

Sediments removed from the Fox River may contain PCBs equal to or greater than 50 ppm. PCB sediment with concentrations less than 50 ppm will be managed as a solid waste in accordance with statutes and rules governing the disposal of solid waste in Wisconsin. PCB sediment with concentrations equal to or greater than 50 ppm will be managed in accordance with the Toxic Substances Control Act (TSCA) of 1976 (Appendix E of the Feasibility Study). The determination that material is subject to regulation under TSCA will be made post-removal but pre-disposal. Presently TSCA compliance would be achieved through the extension of the January 24, 1995 approval issued by EPA to WDNR pursuant 40 CFR 761.60(a)(5) under the authority of TSCA. This TSCA approval, granted by EPA Region 5, states that the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 ppm into an NR 500, WAC landfill that is also in compliance with the conditions of the TSCA approval, provides adequate protection to human health and the environment as required by 40 CFR 761.60(a)(5); and, will provide the same level of protection required by EPA, Region 5 and therefore is no less restrictive than TSCA. However, should other administrative rules pertaining to disposal under TSCA be in effect at the time that TSCA compliance decisions are made for the Fox River sediment, then compliance with those rules will be achieved.

10. DESCRIPTION OF ALTERNATIVES

Following development of the RAOs, WDNR conducted a rigorous screening and evaluation process in accordance with CERCLA and the NCP. First, potentially applicable remedial technologies or process options for addressing PCB-contaminated sediments in the Fox River and Green Bay were identified and screened (evaluated) based on effectiveness and technical implementability at the Site. Retained technologies were then evaluated in a second screening based on effectiveness, implementability and cost. After the second screening, the following four technologies were retained for consideration in the analysis of remedial alternatives: 1) no action, evaluation of which is required by the NCP; 2) Monitored Natural Recovery (MNR); 3) capping to the maximum extent practicable with dredging in areas where capping was not appropriate; and 4) removal/dredging (i.e., environmental dredging) followed by MNR.

Process options for treatment and disposal that were retained include dehalogenation, physical separation and solidification, vitrification and high-pressure oxidation.

After the technology screening, WDNR and EPA developed and screened remedial alternatives. A specified “cleanup value” or “action level” for PCBs in sediment was not developed for purposes of evaluating remedial alternatives. Because consumption of fish is the major pathway of concern, WDNR and EPA developed remedial goals based on PCB concentrations in fish (see Section 9). Therefore, remedial alternatives were evaluated based on their ability to reduce PCB concentrations in fish. PCB concentrations in fish are controlled by PCB concentrations in both the sediment and the water column and, therefore, sediment cleanup is considered the means to the goal of protecting human health and the environment.

For the capping alternative, locations where it was feasible were considered in determining where this technology could be applied based on criteria identified in section 6.4.4 of the Feasibility Study. For excavation alternatives, WDNR and EPA evaluated the following action levels for the Fox River: PCB concentrations of 0.125 ppm, 0.25 ppm, 0.5 ppm, 1.0 ppm, 5.0 ppm, and no action. These results were then compared to the RAOs, particularly RAOs 2 and 3, which deal with protection of human health and the environment. On the basis of that analysis and to achieve the risk reduction objectives using a consistent action level, 1.0 ppm was agreed upon as the appropriate remedial action level. In making this determination, the agencies relied on projections of the time necessary to achieve the risk reduction, the post-remediation surface-weighted average concentration (SWAC), and cost.

Table 15 shows that for the selected Action Level of 1.0 ppm, time to acceptable fish tissue concentrations for walleye, would be achieved within one year in OU 1. This compares to more than 50 years under a No Action alternative also shown in the table.

Table 15 Years to Human Health and Ecological Thresholds for Lower Fox River at 1 ppm PCB Action Level and No Action in OU 1

Fish	Risk Level	Receptor	Estimated Years (for 1.0 ppm Action Level)	Estimated Years (for No Action)
Walleye[1]	RME[2] hazard index of 1.0	Recreational Angler	<1	51
Walleye	RME hazard index of 1.0	High-intake fish consumer	4	65
Walleye	RME 10^{-5} cancer risk level	Recreational Angler	9	84
Walleye	RME 10^{-5} cancer risk level	High-intake fish consumer	14	100
Carp	NOAEC[3]	Carnivorous bird deformity	14	100
Carp	NOAEC	Piscivorous mammal	29	100+

1. Shaded row represents removal of fish advisories.

2. RME indicates the reasonable maximum exposure.

3. NOAEC is the no observed adverse effect concentration.

It is estimated that it would take 40 years to remove fish advisories for OU 2, under the selected remedy, Monitored Natural Recovery. However, the removal of Deposit N (completed in a dredging demonstration project during 1998 and 1999) and Deposit DD (under consideration for remediation in the ROD for OU s 3-5) is not considered in the modeling upon which this estimate was made.

The SWAC is a measure of the surface (upper 10 cm) concentration against a given area. In terms of the Lower Fox River, this would be the average residual contaminant concentration in the upper 10 cm divided by the area of the Operable Unit. The SWAC calculation includes interdeposit areas. The estimated post-removal SWAC value for OU 1 at an action level of 1 ppm is 185 µg/kg.

The SWAC value provides a number that can be compared to the SQTs developed in the RA. SQTs are estimated concentrations that link risk in humans, birds, mammals, and fish with safe threshold concentrations of PCBs in sediment. Human health and ecological SQTs for carp and walleye are listed in Tables 16 and 17, respectively.

Table 16 Human Health Sediment Quality Threshold (SQT) Values

		Recreational Angler		High-Intake Fish Consumer	
		RME[1] µg/kg	CTE[2] µg/kg	RME µg/kg	CTE µg/kg
Cancer Risk at 10^{-5}					
Carp		16	180	11	57
Walleye		21	143	14	75
Non-Cancer Risk (HI =1)					
Carp		44	180	28	90
Walleye		58	238	37	119

1. RME indicates the reasonable maximum exposure;
2. CTE is the central tendency exposure.

Table 17 Ecological Sediment Quality Threshold (SQT) Values

	NOAEC (µg/kg)
Carp – fry growth and mortality	363
Walleye – fry growth and mortality	176
Common Tern – hatching success	3,073
Common Tern – deformity	523
Cormorant – hatching success	997
Cormorant – deformity	170
Bald Eagle – hatching success	339
Bald Eagle – deformity	58
Mink – reproduction and kit survival	24

The volume of sediment and PCB mass that would be removed, as well as the cost to implement the remedy at the 1.0 ppm action level, were also considered. For OU 1 an estimated 784,200 cubic yards and 1,715 kilograms of PCBs would be removed. The cost for remediation of OU 1 is estimated to be $66.2 million.

WDNR and EPA selected six remedial alternatives for detailed analysis: No Action, Monitored Natural Recovery and Institutional Controls, Dredge and Off-Site Disposal, Dredge to a Confined Disposal Facility (CDF), Dredge and Vitrification, and In-situ Capping. These alternatives cover the range of viable approaches to remedial action and include a no-action alternative, as required by the NCP.

10.1 Description of Alternative Components

Remedial Alternatives **-** WDNR and U.S. EPA evaluated several alternatives to address contamination in the Lower Fox River and Green Bay. Because the level of contamination and size of the OUs vary, a specific proposed cleanup plan was developed for each OU. The FS outlines the process used to develop and screen appropriate technologies and alternatives for addressing PCB-contaminated sediment and provides detailed descriptions of the remedial alternatives. The suite of remedial alternatives is intended to represent the remedial alternatives that are available, not to be inclusive of all possible approaches. The proposed alternative for an Operable Unit may consist of any combination of the alternatives described below. Other implementable and effective alternatives could theoretically be used; however, a ROD amendment or Explanation of Significant Difference (ESD) would be required before another alternative could be substituted for the selected remedy.

Alternative A: No Action - A No Action alternative is included for all River reaches and Bay zones. This alternative involves taking no action. The No Action alternative is required by the National Contingency Plan, because it provides a basis for comparison with the alternatives for active remediation.

Alternative B: Monitored Natural Recovery - Similar to Alternative A, the MNR alternative relies on naturally occurring degradation, dispersion, and burial processes to reduce the toxicity, mobility, and volume of contaminants. However, the MNR option also includes a 40-year, long-term monitoring program for measuring PCB and mercury levels in water, sediment, invertebrates, fish, and birds to effectively determine achievement of and progress toward the RAOs. Until the RAOs are achieved, institutional controls are necessary to prevent exposure of human and biological receptors to contaminants. Land and water use restrictions, fishing restrictions and access restrictions may require local or state legislative action to prevent development or inappropriate usage of contaminated areas of the River. Institutional controls include measures that restrict access to or uses of a site. They typically consist of some combination of physical restraints (such as fences to limit access), legal restrictions (such as local ordinances and restrictive covenants that limit land development), and outreach activities (such as public education programs and health advisories).

Alternative C: Dredge and Off-Site Disposal - Alternative C includes the removal of sediment having PCB concentrations greater than the remedial action level using a hydraulic or mechanical dredge, dewatering the sediment either passively or mechanically, treating the water before discharging it back to the River, and then disposing of the sediment off site, transporting it by truck. Sediment disposal would be at a local landfill in compliance with the requirements of NR 500 Wisconsin Administrative Code (WAC), which regulates the disposal of waste and the WDNR's TSCA approval issued by EPA. EPA issued this approval under the authority of the federal TSCA. This approval allows for the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 mg/kg (ppm) in landfills that are licensed under the NR 500 rule series, WAC provided that certain requirements are met.

Alternative D: Dredge to a Confined Disposal Facility (CDF) - Alternative D includes the removal of sediment having PCB concentrations greater than the remedial action level to an on-site CDF for long-term disposal. A CDF is an engineered containment structure that provides both dewatering and a permanent disposal location for contaminated sediment. A CDF can be located in the water adjacent to the shore or at an upland location near the shore. Sediment with PCB concentrations equal to or greater than 50 mg/kg would not be disposed of in a CDF. Such sediments would be mechanically dredged for solidification and disposal at a solid waste landfill conforming to requirements defined by the state in the NR 500 rule series and WDNR's TSCA approval. Conceptual near-shore CDF locations were identified in OU 1.

Alternative E: Dredge and Vitrification - This alternative is similar to Alternative C except that all the dewatered sediment would be thermally treated using a vitrification process. Alternative E assumes that the residual material would be available for possible beneficial reuse after vitrification. Vitrification has been used as a representative thermal treatment process option and was included as an alternative due to a recently completed pilot-scale evaluation.

Alternative F: In-situ (In-place) Capping - Alternative F includes primarily sand capping to the maximum extent possible. The maximum extent of the capping action was defined in each River reach on the basis of site specific conditions such as water depth, average river current, river current under flood conditions, wave energy, ice scour, and boat traffic. Using these criteria, it was determined that capping alone is not a viable option to achieve the site RAOs. Where capping is viable, a 20-inch sand cap overlaid by 12 inches of graded armor stone was selected. Sediment that is not capped but still exceeds the action level would be hydraulically dredged to an on-site CDF, similar to Alternative D. In the FS, several cap designs were retained for possible application; design factors that influence the final selection of an in-situ cap include an evaluation of capping materials and cap thickness when applied in the field. In general, sandy sediment is a suitable capping material, with the additional option of armoring at locations with the potential for scouring and erosion. Laboratory tests developed in the past indicate that a minimum in-situ cap thickness of 12 inches (30 cm) is required to isolate contaminated sediment, as indicated in FS Section 7.1, page 7-4 to 7-5. Full-scale design would require consideration of currents during storm events, wave energy, and ice scour. A minimum river depth of 6 feet would be required (FS Section 7.1.1, page 7-5) for any location where a cap is proposed. Institutional controls and monitoring and maintenance are also components of this alternative. Institutional controls may be necessary to ensure the long-term integrity of the cap. Monitoring and maintenance would be required in perpetuity to ensure the integrity of the cap and the permanent isolation of the contaminants. Alternative F was determined not feasible for OU 2.

In evaluating the alternatives, WDNR and EPA considered the level of protection that would satisfy the concern of the natural resource trustees that future natural resource injuries be minimized. Many of the natural resource trustees cooperated in the development of the proposed plan and agreed with the combination of active remediation to a proposed cleanup level of 1.0 ppm PCBs and the use of Monitored Natural Recovery in areas where active remediation will not occur.

10.2 Key/Common Elements

The following discussion applies primarily to the dredging or dredging and capping alternatives.

Phasing - The first construction season of remedial dredging will include an extensive monitoring program of all operations. Monitoring data will be compared to performance standards developed during remedial design. Performance standards are likely to address (but may not be limited to) resuspension rates during dredging, production rates, and residuals after dredging, and community impacts *(*e.g., noise, air quality, odor, navigation). Data gathered will enable WDNR to determine if adjustments are needed to operations in the succeeding phase of dredging, or if performance standards need to be reevaluated. WDNR will make the data, as well as its final report evaluating the work with respect to the performance standards, available to the public.

Institutional Controls - Institutional controls (fish consumption advisories and fishing restrictions) would be utilized with the Monitored Natural Recovery, capping and removal alternatives. Institutional Controls are considered to be limited action alternatives, and therefore are not included in the No Action alternative.

Source Control - Point sources of contaminants to the Fox River have been effectively addressed by water discharge permits for the Fox River. Thus, no additional actions related to source control are necessary.

Monitored Natural Recovery - Natural recovery refers to the beneficial effects of natural processes that reduce surface sediment concentrations of PCBs. These processes include biodegradation, diffusion, dilution, sorption, volatilization, chemical and biochemical stabilization of contaminants, and burial by natural deposition of cleaner sediments. The primary mechanisms for natural recovery in the Fox River and Green Bay are desorption and dispersion in the water column (i.e., as a dissolved constituent), burial, and sediment resuspension and transport. Biodegradation is a negligible contributor to the lowering of PCB concentrations and is not a factor for mercury. The relative importance of each of these mechanisms in reducing PCB concentrations in the Fox River and Green Bay is not easily estimated based on available data. Some or all of these processes may be occurring at varying rates at any given time and location within the River or Bay. During the design phase, a monitoring program will be developed to measure the net effects of the natural attenuation processes after remedial activities are completed until the remediation goals are reached.

Sediment Concentrations - Sediments that may significantly contribute to the PCB levels in fish, both now and in the future, are considered principal threats. The determination of the significance of the sediment contribution to fish is based primarily on model projections, in conjunction with geochemical and statistical analyses. The model projections indicate that the significance of the sediment contribution to PCB fish tissue levels varies by Operable Unit; therefore, the sediment levels that are considered principal threats will correspondingly vary by Operable Unit.

Treatment - Conventional treatment technologies, such as thermal desorption, are technically feasible; however, the associated costs would be substantially greater than off-site landfill disposal. However, vitrification of sediments is feasible and as such is considered a possible alternative to the current plans for conventional disposal in an approved, licensed landfill. Materials that would be processed using vitrification technology could be beneficially re-used.

Sediment Processing/Transfer Facilities - It is expected that sediment processing/transfer facilities would be established to handle materials from the environmental dredging process. The locations of these facilities will be determined during the remedial design phase of the remedy considering engineering issues (such as those associated with the type of dredging selected), property issues, noise, air impacts and other appropriate factors. Although it is projected that these facilities would be land-based, water-based facilities will also be evaluated.

Dredged sediments will be mechanically dewatered and loaded onto trucks for transport to disposal facilities.

Water that is separated from the dredged sediment will undergo treatment to remove fine sediment particles and dissolved PCBs. Ultimately, the water will be discharged back into the Fox River in compliance with the substantive requirements of the State of Wisconsin Pollutant Discharge Elimination System, which is an ARAR for this Site.

Transportation - Dredged materials will be transported from the dredging site to the sediment processing/transfer facilities by barge or in-river pipeline. Transportation from the sediment processing/transfer facilities to disposal facilities will be by truck.

Disposal - Disposal of PCB contaminated sediment from OU 1 will be to either an existing upland landfill or into a newly constructed or modified landfill designed to receive the dewatered sediment. ARARs/TBCs specific to the landfill option include the siting requirements for a landfill (Chapter 289, Wisconsin Statutes) and the technical requirements for construction, operation, and closure of a landfill in the NR 500 rule series, WAC.

Sediments removed from the Fox River may contain PCBs equal to or greater than 50 ppm. PCB sediment with concentrations less than 50 ppm will be managed as a solid waste in accordance with statutes and rules governing the disposal of solid waste in Wisconsin. PCB sediment with concentrations equal to or greater than 50 ppm will be managed in accordance with the Toxic Substances Control Act of 1976 (Appendix E of the Feasibility Study). Presently TSCA compliance would be achieved through the extension of the January 24, 1995 approval issued by EPA to WDNR pursuant 40 CFR 761.60(a)(5) under the authority of TSCA. This TSCA approval, granted by EPA Region 5, states that the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 ppm into an NR 500, WAC landfill that is also in compliance with the conditions of the TSCA approval, provides adequate protection to human health and the environment as required by 40 CFR 761.60(a)(5); and, will provide the same level of protection required by EPA, Region 5 and therefore is no less restrictive than TCSA. However, should other administrative rules pertaining to disposal under TSCA be in effect at the time that TSCA compliance decisions are made for the Fox River sediment, then compliance with those rules will be achieved.

Therefore, this disposal method meets the TSCA regulatory requirement 40 CFR 761.61(c) that the risk-based method for disposal of PCB remediation waste does not pose an unreasonable risk of injury to health and the environment.

Although off-site landfilling is anticipated, vitrification and beneficial re-use of dredged excavated sediments will be evaluated during the design phase. Value engineering to reduce waste volumes (that will also reduce costs) will be explored and, if appropriate, finalized during remedial design.

Monitoring - Short- and long-term (i.e., pre-, during, and post-construction) monitoring programs will be developed to ensure compliance with performance standards and protection of human health and the environment. The types and frequency of pre-construction monitoring will be developed during remedial design. Plans for monitoring during and after construction will be developed during the remedial design and modified during and after construction as appropriate. This approach is consistent with the NRC Report recommendation that long-term monitoring evaluate the effectiveness of the remedial action as well as ensure protection of public health and the environment.

11. COMPARATIVE ANALYSIS OF ALTERNATIVES

In selecting a remedy for a site, WDNR and EPA consider the factors set forth in CERCLA § 121, 42 U.S.C. § 9621, by conducting a detailed analysis of the viable remedial alternatives pursuant to the NCP, 40 CFR § 300.430(e)(9), EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies, OSWER Directive 9355.3-01, and EPA's 'A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents, OSWER 9200.1-23.P. The detailed analysis consists of an assessment of the individual alternatives against each of nine evaluation criteria (two threshold, five primary balancing and two modifying criteria) and a comparative analysis focusing upon the relative performance of each alternative against those criteria.

Threshold Criteria

1. **Overall Protection of Human Health and the Environment** addresses whether a remedy provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced or controlled through treatment, engineering, or institutional controls. The selected remedy must meet this criterion.
2. **Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)** addresses whether a remedy will meet applicable or relevant and appropriate federal and state environmental laws and/or justifies a waiver from such requirements. The selected remedy must meet this criterion or a waiver of the ARAR must be attained.

Primary Balancing Criteria

3. **Long-Term Effectiveness and Permanence** refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met.
4. **Reduction of Toxicity, Mobility, or Volume Through Treatment** addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. This preference is satisfied when treatment is used to reduce the principal threats at the site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.
5. **Short-Term Effectiveness** addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed, until cleanup levels are achieved.

6. **Implementability** is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.
7. **Cost** includes estimated capital costs, annual operation and maintenance costs (assuming a 30-year time period), and net present value of capital and operation and maintenance costs.

Modifying Criteria

8. **Agency Acceptance** considers whether the support agency, EPA in this instance, concurs with the lead agency's remedy selection and the analyses and recommendations of the RI/FS and the proposed plan.
9. **Community Acceptance** addresses the public's general response to the remedial alternatives and proposed plan. The ROD includes a responsiveness summary that presents public comments and the WDNR and EPA responses to those comments. The level of community acceptance of the selected alternative is outlined in the Responsiveness Summary (see Appendix A).

11.1 Operable Unit 1 (Little Lake Butte des Morts)

Table 18 summarizes the evaluation for OU 1 alternatives and how each alternative meets, or does not meet requirements for each of the nine criteria described above. A detailed comparative analysis for all alternatives follows.

Table 18 Operable Unit 1. Little Lake Butte des Morts Alternatives

				Selected Alternative			
Yes = Fully meets criteria Partial = Partially meets criteria No = Does not meet criteria	Alternative A No Action	Alternative B Monitored Natural Recovery	Alternative C1 Dredge with off site disposal	Alternative C2 Dredging with off site disposal	Alternative D Dredge to a Confined Disposal Facility	Alternative E Dredge and Vitrification	Alternative F In Situ Capping
1. Overall protection of human health and the environment	No	No	Yes	Yes	Yes	Yes	Yes
2. Compliance with Applicable or Relevant & Appropriate Requirements	No	Partial	Yes	Yes	Yes	Yes	Yes
3. Long-term Effectiveness and Permanence	No	No	Yes	Yes	Yes	Yes	Partial
4. Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	No	No	Yes	Yes	Yes	Yes	Partial
5. Short-term Effectiveness	No	No	Yes	Yes	Partial	Partial	Partial

				Selected Alternative			
Yes = Fully meets criteria Partial = Partially meets criteria No = Does not meet criteria	Alternative A No Action	Alternative B Monitored Natural Recovery	Alternative C1 Dredge with off site disposal	Alternative C2 Dredging with off site disposal	Alternative D Dredge to a Confined Disposal Facility	Alternative E Dredge and Vitrification	Alternative F In Situ Capping
6. Implementability	Yes	Yes	Yes	Yes	Partial	Partial	Partial
7. Cost (millions of $)	$ 4.5	$ 9.9	$ 116.7	$ 66.2	$ 68.0	$ 63.6.0	$ 90.5
8. Agency Acceptance	The WDNR has been the lead agency in developing the RI/FS and the ROD. Both WDNR and EPA support the selected alternative for this OU at the 1.0 ppm action level.						
9. Community Acceptance	The level of community acceptance of the selected alternative is outlined in the Responsiveness Summary.						

11.1.1 Threshold Criteria for Operable Unit 1

Protection of Human Health and the Environment
The primary risk to human health associated with the contaminated sediment is consumption of fish. The primary risk to the environment is the bioaccumulation of PCBs from the consumption of fish or, for invertebrates, the direct ingestion/consumption of sediment. Protection of human health and the environment were evaluated by residual risk in surface sediment using five lines of evidence:

- Residual PCB concentrations in surficial sediment using surface-weighted averaging after completion of a remedy;
- Average PCB concentrations in surface water;
- The projected number of years required to reach safe consumption of fish;
- The projected number of years required to reach a surface sediment concentration protective of fish or other biota, and
- PCB loadings to downstream areas and total mass contained or removed.

Each of these is discussed below.

<u>Residual PCB concentrations in surficial sediment and surface water</u>
As shown in Table 19 below, substantial reductions in the average concentration of surficial sediment and in surface water for OU 1 is achieved by all active remediation alternatives (C1, C2, D, E and F) when compared to the No Action and MNR alternatives (A and B). The implementation of active remediation alternatives results in a 95 percent reduction in residual PCB concentrations in surface sediment using surface-weighted averaging after completion of the Alternatives C1, C2, D, E or F, when compared to the No Action or MNR Alternatives, respectively (i.e., 3.699 versus 0.185 ppm, respectively -- see Table 19). Similarly, the estimated surface water concentrations 30-years after remediation is reduced 94 percent for active remediation alternatives (B, C1, C2, D, E and F), relative to No Action and Monitored Natural Recovery (A, and B, respectively) – i.e., 2.99 versus 0.18 ppm, respectively -- see Table 19.

Table 19 Post-Remediation Sediment and Surface Water Concentrations in OU 1

Alternative	Average PCB Concentrations in Surficial Sediments (ppm)	Estimated Surface Water Concentrations 30-years after Remediation (ng/L)
A, B	3.699	2.99
C1, C2, D, E, F	0.185	0.18

Data is from FS Tables 5-4, and 8-5B.

Time to reach acceptable fish tissue concentrations
Substantial reductions in the time when humans could safely consume fish are achieved by active remediation alternatives (C1, C2, D, E, and F), when compared to the No Action and Monitored Natural Recovery (MNR) alternatives (A and B). The implementation of active remediation alternatives results in an 86 percent to 99 percent reduction in the time required to reach acceptable fish tissue concentrations in walleye when compared to the No Action or MNR alternatives (i.e., 1 to 14 years for active remediation versus 51 to 100 years for No Action or MNR – see Table 20). Recovery times for additional human health receptors are presented the FS, Chapter 8, Table 8-6.

Table 20 Time Achieve Acceptable Fish Tissue Concentrations for Walleye in OU 1

Fish	Receptor	Risk Level Goal	Estimated Years to Achieve	
			Alternatives C1, C2, D, E, F	Alternatives A, B
Walleye	Recreational Angler	RME Hazard Index of 1.0	<1	51
Walleye	High Intake Fish Consumer	RME Hazard Index of 1.0	4	65
Walleye	Recreational Angler	RME 10^{-5} cancer risk level	9	84
Walleye	High Intake Fish Consumer	RME 10^{-5} cancer risk level	14	100

Data is from FS Table 8-14.

Time required to achieve surface sediment concentration protective of fish or other biota
Substantial reductions in the time required to reach protective levels for ecological receptors are achieved by all active remediation alternatives (C1, C2, D, E, and F) relative to the No Action and MNR alternatives. For receptors representative of fish or other biota, implementation of active remediation alternatives results in a 40 percent to 86 percent reduction relative to No Action or MNR (i.e., 14 to 60 years for active remediation versus 100 years or more for No Action and MNR, shown in Table 21, below). Recovery times for additional ecological receptors are presented in the FS, Chapter 8, Table 8-6.

Table 21 Time Required to Achieve Protective Levels in Sediments for Representative Ecological Receptors in OU 1

Fish	Receptor	Risk Level Goal	Estimated years to achieve	
			Alternatives C1, C2, D, E, F	Alternatives A, B
Carp	Carnivorous bird	NOAEC	14	100
Carp	Piscivorous mammal	NOAEC	29	>100
Sediment	Sediment invertebrate	TEL	60	>100

Data is from FS Table 8-16.

PCB loadings to downstream areas and total mass contained or removed

Reduction of the PCB load transported over the Appleton Dam into the downstream areas of the Fox River is a measure of the overall protection of human health and the environment. Reduced PCB loading from OU 1 will ultimately contribute to downstream reduction of concentrations of PCBs in sediment, water and fish, and thereby reduce risk to humans and ecological receptors in the Fox River. After implementation of active remedial alternatives (C1, C2, D, E, and F) estimates for releases over the Appleton Dam would be reduced from 88 pounds/year presently to 1.5 pounds/year 30 years after completion of remediation, compared to 25 pounds for the No Action and MNR alternatives (also after 30 years). Thus the active remedial alternatives would give a 94 percent reduction in loadings relative to No Action and MNR.

Summary

The active remediation alternatives provide a substantially more protective remedy than the No Action and MNR alternatives. The No Action and MNR Alternatives are not protective of human health and the environment.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121 (d) of CERCLA and NCP §300.430(f)(1)(ii)(B) requires that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria and limitations which are collectively referred to as “ARARs,” unless such ARARs are waived under CERCLA section 121(d)(4).

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking a waiver.

The ARAR discussion, below, is divided by the different operational components of the alternatives (Table 22, and discussion below), as various components are utilized in an essentially the same manner for some alternatives and apply equally to those alternatives with a common component. There is also additional discussion of ARARs in Section 14.2.

Table 22 Operational Components for OU 1 Alternatives

		Alternatives						
		A	B	C1	C2	D	E	F
Removal				X	X	X	X	X
Dewatering	Mechanical				X			
	Passive			X		X	X	X
Sediment Treatment				*	*		X	*
Water Treatment				X	X	X	X	X
Trucking or Rail Transportation				X	X	X	X	X
Disposal	Upland			X	X	X**	(residuals)	X
	In-water CDF					X		
Capping								X

X: Required activity for alternative.
** Possible supplement.*
*** Upland disposal for this alternative would only be for sediments with PCB concentrations equal to or greater than 50 ppm (16,165 cubic yards of 800,357). Sediments with concentrations less than 50 ppm (784,192 cubic yards) would be disposed in an in-water CDF.*

A description of the components listed in Table 22, above follows:

- **Removal.** The removal technology utilized for active remedial alternatives Alternatives C1, C2, D, E, and F is dredging (although Alternative F also includes capping). The ARARs that directly relate to the removal of sediment from the Lower Fox River and Green Bay concern the protection of surface water (NR 322, 200, and 220 through 297). The surface water ARARs limit the discharge of PCBs into the receiving water bodies so that water quality is not adversely affected. These ARARs will be achieved by all active remedial alternatives.
- **Dewatering and Water Treatment.**
  - ♦ Mechanical dewatering would be utilized for Alternative C2. Discharge requirements (NR 200 and 220 through 297, WAC) are set forth for the discharge of water to publicly owned treatment works (POTWs) and to navigable waters such as the Lower Fox River (NR 105 and 106, WAC). Discharges from prior remedial activities on the Lower Fox River provide an indication of the treatment requirements for discharging effluent water to the Lower Fox River or to a POTW. Another requirement covers stormwater discharge. A potentially important ARAR (NR 108, WAC) relates to the construction of a wastewater treatment facility specifically to treat water from remedial activities.
  - ♦ Passive dewatering ponds would be part of Alternative C2, D, E and F and would be constructed under the wastewater ARAR (NR 213, WAC), which associated with wastewater treatment lagoons. Based on previous experience gained during the SMU 56/57 pilot dredging project, ARARs associated with passive dewatering lagoons are achievable.
- **Ex-Situ (Off-site) Treatment.** ARARs specific to vitrification technology (Alternative E) relate to the air emission and permitting requirements of thermal treatment units (40 CFR 701 and NR 400 through 499). In addition, the thermal unit must meet performance requirements in NR 157 for the efficient treatment of PCB sediment. These ARARs would be met.
- **Transportation.** The likely method for transporting PCB sediment to upland disposal locations for Alternatives C1, C2, and F is by trucking to the disposal facility, although other transportation methods could be used if it is determined during design that there are better methods. ARARs and TBCs important to this process option include the requirements to prevent spills and releases of PCB materials (NR 140 and 157, WAC). Two ARARs applicable only to the trucking method include Wisconsin Department of Transportation (WDOT) requirements for the shipping of PCB materials and NR 157 shipping requirements. ARARs and TBCs related to in-water transportation activities (i.e., piping) include the protection of surface water (NR 322, 200, and 220 through 297,WAC). Alternatives C1, C2 and F will comply with these ARARs.
- **Disposal.** For Alternatives C1, C2, and F, disposal of contaminated sediment removed (i.e., dredged) from OU 1 will be disposed at either an existing upland landfill or in a newly constructed or modified landfill designed to receive the dewatered sediment. ARARs specific to this process option include the siting requirements for a landfill (Chapter 289, Wisconsin Statutes) and the technical requirements for construction, operation, and closure of a landfill in the NR 500 rule series, WAC. For contaminated sediments with PCB concentrations equal to or greater than 50 ppm, disposal will comply with the Toxic Substances Control Act, 40CFR Part 761. Alternative D would also have a relatively small portion (i.e., 2 percent) of dredged materials with concentrations equal to or greater than 50 ppm that would also be disposed at a TSCA compliant upland landfill. General disposal requirements for PCB-containing sediments are simplified by the EPA’s current approval requirements for placing TSCA-level PCB-containing material in a state-licensed landfill. In

all cases, for sediment to be disposed of at a local landfill, the landfill must be in compliance with the requirements of the NR 500 WAC series regulating the disposal of waste and WDNR's TSCA approval issued by EPA. This EPA approval currently allows for the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 mg/kg in landfills licensed under the NR 500 rule series, WAC, provided that certain technical and administrative requirements are met. These ARARs will be met by alternatives C1, C2 and F.

- **Capping.** For Alternative F, some sediments would be capped in-place, primarily in the central (deeper water) portions of OU 1. This would require compliance with Section 10 of the Rivers and Harbor Act of 1899 (22 CFR 403), and may require compliance with the Wisconsin Statutes Chapter 30 (defining riparian rights of upland owners which extend to the center of a stream). If the capping area is considered to be located in a lake, then the State, through the Board of Commissioners of Public Lands, may lease "rights of the beds of lakes and rights to fill in beds of lakes or navigable streams." It is expected that these ARARS would be met.

11.1.2 Balancing Criteria for Operable Unit 1

Long-Term Effectiveness and Permanence

Reduction of Residual Risk
The No Action and MNR alternatives result in a continuation of the degraded condition of the sediments and surface water quality of Little Lake Butte des Mort (OU 1), for at least several decades. The No Action and MNR Alternatives do not eliminate PCBs from the River and do not reduce PCB levels in fish to acceptable levels for the foreseeable future.

Alternatives C1, C2, D, E and F reduce residual risk through removal or containment of 800,357 cubic yards of sediments containing approximately 1715 kg (about 3800 pounds) of PCBs over an area of 526 acres. The reduction in the time required to reach acceptable fish tissue concentrations ranges from 86 percent to 99 percent (i.e., 1 to 14 years for active remediation and 51 to 100 years for No Action/MNR – see Table 20).

Adequacy of Controls
The No Action and MNR alternatives do not produce reduction in human risk and exposure in the foreseeable future, unlike active engineering controls. Additionally, fish consumption surveys indicate that 50 percent of anglers do not follow fish advisories. Therefore, existing institutional controls do not adequately reduce human exposure to PCBs from consumption of contaminated fish. In addition, institutional controls are not protective for ecological receptors (e.g., the birds, mammals and fish). Given the survey data, it is unlikely that sole reliance on these types of controls would be reliable in the long term to ensure human health and ecological protection.

The active remediation alternatives (C1, C2, D, and E) provide for the removal of most of the PCB-contaminated sediments in OU 1. Alternative F also removes a large portion of PCB-contaminated sediments and provides for an engineered cap over approximately 20 percent of contaminated deposits in OU 1. Like the MNR alternative, Alternative F also requires institutional controls such as Site use restrictions in capped areas (e.g., prohibition of sediment disturbance activities). Although institutional controls would still be required for the two removal alternatives, the risk to consumers of fish would be greatly reduced by these alternatives.
All alternatives would require institutional controls, such as the fish consumption advisories and fishing restrictions until remedial action objectives were met at a future date, but they are unlikely to require additional Site use restrictions after removal activities are completed.

All alternatives will require some degree of monitoring. Monitoring programs will be developed, as appropriate, for all phases of the project.

Alternatives C1, C2, D and F rely on engineering controls at the disposal facility. Properly designed and managed landfills provide proven, reliable controls for long-term disposal for Alternatives C1, C2 and F (which have off-site landfill disposal). Alternative F would also require a long-term operation and maintenance plan to ensure containment of PCBs in perpetuity. Alternative D would require on-site engineering controls at an in-water disposal facility. Long-term monitoring and maintenance are included in operation of the landfill and confined disposal facility. The final disposition of contaminated sediments is listed in the following table.

Table 23 Final Disposition of Contaminated Sediments in OU 1

	Alternatives (cubic yards)					
	A	B	C1/C2	D	E	F
Treated and residual disposal	0	0	0	0	784,192	0
Removed and disposed at upland landfill	0	0	784,192	16,165	0	16,645
Removed and disposed at in-water CDF (on-site)	0	0	0	768,027	0	619,381
Capped in-place	0	0	0	0	0	148,646

Data is from FS Table 7-2.

Reliability of Controls

For the active remedies (Alternatives C1, C2, D, E and F), and MNR, fish consumption advisories and fishing restrictions will continue to provide some protection of human health until PCB concentrations in fish are reduced to the point where the fish consumption advisories and fishing restrictions can be relaxed or lifted. However, in the interim, these controls will only provide an uncertain measure of protection. Among the active alternatives, sediment capping, sediment removal (dredging and excavation), and off-site disposal/treatment of removed sediments are all established technologies.

The capping portion of Alternative F relies upon proper design, placement and maintenance of the cap in perpetuity for its effectiveness, continued performance and reliability. A cap integrity monitoring and maintenance program would provide reasonable reliability, although there are inherent challenges in monitoring and maintaining a cap in the Fox River riverine environment. The capping portion of Alternative F (see Table 23, above for the volume of capped contaminated sediments) may not be as reliable as the removal alternatives due to the unknown potential for damage to the cap, potentially exposing PCBs. In addition, the capping component of Alternative F is vulnerable to a catastrophic flow event, such as might be seen during a 500-year flood or a dam failure. However, with proper design and maintenance, these risks can be minimized.

In general, Alternatives C1 and C2, D and E are the most reliable, as there is little or no long-term additional on-site maintenance associated with the remedial work. These Alternatives permanently remove the greatest amount of contaminated sediment and PCBs from the River, and achieve the greatest reduction of the potential scour-driven resuspension of PCB-contaminated sediments. However, Alternative F is also considered to be sufficiently reliable.

Summary
Based on the above analysis of reduction in residual risk and adequacy and reliability of controls, the five active remediation alternatives (C1, C2, D, E and F) are superior to the No Action and MNR alternatives due to the greater risk reduction and mass of PCBs removed from the River. The five active remediation alternatives are similar to each other in terms of risk reduction with C1, C2, and E being the most effective over time. EPA's analysis of residual risk for each alternative is consistent with the National Research Council (NRC) report recommendation to consider options to reduce risk and to consider residual risks associated with material left behind.

Reduction of Toxicity, Mobility, and Volume
Reduction in Toxicity, Mobility, or Volume of Contaminants through Treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment and the amount of contamination present.

The No Action and MNR alternatives do not involve any containment or removal of contaminants from Little Lake Butte des Morts sediments. The No Action and MNR alternatives rely on natural attenuation processes such as burial by cleaner sediments, biodegradation, bioturbation and dilution to reduce concentrations of PCBs in sediments and surface water.

Natural degradation processes were not found to be effective in reducing PCB concentrations or toxicity in Fox River sediments (FS Appendix F, "Dechlorination Memorandum"). Nevertheless, concentrations of PCBs in fish populations will respond slowly over time to slow natural decreases in concentrations in sediments and surface water due primarily to dilution and the burial of contaminated sediments by cleaner sediments.

For Alternative F, the mobility of the PCBs in capped areas (approximately 135 acres) would be reduced because these PCBs are sequestered under the cap. However, capping does not satisfy the CERCLA statutory preference for treatment. In addition, there is no reduction in the toxicity or volume of the PCBs under the cap. Under this alternative, the mass of PCBs and the volume of contaminated sediments within Little Lake Butte des Morts are permanently reduced because approximately 620,000 cubic yards of sediment would be removed, and approximately 150,000 cubic yards would be contained under a cap in OU 1. A total of approximately 1715 kg (about 3770 lbs) of total PCBs would be removed or isolated from the ecosystem by this alternative. In addition, after construction of the remedy is completed, natural attenuation processes could provide additional reductions in PCB concentrations in the remaining sediments and surface water.

For Alternatives C1, C2, D, and E, the mass of PCBs and volume of contaminated sediments in Little Lake Butte des Morts are permanently reduced because sediment volumes of approximately 784,000 cubic yards of contaminated sediment, containing a mass of total PCBs of approximately 1715 kg (about 3770 lbs) would be removed from the ecosystem. Also, as stated for Alternative F, after construction of the remedy is completed, natural attenuation processes would provide additional reductions in PCB concentrations in the remaining sediments and surface water.

While the active remedial alternatives (Alternatives C1, C2, D and F) would permanently remove large volumes of PCBs from the River (thereby reducing their mobility), they do not satisfy the statutory preference for treatment as a principal element of the remedy. Given the volume of material to be removed, treatment of the dredged material prior to off-site disposal may not be cost-effective, other than the stabilization of the sediments for handling purposes. During remedial design, WDNR will further consider the cost-effectiveness of vitrification for dredged material. Alternative E in the FS has been revised to consider vitrification. Vitrification would reduce toxicity, mobility, and volume, and the glass aggregate product would be available for beneficial re-use.

Short-Term Effectiveness

Short-term Effectiveness relates to the length of time needed to implement an alternative and the risks the alternative poses to workers, residents and the environment during implementation up until the time that remediation levels are achieved.

Length of Time Needed to Implement the Remedy

The implementation times for the active alternatives are approximately 6 years for Alternatives C1 and C2, D, E and approximately 5 years for Alternative F. This represents the estimated time required for mobilization, operation and demobilization of the remedial work, but does not include the time required for long-term monitoring or O&M. The No Action and MNR alternatives do not involve any active remediation and therefore require no time to implement.

Protection of the Community and Workers During Remedial Action

No construction activities are associated with the remediation of sediments for the No Action and MNR alternatives, so neither alternative increases or decreases the short-term potential for direct contact with or ingestion and inhalation of PCBs from the surface water and sediments.

Community Protection. Access to sediment processing/transfer facilities and process and treatment areas under the active remediation alternatives (C1, C2, D, E and F) will be restricted to authorized personnel. Controlling access to the dredging locations and sediment processing/transfer facilities along with monitoring and engineering controls developed during the design phase will minimize potential short-term risks to the community. The design will also provide for appropriate control of air emissions, noise and light through the use of appropriate equipment that meets all applicable standards. Compliance with these design provisions will be monitored during construction, operation and demobilization. Vehicular traffic will increase due to workers and supply deliveries at the sediment processing and transfer facilities. These effects are likely to be minimal, in part because the transportation of sediments for disposal will take place within the Fox River area. If a beneficial use of some portion of the dredged material is arranged, then an appropriate transportation method will be determined (e.g, rail, truck, or barge).

For the active remediation alternatives (Alternative C1, C2, D, E and F), work in the River will also be designed with provisions for control of air emissions, noise and light. Work areas will be isolated (access-restricted), with an adequate buffer zone so that pleasure craft can safely avoid these areas. Environmental dredging in the River will be conducted at times and in ways to minimize disruption to river traffic. Targeted dredging will be sequenced and directed to ensure minimal impacts to navigation within the River. To help ensure that navigation is not impeded, WDNR and EPA will consult with the local authorities during remedial design and construction phases on issues related River usage, and other remedy-related activities within Little Lake Butte des Morts. Discrete areas of the River will be subject to dredging and related activities only over short periods of time; once an area is dredged, dredging equipment will move to another area, thereby minimizing locational impacts.

Based on air monitoring for the SMU 56/57 demonstration project, air emissions at dredging sites and at land-based facilities are expected to be minimal. Action levels will be established, monitoring conducted as required, and appropriate engineering control measures employed to ensure that any air releases do not exceed acceptable levels.

Vehicles used for the transportation of hazardous waste will be designed and operated in conformance with State and local regulations. WDNR and EPA will provide the community and local government the opportunity to have input on plans related to the off- Site transportation of hazardous wastes. This approach is consistent with the NRC recommendation to involve the local communities in risk management decisions.

WDNR and EPA believe that implementation of any of the active remediation alternatives (C1, C2, D, E and F) will have little if any adverse impact on local businesses or recreational opportunities. Indeed, WDNR and EPA believe that the remedy will have substantial positive economic impacts on local communities and will facilitate enhanced recreational activities in and along the River. To the extent that any adverse local impacts do occur, WDNR and EPA expect that they will be short-term and manageable. Moreover, the Agencies believe that any such impacts will far outweigh the long-term benefits of the remediation on human health and the environment.

Worker Protection. For the No Action and MNR alternatives, occupational risks to persons performing the sampling activities (for the 5-year reviews) will be unchanged from current levels. There is some minimal increase in occupational risk associated with the MNR alternative due to the greater degree of sampling involved in the River.

For the five active remediation alternatives (C1, C2, D, E and F), potential occupational risks to Site workers from direct contact, ingestion and inhalation of PCBs from the surface water and sediments, as well as routine physical hazards associated with construction work and working on water, are higher than for the No Action and MNR alternatives. For these alternatives, as well as the No Action and MNR alternatives, personnel will follow a site-specific health and safety plan and OSHA health and safety procedures and wear the necessary personal protective equipment; thus, no unacceptable risks would be posed to workers during the implementation of the remedies.

In summary, the active remedial alternatives would not pose significant risk to the nearby communities. A short-term risk to the community and site workers may be possible as a result of potential air emissions and noise from construction equipment, dewatering operations, and hauling activities. However, as successfully shown during the Lower Fox River demonstration dredging projects, these risks can be effectively managed/minimized by: (1) coordinating with and involving the community; (2) limiting work hours; and (3) establishing buffer zones around the work areas; as well as through (4) using experienced contractors who would assist project design.

<u>Environmental Impacts of Remedy and Controls</u>
Environmental impacts consist of PCB releases from removed sediment into the air and water. As successfully shown during the Lower Fox River demonstration dredging projects, environmental releases will be minimized during remediation by (1) treating water prior to discharge; (2) controlling storm water run-on and runoff from staging and work areas; and (3) utilizing removal techniques that minimize losses; as well as through (4) the possible use of silt curtains where necessary to reduce the potential downstream transport of PCBs.

Habitat impacts from active remedial activities (Alternatives C1, C2, D, E and F) are expected to be minimal, as the benthic community should recover relatively quickly (see White Paper Number 8 for details) from dredging activities. Additionally, dredging remediation can result in collateral benefits in the course of mitigation, including removal of nuisance species, reintroduction of native species, aeration of compacted and anaerobic soils and other enhancements of submerged habitats. For the capping portion of Alternative F, there could be similar effects on aquatic vegetation and benthic invertebrate and fish communities, but recovery of benthic invertebrate communities would likely be slower (relative to recovery from dredging) due to changes in the sub aqueous habitat to sand and rock as well as decreases in organic content of the sediment decreasing the organic content of the sediment.

Potential Adverse Environmental Impacts During Construction
No construction activities associated with the River sediments are conducted for the No Action and MNR alternatives. Neither continuation of the existing limited sampling activities for the No Action alternative nor the increased monitoring program for the MNR alternative is anticipated to have any adverse effect on the environment, beyond that already caused by the PCB contamination of the sediments and the ongoing releases of PCBs from those sediments in Little Lake Butte des Morts. For the five active remediation alternatives (C1, C2, D, E and F), the release of PCBs from the contaminated sediments into the surface water during construction (dredging and cap placement), will be controlled by operational practices (e.g., control of sediment removal rates, use of environmental dredges and possible use of sediment barriers). Although precautions to minimize resuspension will be taken, it is likely that there could be a localized temporary increase in suspended PCB concentrations in the water column and possibly in fish PCB body burdens. Analysis of results from projects on Deposit N and SMU 56/57, and comparison to yearly sediment resuspension rates, as well as resuspension quantities during yearly high flow events, shows the expected resuspension due to dredging to be well within the variability that normally occurs on a yearly basis. Analysis of results from other dredging projects indicates that releases from environmental dredging are relatively insignificant (substantially less than 1 percent of the mass of contaminants). The performance standards and attendant monitoring program developed during design will ensure that dredging operations are performed consistent with the environmental and public health goals of the project. This was readily achieved on the Deposit N and SMU 56/57 projects and is expected to be feasible for other River dredging activities.

Dredging activities may result in short-term temporary impacts to aquatic and wildlife habitat of the Little Lake Butte des Morts, but as discussed below, and in White Paper 8, “Habitat and Ecological Considerations as a Remedy Component for the Lower Fox River”, it is expected that recovery would be rapid.

For the active remediation alternatives (C1, C2, D, E and F), there is the potential transient impact from the temporary exposure of deeper, more highly contaminated sediments during excavation activities. This impact would be minimized by the quick completion of removal activities, and (if needed) placement of a post-dredging sand cover as soon as practicable after the removal operations are complete.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility and coordination with other governmental entities are also considered.

Technical Feasibility
Both the No Action and MNR alternatives are technically feasible because no active measures other than continued sampling would be taken. Technical feasibility for the active remediation alternatives is discussed below in terms of the main components of the alternatives. Additional information is provided in the FS.

Sediment Processing/Transfer Facilities. Alternatives C1, C2, D, E and F require sediment processing/transfer facilities. At these facilities, the transfer, dewatering and stabilization of dredged material would be conducted. Each of these activities is considered a readily implementable, commonly engineered activity. Design of sediment processing/transfer facilities will include requirements for the control of light, noise, air emissions, and water discharges.

WDNR and EPA have not determined the location of the sediment processing/transfer facilities. Preliminary criteria were utilized to establish a list of preliminary candidate sites to allow for the preparation of a cost estimate. In preparing the cost estimate in the Feasibility Study, WDNR and EPA assumed upland staging area in the vicinity of Arrowhead Park, at the southern end of Little Lake Butte des Morts. This facility (wherever located) would be temporary and removed after completion of the active remedial activities.

Removal. Alternatives C1, C2, D, E, and F require the dredging of contaminated sediments. Dredging of sediments is a readily implementable and environmentally effective engineering activity. Two concerns are relevant to whether sediments can be dredged effectively: 1) resuspension and releases during dredging and, 2) resulting residual contaminant concentrations that may remain in sediments after dredging is completed. Regarding resuspension, as discussed above environmental dredges have been shown to generally not release significant quantities of contaminants during removal operations. The type of dredging equipment (mechanical and/or hydraulic) will be selected during the remedial design, using the most appropriate equipment for the specific conditions in the River. The use of silt screens or other barriers, as appropriate, could further assist in limiting downstream migration of PCBs and may be used as well. Regarding post-dredging residual contaminant concentrations comparable projects indicate that achieving the 1 ppm Action Level in remaining sediments is readily achievable. The Fox River SMU 56/57 dredging project achieved a 96 percent reduction in the average concentration of contaminated sediments targeted for removal in that project. This is consistent with results for other dredging projects having similar site conditions (see Appendix B of the FS, and Hudson River White Paper ID 312663, "Post-Dredging PCB Residuals).

Dewatering. Alternatives C1, C2, D, E and F would require removal of excess water from dredged sediments. Either mechanical or passive dewatering would be used for this purpose. These are conventional, commonly utilized proven technologies, and are readily implementable and effective.

Water Treatment. Conventional water treatment technologies for dredge water have been proven commonly reliable, and are readily implementable and effective.

Capping. Alternative F includes some capping of areas that meet the criteria for areas that are acceptable for capping. The placement of capping materials is a readily implementable engineering activity. Sand, gravel and/or fine materials may be utilized for capping. Clean sand could be placed over contaminated deposits to give a surficial concentration in the capped areas that is essentially without contamination. The type (e.g., texture/size and sorting) of cap material will be determined on a location specific basis.

Post-Dredging Sand Cover. The selected alternative envisions an option of limited backfilling if required. The placement of backfill is a readily implementable engineering activity. Sand or other materials, as appropriate may be utilized for backfill.

Transportation. Dredged materials may be transported in-river to sediment processing / transfer facilities using barges or pipelines. These are considered readily implementable engineering activities. Transportation via pipeline is limited to certain distances because of pumping and right-of-way limitations. Consequently, in some areas of the River, pipelines may not be implementable.

Off-site transportation of dredged materials to disposal facilities will be by truck, rail and/or barge. These forms of transportation are routine engineering activities that have been employed at many Superfund sites and are technically implementable. WDNR and EPA will comply with all legal regulatory requirements for transporting both hazardous and non-hazardous wastes.

Disposal. Off-site disposal is a common activity at many Superfund sites. The number and location of off-site disposal facilities will be based on dredged material volume, transportation and cost considerations. It is expected that appropriate disposal will be in the Fox Valley area.

Alternatives C1, C2 and F all include disposal options. Alternative D uses an in-water confined disposal facility for disposal. These are conventional technologies and readily implementable. Under Alternative F, approximately 20 percent of the sediments will be capped in-situ (see Table 23, above). For the areas that will be capped, it is considered technically achievable. It should be noted that certain areas are not amenable to capping and are thus "off limits" for capping. This is because these areas fail to meet certain criteria for capping (e.g., sufficient water depth).

An ex-situ treatment alternative (Alternative E), vitrification, was determined to be technically feasible. This does require reuse of residual materials after treatment.

Treatment. Alternative E includes thermal treatment by vitrification, and is technically implementable to meet cleanup goals.

<u>Administrative Feasibility</u>
Both No Action and MNR require no active measures. All alternatives, except No Action include an administrative requirement for fish consumption advisories. Since fish consumption advisories are already in place, this alternative requirement is already met and would continue even under the No Action alternative. The active remedial measures are somewhat more difficult to implement from an administrative feasibility perspective due to the need for siting the sediment processing/transfer facilities and addressing the associated real property issues, and the need to make arrangements to utilize the River with minimal interruption of boat traffic.

Sediment Processing/Transfer Facilities. For the active remediation alternatives (Alternatives C1, C2, D, E and F), the transfer facilities, constructed on land adjacent to the River, or in-river, are considered "on-site" for the purposes of the permit exemption under CERCLA Section 121(e), although any such facilities will comply with the substantive requirements of any otherwise necessary Federal or State permits.

Removal. Operations under these alternatives will have to be performed in conformance with the substantive requirements of regulatory programs implemented by the U.S. Army Corps of Engineers under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. In addition, discharges during remediation will conform to Wisconsin Statutes and substantive WDNR regulations related to dredging and maintaining water quality.

Disposal. Identifying a local landfill for disposal of sediments dredged from Little Lake Butte des Morts is feasible. This would have to be coordinated with local authorities, consistent with appropriate ARARs.

Capping and CDF. For Alternative D and F, a lake bed grant would likely be required from the Wisconsin legislature to construct a cap or in-water CDF. If riparian rights exist, agreements with landowners with riparian rights would be required. These considerations would be addressed during design.

Treatment. Alternative E is administratively feasible. Air emissions permits would be required if sediments are treated off-site.

Availability of Services and Materials. For the No Action and MNR alternatives, all needed services and materials are available. For the active remediation alternatives (Alternatives C1, C2, D, E and F), equipment and personnel related to dredging and materials handling (e.g., sediment dewatering) are commercially available. Technology and associated goods and services for capping or a post-dredging sand cover, upland landfill or CDF construction are locally available.

<u>Cost</u>
Cost includes estimated capital and annual operation and maintenance costs, as well as total capitol cost. Present worth cost is the total capital cost and operation and maintenance costs of an alternative over time in today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent. (This is a standard assumption in accordance with EPA CERCLA guidance.)

The net present worth of the remedial alternatives range from $4.5 million for No Action to $116.7 million for Alternative C1. For the active remedial alternatives, the present worth of the capital and present worth of operation and maintenance costs which range from approximately $63.6 million for Alternative E to $116.7 million for Alternative C1. Capital costs, present worth of operation and maintenance costs, and the total costs are listed in Table 24, below.

Table 24 Comparison of Present Worth Costs for OU 1 Alternatives at the 1 ppm RAL

	Estimated Volume Removed or Contaminated (cubic yards)	Estimated PCB Mass Remediated (pounds)	Capital Costs ($ millions)	O&M Cost ($ millions)	Present Worth Total Cost ($ Millions)
A – No Action	0	0	0	4.5	4.5
B – Monitored Natural Recovery	0	0	0	9.9	9.9
C1 – Dredging/passive dewatering/off-site disposal	784,000	3770	112.2	4.5	116.7
C2 – Dredging/mechanical dewatering/off-site disposal	784,000	3770	61.7	4.5	66.2
D – Dredge to a Confined Disposal Facility	784,000	3770	63.5	4.5	68.0
E – Dredge and Vitrification	784,000	3770	59.1	4.5	63.6
F – Dredging and Capping to Maximum extent practicable	635,500	3770	86.0	4.5	90.5

From Section 7 and Appendix H of the FS.

11.1.3 Agency and Community Criteria for Operable Unit

<u>Agency Acceptance</u>
The State of Wisconsin has been actively involved in managing the resources of the Lower Fox River since before there was a federal Superfund law. These efforts have led to significant state knowledge and understanding of the River and Bay and of the contamination problems within those areas. As a result of this expertise, WDNR has served as the lead agency responsible for assessing risks and conducting the RI/FS, which forms the basis for the Proposed Plan and Record of Decision (ROD). As the lead agency, WDNR has worked closely with EPA to cooperatively develop this ROD. Both WDNR and EPA support the selection of this remedy as is evidenced by the joint issuance of this ROD by both WDNR and EPA.

<u>Community Acceptance</u>
Community Acceptance considers whether the local community agrees with EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance. Community acceptance of the Proposed Plan was evaluated based on comments received at the public meetings and during the public comment period. There were more than 4800 comments concerning the Proposed Plan. This ROD includes a responsiveness summary, Appendix B, which addresses public comments.

11.2 Operable Unit 2 (Appleton to Little Rapids)

Table 25 below summarizes the comparative analysis for OU 2 alternatives and how each alternative meets, or does not meet requirements for each of the nine criteria, described above.

A detailed comparative analysis for four of the nine criteria, Protection of Human Health and the Environment, Long-term Effectiveness and Permanence, Implementability and Cost are discussed below for all alternatives. A comparison for five of the nine criteria (Compliance with Applicable or Relevant and Appropriate Requirements, Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment, Short-term Effectiveness, Agency Acceptance and Community Acceptance) is substantially the same as Alternatives discussed in OU 1 and are therefore not repeated. Similar to the OU 1, Alternatives C and E for OU 2 are also considered “Active Remediation Alternatives.”

The major differences between OU 1 and OU 2 that relate to this comparative analysis of alternatives are the following:

1) Mass of PCB contaminants in OU 2 is relatively small and potential for downstream release proportionally less, and result in a relatively faster time to recovery,
2) Bedrock immediately underlies contaminated sediment in the upper portion of the OU 2, where most of the deposits are located; this makes complete removal of contaminated materials impracticable,
3) Locks, dams, and the urban/residential setting of a considerable portion of OU 2 make access more difficult than in OU 1.

Table 25 Operable Unit 2. Appleton to Little Rapids Alternatives

		Selected Alternative		
Yes = Fully meets criteria Partial = Partially meets criteria No = Does not meet criteria	Alternative A No Action	Alternative B Monitored Natural Recovery	Alternative C Dredge with off site disposal	Alternative E Dredge and Virtification
1. Overall protection of human health and the environment	No	Partial	Partial	Partial
2. Compliance with Applicable or Relevant & Appropriate Requirements	No	Partial	Yes	Partial
3. Long-term Effectiveness and Permanence	No	Partial	Yes	Yes
4. Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment	No	No	Yes	Yes
5. Short-term Effectiveness	No	Partial	Partial	Partial
6. Implementability	Yes	Yes	Partial	Partial
7. Cost (millions of $)	$ 4.5	$ 9.9	$ 16.5 to 38.3	$ 15.2 to 26.2
8. Agency Acceptance	The WDNR has been the lead agency in developing the RI/FS and the ROD. Both WDNR and EPA support the selected alternative of Monitored Natural Recovery for this OU.			
9. Community Acceptance	The level of community acceptance of the selected alternative is outlined in the Responsiveness Summary.			

11.2.1 Threshold Criteria for Operable Unit 2

Protection of Human Health and the Environment

The primary risk to human health associated with the contaminated sediment is consumption of fish. The primary risk to the environment is the bioaccumulation of PCBs from the consumption of fish or, for invertebrates, the direct ingestion/consumption of sediment. Similar to the evaluation for OU 1, protection of human health and the environment was evaluated using five lines of evidence:

- Residual PCB concentrations in surficial sediment using surface-weighted averaging after completion of a remedy;
- Average PCB concentrations in surface water,
- The projected number of years required to reach safe consumption of fish;
- The projected number of years required to reach a surface sediment concentration protective of fish or other biota, and
- PCB loadings to downstream areas and total mass contained or removed.

These are discussed below.

Residual PCB concentrations in surficial sediment and surface water
Alternatives C and E for OU 2 could achieve greater reductions in average concentration of contaminants in surficial sediment and in surface water relative to the No Action and MNR Alternatives (Alternatives A and B, respectively) – see Table 26 below. Alternatives C and E produce a reduction in residual PCB concentrations in surface sediment using surface-weighted averaging after completion, when compared to the No Action or MNR Alternatives. The estimated surface water concentrations 30-years after remediation is reduced 93 percent for Alternatives C or E relative to No Action and Monitored Natural Recovery (i.e., 0.19 ng/L versus 2.76 ng/L in Table 26, below). It should be noted that these estimates do not take into account the already completed removal of Deposit N that occurred during 1998-1999. Deposit N comprised 32 percent of the mass (i.e., 65 pounds) of PCBs in OU 2. More recent calculation estimated the average SWAC for OU 2 is 0.61 ppm with the PCB mass from Deposit N and O removed.

Table 26 Post-Remediation Sediment and Surface Water Concentrations in OU 2

Alternative	Average PCB Concentrations in Surficial Sediments (ppm)	Estimated Surface Water Concentrations 30-years after Remediation (ng/L)[3]
A, B	0.61[1]	2.76
C, E	0.066[2]	0.19

1. *Value is from November 14, 2002 email from RETEC to WDNR on SWAC values in OUs 1 – 4*
2. *Value is from FS Tables 5-4*
3. *Values are from Table 8-5 B*

Time to Reach Acceptable Fish Tissue Concentrations
Reductions in the time required to reach levels safe for human consumption of fish after implementation of Alternatives C and E relative to the No Action and Monitored Natural Recovery (MNR) alternatives are listed in Table 27 below. Recovery times for other human health receptors are presented in the FS, Chapter 8, Table 8-7. Again, these calculations do not consider the removal of Deposit N, completed by WDNR during 1998-1999.

Table 27 Time to Achieve Acceptable Fish Tissue Concentrations for Walleye in OU 2 at 1 ppm

Fish	Receptor	Risk Level Goal	Estimated Years to Achieve	
			Alternatives C, E	Alternatives A, B
Walleye	Recreational Angler	RME Hazard Index of 1.0	4*	40
Walleye	High Intake Fish Consumer	RME Hazard Index of 1.0	7*	55
Walleye	Recreational Angler	RME 10^{-5} cancer risk level	70*	42
Walleye	High Intake Fish Consumer	RME 10^{-5} cancer risk level	89*	65

** Does not consider removal of Deposit N.*
Data is from FS Table 8-14.

Time to Surface Sediment Concentration Protective of Fish or Other Biota
Alternatives C and E would achieve rreductions in the time required to reach protective levels for ecological receptors, relative to the No Action and MNR alternatives. For representative receptors, implementation of active remediation alternatives results in time reduction relative to

No Action or MNR as is shown in Table 28, below. Recovery times for additional ecological receptors and recovery times are presented in the FS, Chapter 8, Table 8-7. These calculations do not consider removal of Deposit N that occurred during 1998-1999.

Table 28 Time to Protective Levels in Sediments for Representative Ecological Receptors in OU 2

Fish	Receptor	Risk Level Goal	Estimated years to achieve	
			Alternatives C, E	Alternatives A, B
Carp	Carnivorous bird	NOAEC	17*	71
Carp	Piscivorous mammal	NOAEC	34*	100
Sediment	Sediment invertebrate	TEL	28*	81

** Does not consider removal of Deposit N.*
Data is from FS Table 8-16.

PCB loadings to downstream areas and total mass contained or removed
Reduction of the PCB load transported over the Little Rapids Dam into the downstream areas of the Fox River is a measure of the overall protection of human health and the environment. Reduced PCB loading from OU 2 will ultimately contribute to reduction of concentrations of PCBs in sediment, water and fish, and thereby reduce risk to humans and ecological receptors in the Fox River. Alternatives C or E provide for improvement relative to No Action and MNR.

Summary
No Action and MNR may take 40 to 70 years to reach acceptable fish tissue concentrations for recreational anglers and may take more than 80 years to reach safe ecological levels for carp. Surface water WQS will not be met in 100 years. However, the recovery times may be overestimated, as these estimates do not consider the removal of Deposit N, which occurred during 1998-1999. Finally, although Alternatives C or E provide a more protective remedy than the No Action and MNR alternatives, risks would only be moderately reduced.

The comparative analysis for compliance with Applicable or Relevant and Appropriate Requirements is substantially the same as discussed for the OU 1 evaluation and is not repeated.

11.2.2 Balancing Criteria for Operable Unit 2

Long-term Effectiveness and Permanence

Reduction of Residual Risk
The No Action and MNR alternatives result in a continuation of the degraded condition of the sediments and surface water quality of OU 2, for at least several decades. Nevertheless, modeling demonstrates that OU 2 will eventually recover, due to slow natural decreases in PCB concentrations, primarily due to burial and dilution.

Alternatives C and E would reduce residual risk through removal of 46,200 cubic yards of sediments containing approximately 92 kg (about 200 pounds) of PCBs over an area of 34 acres at the 1 ppm RAL for OU 1. This does result in a reduction in time required to reach safe human fish consumption rates when compared to the No Action and MNR Alternatives. However, based on results already achieved at the Deposit N project with conditions representative of those present in the remainder of OU 2 (bedrock underlying contaminated sediments), it may not be possible to consistently meet the RAL of 1 ppm. The Deposit N pilot project demonstrated that a significant percentage of PCB contaminated sediment could be removed, although it did not nor was it designed to, demonstrate that a consistent reduction in contaminant concentration in residual sediments was feasible. This is especially true for the portions of OU 2 where there is bedrock underlying contaminated sediments.

<u>Reliability of Controls</u>
For Alternatives C and E, No Action and MNR, fish consumption advisories and fishing restrictions can provide limited protection to humans until PCB concentrations in fish are reduced to the point where the fish consumption advisories and fishing restrictions can be relaxed or discontinued entirely.

Alternatives C and E permanently remove contaminated sediment from the River, and can achieve risk reduction as well as reduce the potential of releases by scour of PCB-contaminated sediments. Alternatives C and E utilize established technologies and are considered in part to be sufficiently reliable. As discussed below, dredging does not work well with bedrock underlying shallow sediment deposits (as is present for most of the sediment deposits in OU 2).

<u>Summary</u>
Based on the above analysis of reduction in residual risk and adequacy and reliability of controls, Alternatives C and E are marginally better than the No Action and MNR alternatives but are likely to have difficulty in consistently achieving the 1 ppm RAL.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility and coordination with other governmental entities are also considered.

Both the No Action and MNR alternatives are technically feasible, as no active measures would be taken for the PCB-contaminated sediments.

Technical feasibility for the active remediation alternatives is discussed below for operational aspects of the alternatives that differ from OU 1.

Sediment Processing/Transfer Facilities – WDNR and EPA have not determined the location of the sediment processing/transfer facilities for Alternatives C and E. Preliminary criteria were utilized to establish a list of preliminary candidate sites to allow for the preparation of a cost estimate. This analysis indicates that several access locations would be required due to navigation impediments by numerous dams and locks between the Appleton dam and Little Rapids dam. For cost purposes, access locations were assumed in Kimberly, near Wrightstown and near the Little Rapids dam. Due to the number of access locations required and the physical barriers presented by the many locks and dams in this Operable Unit, access limitations would make implementation more difficult or could require modifications to conventional dredging technologies.

Removal - Alternatives C and E require the dredging of contaminated sediments. For the majority of OU 2, bedrock underlying contaminated sediments may make complete removal of contaminated sediment and achieving the Action Level objective of 1 ppm impracticable. Additionally, due to higher water velocities for this Operable Unit, a post-dredging sand cover would likely not be effective in reliably covering post-dredging high concentrations of residual PCBs due to the greater water velocities.

Summary

Alternatives C and E may be difficult to effectively implement due to site conditions with bedrock underlying contaminated sediments, and the large number of locks and dams which would limit river access and navigation. Administrative implementability would be consistent with OU 1.

Cost

Cost includes estimated capital and annual operation and maintenance costs, as well as total capitol cost. Present worth cost is the total capital cost and operation and maintenance costs of an alternative over time in today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent. (This is a standard assumption in accordance with EPA CERCLA guidance.)

The net present worth of the remedial alternatives range from $4.5 million for No Action to $20.1 million for Alternative C (see Table 29, below).

The comparative analysis for Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment, and Short-term Effectiveness is substantially the same as for the OU 1 evaluation and are not repeated.

11.2.3 Agency and Community Criteria for Operable Unit 2

The comparative analysis for Agency Acceptance and Community Acceptance is substantially the same as discussed for the OU 1 evaluation and is not repeated.

Table 29 Comparison of Present Worth Costs for OU 2 Alternatives at a 1 ppm RAL

	Estimated Volume Removed or contained (cubic yards)	Estimated PCB Mass Remediated (pounds)	Capital Costs ($ millions)	O&M Cost ($ millions)	Present-Worth Total Cost ($ millions)
A – No Action	0	0	0	4.5	4.5
B – Monitored Natural Recovery	0	0	0	9.9	9.9
C – Dredging/passive dewatering/off-site disposal	46,200	200	33.8	4.5	20.1
E – Dredge and Vitrification	46,200	200	21.7	4.5	17.1

From Section 7 and Appendix H of the FS.

12. PRINCIPAL THREAT WASTES

The National Contingency Plan (NCP) establishes an expectation that treatment will be used to address the principal threats at a site whenever practical. Engineering controls, such as on-site or off-site containment, may be used for wastes that pose a relatively low long-term threat or where treatment is impractical (NCP Section 300.430(a)(1)(iii) and Superfund Publication 9380.3-06FS, November 1991 “A Guide to Principal Threat and Low Level Threat Wastes”).

The concept of principal threat and low-level threat wastes is applied on a site-specific basis when characterizing source material. Source material is defined as material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water, to air, or acts as a source for direct exposure. In the Lower Fox River and Green Bay Site, the contaminated sediment are source materials.

Principal threat wastes are those source materials considered to be highly toxic or highly mobile which cannot be reliably contained or that would present a significant risk to human health or the environment should exposure occur. The manner in which principal threats are addressed generally will determine whether the statutory preference for treatment as a principal element is satisfied. Although USEPA has not established a threshold level of toxicity/risk to identify a principal threat waste, generally where toxicity and mobility of source material combine to pose a potential risk of 10^{-3} or greater the source material is considered principal threat waste.

With respect to the Fox River sediments in OU 1, some PCB concentrations create a risk in the range of 10^{-3} or more. The preference for treatment outlined above applies to these particular sediments. However, it would be impracticable to closely identify, isolate and treat these principal threat wastes differently than the other PCB sediments in OU 1. The dredging technology that will be employed to accomplish the OU 1 remedy does not distinguish among gradations of contamination in source materials. Nevertheless, at the conclusion of the OU 1 remedy the source materials (and principal threat wastes) will have been removed from the River, dewatered, and deposited in a landfill. In so doing the mobility of the principal threat wastes will have been greatly reduced.

13. SELECTED REMEDY

13.1 The Selected Remedy

The selected remedy for OU 1 is alternative C2. This remedy includes removal, dewatering, and off-site disposal of an estimated 784,200 cubic yards of PCB-contaminated sediment from OU 1 (Little Lake Butte des Morts) with PCB concentrations greater than 1 ppm. These sediments are estimated to contain approximately 1,715 kg (about 3,770lbs) of PCBs, or approximately 90 percent of the total PCB mass in OU 1.

The selected remedy for OU 2 is Alternative B, Monitored Natural Recovery and Institutional Controls.

<u>Summary and Description of the Rationale for the Selected Remedy</u>

The summary of the rationale for the selected remedy will be addressed for each Operable Unit. The following sections discuss specifics of how the selected alternative would be implemented at each OU. Five-year reviews will be conducted of remedial activities at each OU to determine remedy effectiveness.

Operable Unit 1 – Little Lake Butte des Morts, Alternative C2 - Alternative C2 includes the removal of sediment with PCB concentrations greater than the 1.0 ppm remedial action level (RAL) using an environmental dredge, followed by dewatering and off-site disposal of the sediment. The total volume of sediment to be dredged in this alternative is approximately 784,200 cy.

- **Site Mobilization and Preparation.** The staging area for this OU will be determined during the design stage. Site preparation at the staging area will include collecting soil samples, securing the onshore property area for equipment staging, and constructing the mechanical sediment dewatering facility, water treatment facilities, and sediment storage and truck loading areas. A docking facility for dredging may need to be constructed. Assuming a staging area can be found south of the railroad bridge, a separate staging area for the dredge when operating north of the railroad bridge may be needed. This facility would be used solely for the purpose of docking dredging equipment—any dredge slurry will be pumped to southern staging area.

- **Sediment Removal.** Sediment removal will be conducted using a dredge (e.g., cutterhead or horizontal auger or other method). Given the volumes and operating assumptions described in the FS, completing the removal effort is estimated to take approximately six years for OU 1. For a dredging removal, in-water pipelines will carry the slurry from the dredging area to the staging area for dewatering. For longer pipeline runs, it would be necessary to utilize in-line booster pumps to pump the slurry to the dewatering facility. If necessary, silt curtains around the dredging area may be used to minimize sediment resuspension downstream of the dredging operation. Buoys and other waterway markers will be installed around the perimeter of the work area. Other activities associated with sediment removal will be water quality monitoring, post-removal sediment surveys, and site restoration.
- **Sediment Dewatering.** Removal using dredging technologies will require mechanical dewatering requiring land purchase or access, site clearing, and possibly construction of temporary holding ponds. Dewatering techniques would likely be similar to the mechanical processes used for both Lower Fox River demonstration projects, including a series of shaker screens, hydrocyclones, and belt filter presses.
- **Water Treatment.** Water treatment will require the purchase of equipment and materials for flocculation, clarification, and sand filtration. Water treatment will be conducted 24 hours per day, 7 days per week during the dredging season. Discharge water for hydraulic dredging is estimated at 570,000 gallons per day. Daily discharge water quality monitoring is included in the cost estimate. Treated water will be sampled and analyzed to verify compliance with the appropriate discharge requirements. Carbon filtration will likely be necessary.
- **Sediment Disposal.** Sediment disposal includes the loading and transportation of the sediment to an NR 500 landfill with TSCA approval (needed for sediment if concentrations are over 50 mg/kg PCB) after mechanical dewatering. The sediment will be loaded using a front-end loader into tractor-trailer end dumps fitted with bed liners or sealed gates. Each load will be manifested and weighed. The haul trucks will pass through a wheel wash prior to leaving the staging area to prevent the tracking of soil onto nearby streets and highways.
- **Demobilization and Site Restoration.** Demobilization and site restoration will involve removing all equipment from the staging and work areas and restoring the site to, at a minimum, its original condition.
- **Institutional Controls and Monitoring.** Baseline monitoring will include pre- and post-remedial sampling of water, sediment, and biological tissue. Monitoring during implementation will include air and surface water sampling. Verification monitoring to confirm that PCB contamination has been removed to the RAL may include surface and subsurface sediment sampling. Long-term monitoring will include surface water, biological tissue, and possibly surface sediment sampling. The types and frequency of pre-construction monitoring will be developed during remedial design. Plans for monitoring during and after construction will be developed during the remedial design and modified during and after construction as appropriate. Institutional controls may include access restrictions, land use or water use restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Land and water use restrictions and access restrictions may require local or state legislative action to prevent inappropriate use or development of contaminated areas.

- **Achievement of Remedial Action Level Objective.** The mass and volume to be remediated will be based on setting a dredge elevation based on a RAL of 1 ppm while achieving a SWAC of 0.25 ppm for OU 1. The success of the selected remedy for OU 1 will be evaluated based on a SWAC of 0.25 ppm with samples taken from 0-10 cm depth. This is discussed further in section 13.3.

Operable Unit 2 – Appleton to Little Rapids, Alternative B - The MNR alternative will include a 40-year monitoring program as is discussed in the FS for measuring PCB and mercury levels in water, sediment, invertebrates, fish, and birds. The monitoring program will be developed to effectively measure achievement of and progress toward the RAOs. In summary, the monitoring program will include:

- Surface water quality sampling to determine the downstream transport of PCB mass into Green Bay;
- Fish and waterfowl tissue sampling to determine the residual risk of PCB and mercury consumption to human receptors;
- Fish, bird, and zebra mussel tissue sampling to determine the residual risk of PCB uptake to environmental receptors;
- Population studies of bald eagles and double-crested cormorants to assess the residual effects of PCBs and mercury on reproductive viability; and
- Possible surface sediment sampling in MNR areas to assess potential recontamination from upstream sources and the status of natural recovery.

The types and frequency of pre-construction monitoring will be developed during MNR long term monitoring plan design. Plans for monitoring will be developed during the remedial design and modified during and after the upstream construction in OU 1, as appropriate.

Until the RAOs have been achieved, existing institutional controls will have to be maintained to help prevent exposure of human receptors to contaminants. Institutional controls may include access restrictions, land use or water use restrictions, dredging moratoriums, fish consumption advisories, and domestic water supply restrictions. Land and water use restrictions and access restrictions may require local or state legislative action to prevent inappropriate use or development of contaminated areas. Deposit DD, an area in OU 2 of greater contamination, will be addressed as part of the active remediation at adjacent OU 3.

13.2 Summary of the Estimated Costs of the Selected Remedy

The total estimated present-worth cost of the selected remedy is $76.1 million. This is an engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost (based on year 2001 dollars). Changes in the cost elements are likely to occur as a result of new information and data collected during the remedial design. Major changes may be documented in a memorandum in the administrative record, an Explanation of Significant Difference (ESD), or a ROD amendment.

13.3 Cleanup Standards and Outcomes for the Selected Remedy

The selection of a remedy was accomplished through the evaluation of the nine criteria as specified in the NCP. A remedy selected for a site must be protective of human health and the environment, comply with ARARs (or justify a waiver) and offer the best balance of tradeoffs with respect to the balancing and modifying criteria in the NCP.

Through the analyses conducted for the RI/FS, WDNR and EPA have determined that there is an unacceptable risk to human health and the environment from the consumption of fish from the Fox River. It has also been determined that the unacceptable risk will continue for many decades without active remediation of the PCB-contaminated sediments in OU 1.

13.3.1 Achieving Cleanup Standards

WDNR and EPA believe the removal of sediments with PCB concentrations greater than the 1.0 ppm RAL in OU 1 is important to achieving the timely reduction of risks to an acceptable level. WDNR and EPA envision that all sediment contaminated at concentrations above the RAL in OU 1 will be removed. Therefore, this ROD provides that under certain circumstances a sand cover may be used to supplement the primary dredging remedy in order to reach the risk reduction targets. Pre-remediation sampling and characterization efforts will define a spatial “footprint” (both horizontally and vertically) of the sediment in OU 1 that has a concentration of PCBs greater than 1 ppm. It is this footprint that is targeted for removal by dredging. If dredging is able to achieve this result (i.e., remove all sediments with PCB concentrations greater than 1 ppm), the active remediation portion of the OU 1 remedy will be complete.

However, if after dredging is completed for OU 1, sampling shows that the 1 ppm RAL has not been achieved, a SWAC of 0.25 ppm may be used to assess the effectiveness of PCB removal. If that SWAC of 0.25 ppm has not been achieved for OU 1, then the remedy provides certain options to further reduce risk. The first option is that additional dredging may be undertaken to ensure that all sediments with PCB concentrations greater than the 1 ppm RAL are removed throughout the particular deposit. A second option would be to place a sand cover on dredged areas to reduce surficial concentrations such that a SWAC of 0.25 ppm for OU 1 is achieved.

Explanation of Remedial Action Level, Surface Weighted Average Concentration and Sediment Quality Threshold.

The term Remedial Action Level (“RAL”) refers to a PCB concentration in sediment used to define an area or volume of contaminated sediment that is targeted for remediation. In other words, this ROD calls for the removal by dredging of all sediment in OU 1 that has a PCB concentration of greater than1 ppm. If all sediment with a concentration greater than the 1 ppm RAL is removed, then it is expected that the residual Surface Weighted Average Concentration (“SWAC”) of sediment will be 0.19 ppm in OU 1. The SWAC in this instance is less than the RAL because the SWAC is calculated as an average concentration over the entire OU 1, after the removal of sediment from discrete areas (“deposits”) which are above the RAL and includes averaging over areas in which there are surface concentrations less that the RAL. SWAC calculations are discussed in section 5 of the FS.

The term “Sediment Quality Threshold” (SQT) refers to the PCB concentration in the sediment that is protective of specified human and ecological receptors. SQTs vary depending on the sensitivity of the particular receptor (e.g., recreational anglers, “high intake” fish consumers, walleye, mink, etc.). Put another way, if the remediation called for in this ROD results in a sediment concentration at or below the SQT, then the risk to specified human and ecological receptors will have been reduced to a safe level. It is important to understand that immediately upon the completion of the dredging, it is not expected that the SQT will be achieved. Instead, it is contemplated that the SQT will be met only after the river is allowed a certain amount of time to “recover” through natural processes following active dredging.

13.3.2 Expected Outcomes of Selected Remedy and RAL Rationale

RAOs were developed to provide relative comparisons for different remedial alternatives. RAO 1 relates to achieving surface water quality standards. RAOs 2 and 3 relate to protectiveness for human and ecological receptors. RAO 4 evaluates long-term relative releases to Green

Bay and Lake Michigan, and RAO 5 considers short term releases from potential remedies themselves.

RAO 1 may not be achieved in the foreseeable future due to the very stringent goals for PCBs acceptable in surface waters, but nevertheless significant risk reduction will occur (Table 13). Recovery times estimated for RAOs 2 (i.e., protection of human health) and 3 (i.e., protection of ecological receptors) indicate that they will be met well within the defined goals. RAO4 relates to loading of Green Bay and Lake Michigan and indirectly relate to OUs 1 and 2. However, reductions of loadings from removal of contaminants in OU 1 will significantly reduce contaminant migration downstream and will therefore contribute to achieving RAO4. RAO5 is achievable with conventional removal environmental removal technologies for OU 1 and does not apply to OU 2.

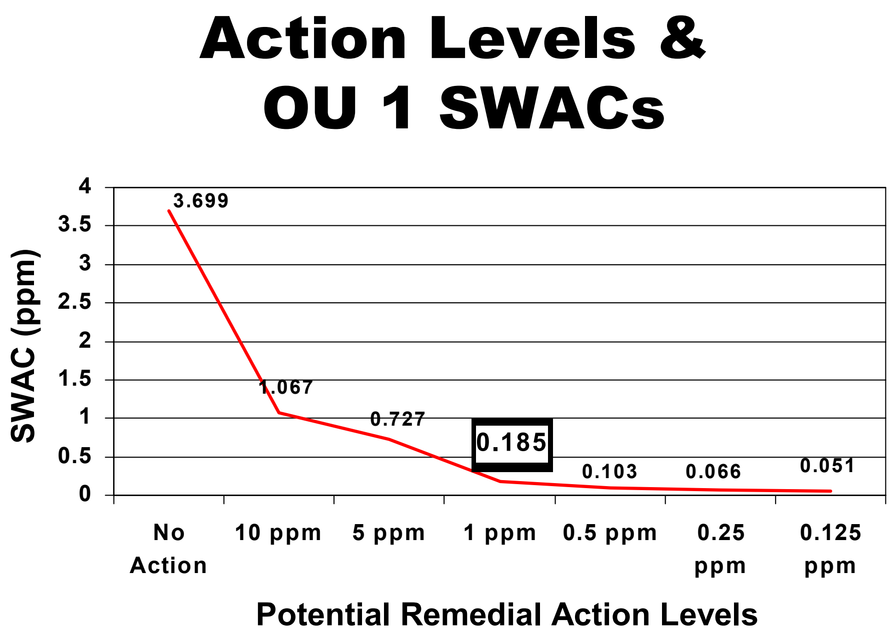
RAOs 2 and 3 are evaluated in the alternative-specific Risk Assessment in the FS by estimating the time required to reach the protectiveness criteria for human health (i.e., removal of fish advisories) and the time required to reach the protectiveness criteria for ecological receptors for no removal and for different remedial action levels for contaminant removal.

A PCB concentration of 1 ppm has been selected as the appropriate Remedial Action Level based on the its ability to achieve Remedial Action Objectives (RAOs) in surface water and for human health and ecological receptors within a reasonable timeframe relative to the anticipated costs. Exposures to PCB sediment concentrations above 1 ppm must be eliminated in order to achieve a protective Surface Weighted Average Concentration (SWAC) within a reasonable timeframe. This RAL will also reduce and minimize surface water concentrations and the release of contaminants to downstream areas of the Fox River. Studies conducted as part of the Lower Fox River and Green Bay RI/FS indicate that a 1 ppm RAL shows the greatest decrease in projected surface water concentrations relative to the other action levels.

PCB RALs of No Action, 5.0 ppm, 0.5 ppm, 0.25 ppm, and 0.125 ppm were also evaluated. However, those RALs greater than 1 ppm would require a significant amount of additional time to achieve the RAOs for the Site. For those RALs less than 1 ppm: the RAOs would not necessarily be achieved sooner than the 1 ppm RAL. The RAOs considered in determination of the RAL are discussed below for Operable Units 1 and 2. It is important to note that the absolute numbers have uncertainty inherent with model predictions, however relative differences among the RALs are reliable

<u>Justification for Operable Unit 1 Remedial Action Level of 1.0 ppm</u>
Figure 5 shows our modeling analysis of sediment RALs in comparison with the Surface Weighted Average Concentrations (SWACs) which will result from the cleanup at the selected 1 ppm RAL. Modeling suggests that a 1 ppm RAL can achieve an estimated 0.185 ppm PCB SWAC for OU 1 (Figure 5 below). Selecting a sediment RAL of 1 ppm clearly stands out as the most effective RAL because the risk declines significantly in a reasonable time period (see figures 6 and figure 7). This will result in reaching risk reductions in the years estimated in Table 30, below.

Figure 5 Remedial Action Levels and Estimated SWACs for Evaluated RALs for OU 1 (from FS Table 5-4)



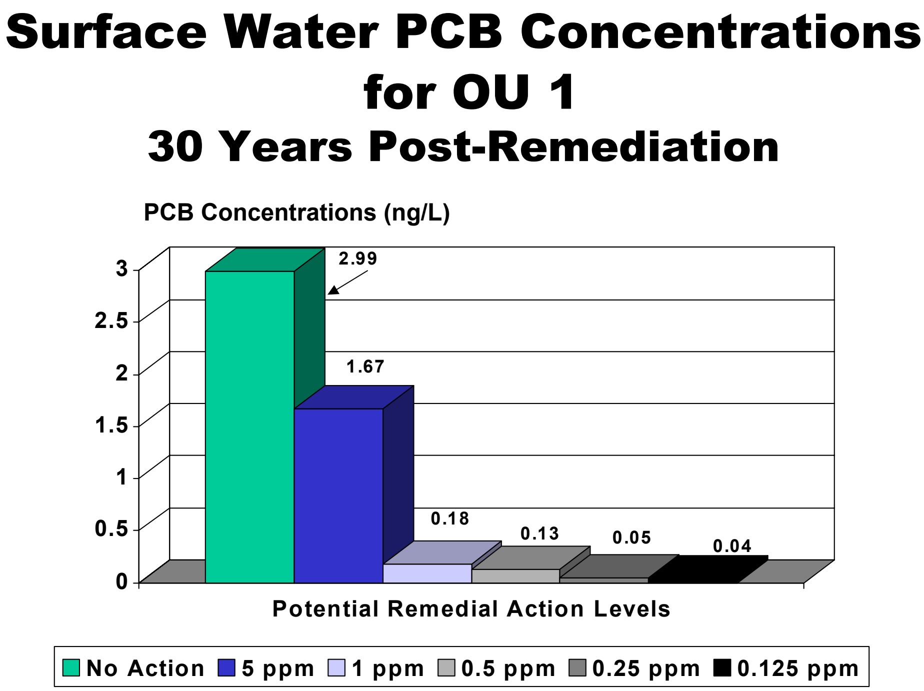
As shown in Table 30 below, modeling suggests that a sediment RAL of 1.0 ppm, and a SWAC of 0.185 ppm will lead to fairly rapid declines in PCB fish tissue concentrations. Using the 1 ppm RAL, Table 30 projects the number of years until the risk of fish ingestion/consumption declines to acceptable levels for different consumers.

Table 30 Estimated Years to Reach Human Health and Ecological Thresholds to Achieve Risk Reduction for the Operable Unit 1 at a RAL of 1 ppm

Fish	Receptor	Risk Level Goal	Estimated Years
Walleye	Recreational Angler	RME Hazard Index of 1.0	<1
Walleye	High Intake Fish Consumer	RME Hazard Index of 1.0	4
Walleye	Recreational Angler	RME 10^{-5} cancer risk level	9
Walleye	High Intake Fish Consumer	RME 10^{-5} cancer risk level	14
Carp	Carnivorous bird	NOAEC	14
Carp	Piscivorous mammal	NOAEC	29

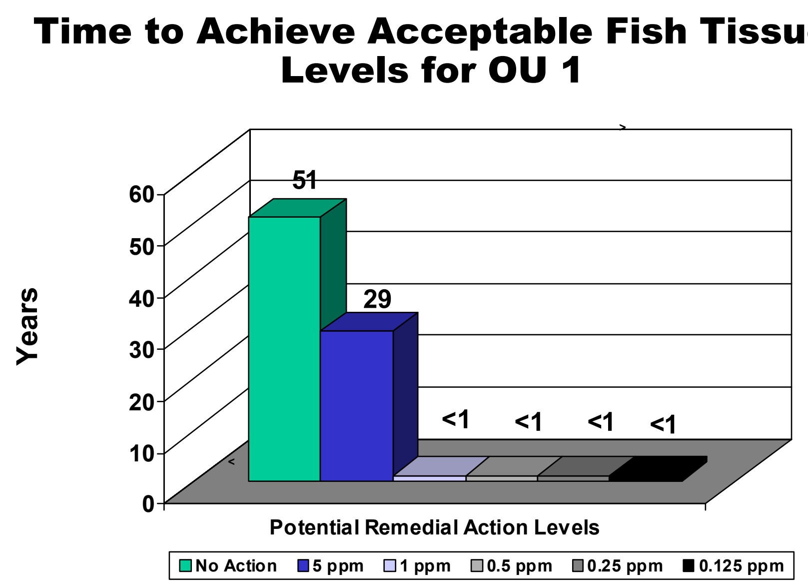
A 1 ppm RAL shows the greatest decrease in projected surface water concentrations. Figure 6 shows model estimates for PCB surface water concentration 30 years after remediation are 2.99 ng/L for No Action, 1.67 ng/L for 5 ppm, and 0.18 ng/L for 1 ppm, which is the largest relative drop. Additional declines for projected surface water concentrations for RAL less than 1 ppm are relatively minimal: 0.13 ng/L, 0.05 ng/L and 0.04 ng/L, respectively for 0.5 ppm, 0.25 ppm and 0.125 ppm RALs. In other words, selection of an RAL less than 1 ppm would only marginally reduce the SWAC and would only marginally reduce surface water concentrations. Thus, a comparison of various RALs shows the 1 ppm RAL has the greatest relative post-remediation decrease in surface water concentrations.

Figure 6 Estimates of Surface Water PCB Concentrations for the Evaluated RALs 30 Years After Completion of Remedial Activities for OU 1



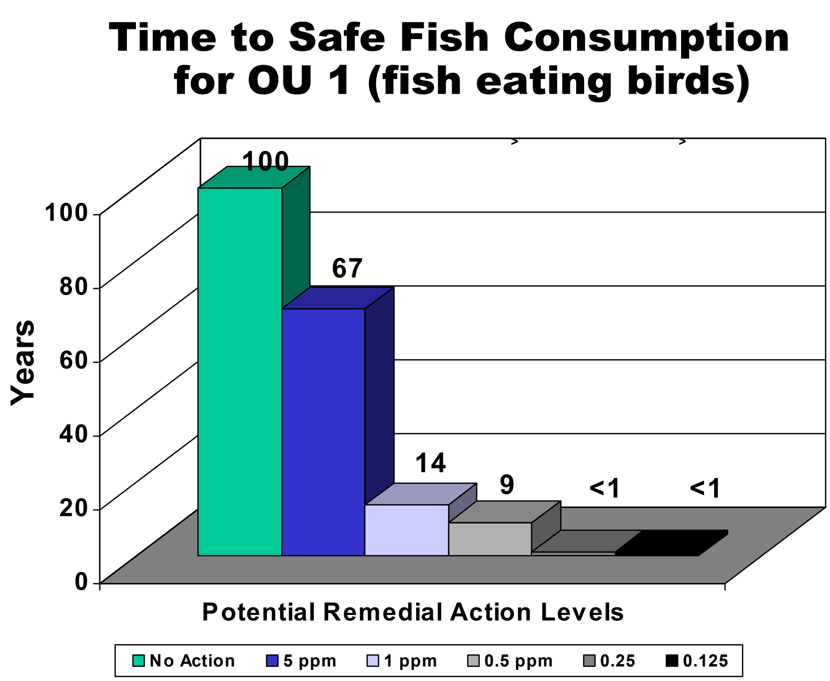
As shown in Figure 7, a 1 ppm RAL shows similar relative decreases in relation to acceptable fish tissue concentrations for walleye. Figure 7 shows that for RAL concentrations greater than 1 ppm, significantly more years will elapse before the risk of fish consumption declines to acceptable levels. The time that it would take to acceptable fish tissue concentrations are 51 years for No Action, 29 years at a RAL of 5 ppm and less than 1 year for a RAL of 1 ppm. The time needed to reach acceptable fish tissue concentrations for RALs less than 1 ppm (0.5 ppm, 0.25 and 0.125 ppm) are almost indistinguishable from the 1 ppm level. Other species of fish show similar reductions and are discussed in detail in the Feasibility Study Chapter 8. Figure 7 clearly shows that there is limited risk reduction achieved by selecting an RAL of less than 1 ppm.

Figure 7 Time to Achieve Acceptable Fish Tissue Concentrations for OU 1



Safe fish consumption by birds showed similar relative reductions for 1 ppm versus other potential cleanup levels (Figure 8). For fish eating birds, the time needed to reach safe fish consumption is 100 years for No Action, 67 years for a 5 ppm RAL, 14 years for a 1 ppm RAL (the greatest relative reduction in time), and 9 years for 0.5 ppm RAL. Thus, similar to the earlier figures, the 1 ppm RAL provides the greatest relative reduction of time to ecosystem recovery.

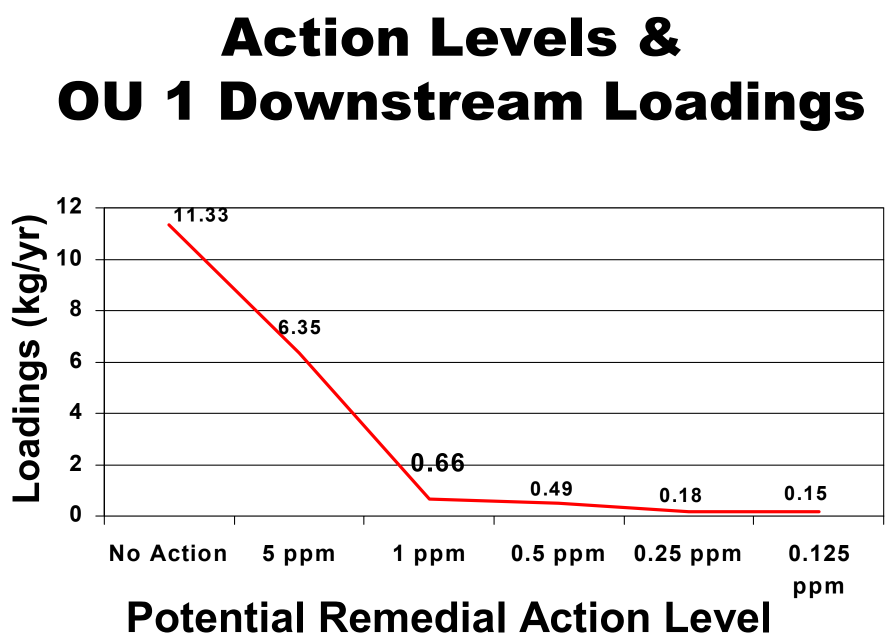
Figure 8 Time to Safe Fish Consumption by Birds in OU 1



A 1 ppm RAL is also the most protective based on estimates of downstream loadings (i.e., movement and migration of PCBs into other areas of the River and eventually Green Bay). Downstream loadings of PCBs from OU 1 relative to remedial activities, are as follows: No

Action - 11.33 kg/year, 5 ppm - 6.35 kg/year, 1 ppm – 0.66 kg/year, 0.5 ppm – 0.49 kg/year, 0.25 ppm – 0.18 kg/year, 0.125 ppm – 0.15 kg/year (Figure 9). The RAL of 1 ppm provides the greatest decrease in downstream loadings relative to the other RALs. Like earlier Figures, Figure 9 shows clearly that, with respect to downstream loadings, the 1 ppm RALs level achieves the most reduction.

Figure 9 RALs and Downstream Loadings in OU 1



In summary, the 1 ppm RAL shows the greatest relative improvement for all the pertinent RAOs resulting in a protective and cost effective cleanup level for OU 1.

<u>Justification for Monitored Natural Recovery for OU 2</u>
WDNR and EPA have determined that Monitored Natural Recovery (MNR) for OU 2 is sufficiently protective of human health and the environment. However, because of Deposit DD proximately to OU 3, the decision on whether to remediate this deposit will be deferred until the ROD for OU 3 is prepared.

The mass of PCBs and volume of contaminated sediments in OU 2 is approximately 109 kg and 339,200 cubic yards, respectively, for all deposit and interdeposit sediments. This is a small portion (2.4 percent) of the PCB mass and sediment volume in the entire 39 miles of the Lower Fox River, which includes 29,855 kg (66,050 pounds) and 14,061,100 cy, respectively. The 20-miles River reach of OU 2 is a relatively long stretch of the River and includes 22 deposits with relatively small sediment volume and PCB mass. Within OU 2, the deposits with the two largest masses are Deposit N (30 kg [65 pounds]) and Deposit DD (34 kg [74 pounds]). These two deposits account for 58 percent of the total PCB mass in this reach; a majority of the PCB mass at Deposit N was removed during the pilot project at that location, and the agencies will evaluate the feasibility of remediating Deposit DD as part of the OU 3 ROD. Because the removal of all the material from Deposit N is not reflected in the volume estimates in the RI/FS, risk for this reach may be overestimated. An evaluation of sediment volumes within individual deposits in OU 2 shows there are no deposits with a sediment volume greater than 10,000 cy having a PCB concentration above the 1.0 ppm action level. This demonstrates that the areas within this Operable Unit needing remediation are relatively few and that the risk of exposure from one of these areas with higher concentration is low. In addition, the SWAC for OU 2, with no active remediation, is 0.61 ppm. This existing SWAC is close to the 0.25 ppm SWAC goal of OU 1.

In addition to the small physical size and the small quantity of PCB mass within the deposits in this reach, there are numerous impediments, such as the presence of several dams, the physical characteristics of the River in this reach, and the lack of good staging areas, that would cause difficulties in implementation and in mobilizing and operating dredging equipment. These same features also limit the ability to effectively cap the areas within this reach. These impediments would necessitate multiple staging areas. The cost estimate for dredging within this reach at the 1.0 ppm action level is $20.2 million to remove 46,200 cy of contaminated sediment. The cost to remediate this river sediment would be almost $440 /cy.

In addition to the above practical considerations, achieving of contaminant concentration (i.e., risk) reductions would be more difficult for dredging areas where bedrock immediately underlies contaminated sediment. Results on projects such as Deposit N or projects with similar conditions (e.g., Manistique River/Harbor) support the idea that achieving reductions in contaminant concentrations would be difficult. Thus, a dredging remedy for a large portion of this reach would be expected to be less effective and could be more costly for likely only modest risk reduction.

13.4 Contingent Remedy - In Situ Capping (i.e., “Partial Capping” or “Supplemental Capping”)

WDNR and EPA have selected alternative C as identified in the proposed plan and the RIFS as the *selected* alternative. However, during the RIFS public comment period, the Agencies received numerous comments relating to the viability of capping as a possible remedy. Based on these public comments, WDNR and EPA have developed this contingent remedy that may supplement the selected remedy in certain circumstances. This contingent remedy may only be implemented if it meets the following requirements:

1. The contingent remedy, consisting of a combination of dredging and capping, shall provide the same level of protection to human health and the environment as the selected remedy,
2. This contingent remedy must be less costly than the selected remedy to be implemented,
3. This contingent remedy shall not take more time to implement than the selected remedy,
4. This contingent remedy shall comply with all necessary regulatory, administrative and technical requirements discussed below, and
5. The capping contemplated in this contingent remedy will not be permitted in certain areas of OU 1:
    - No capping in areas of navigation channels (with an appropriate buffer zone).
    - No capping in areas of infrastructure such as pipelines, utility easements, bridge piers, etc (with appropriate buffer zone).
    - No capping in areas with PCB concentrations exceeding TSCA levels.
    - No capping in shallow water areas (bottom elevations which would result in a cap surface at elevation greater than –3 ft chart datum for OU 1 without prior dredging to allow for cap placement.

13.5 Basis for Implementing the Contingent Remedy (OU 1)

Use of this contingent remedy may be employed in OU 1 to supplement the selected dredging remedy if one or both of the following criteria are demonstrated. The decision as to whether one or both of the criteria below have been met will be determined solely by the EPA and WDNR.

1) Based on sampling results taken after a sufficient amount of OU 1 dredging of contaminated sediment deposits (e.g., dredging of deposits A/B, C, and POG), it can be predicted with a high degree of certainty that a PCB SWAC of 0.25 ppm would not be achieved for OU 1 by dredging alone, or

2) Capping would be less costly than dredging in accordance with the protectiveness provisions and the nine criteria in the National Contingency Plan (40 CFR 300.430).

In addition to capping areas of OU 1 the selected dredging remedy would still be completed in areas not capped. Based on estimates in the Feasibility Study, and due to limitations on where capping could be done, capping would be limited to less than 25 percent of the total volume of contaminated sediments in OU 1. Selection and implementation of this contingency would be documented in an Explanation of Significant Differences (ESD).

It should be noted that if dredging alone achieves cleanup standards, and the contingent remedy is not shown to be more cost-effective than dredging alone, then capping would not be implemented.

13.6 Description of Contingent Remedy

The Contingent Remedy which may supplement the selected remedy, consists of the following components:

- **Cap Design.** Cap construction specifications would be determined during design. Although the Feasibility Study envisioned a cap composed of 20 inches of sand overlain with 12 inches of large cobble “armor” to provide erosion protection, the final cap design would be based on predicted performance. The final cap design must have sufficient thickness to ensure containment of contaminants, resistance to burrowing organisms, and “armoring” to provide sufficient permanence and resistance to erosion and scour.
- **Demobilization and Site Restoration.** Demobilization and Site restoration would require removing all capping-related equipment, fencing, facilities, etc., from staging and work areas.
- **Monitoring.** Operation and maintenance monitoring would be required to ensure proper placement, maintenance of cap integrity, and isolation and containment of contaminants. For this type of capping, monitoring would be performed to ensure that the cap is placed as intended, necessary capping thickness is maintained, and contaminants are contained and do not become bioavailable. In addition to other dredging-related monitoring, cap monitoring would include bathymetric or side-scan sonar profiling, sediment and cap sampling, and capture and analysis of pore water that may migrate through the cap, as well as diver inspections to ensure that the cap is intact and containing contaminants.
- **Institutional Controls.** Institutional controls may include deed restrictions, Site access and anchoring limitations, and continuation of fish and waterfowl consumption advisories as appropriate. Access restrictions could include limitation on the use or development of capped areas, possibly requiring local or State legislative action. These controls and limitations are intended to ensure the permanence of the cap and to minimize re-exposure and/or migration of contaminants.

13.7 Estimated Costs of the Contingent Remedy

Costs would be determined prior to implementation of capping. Estimates of capping costs would be documented in an Explanation of Significant Difference (ESD).

14. STATUTORY DETERMINATIONS

Under CERCLA Section 121 and the NCP, the remedies that are selected for Superfund sites must be protective of human health and the environment, comply with applicable or relevant and appropriate requirements (unless a statutory waiver is justified), be cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the selected remedy meets these statutory requirements.

14.1 Protection of Human Health and the Environment

Implementation of the selected remedy will adequately protect human health and the environment through the removal and off-site disposal of PCB-contaminated sediment and the monitoring of the natural recovery of PCB contaminated sediment that is left in place. The selected remedy will target a sediment clean up level of 1.0 ppm in OU 1. This residual risk posed by this action level in OU 1 in years to reach human health and ecological thresholds are presented in Table 30 above. This table indicates that for the selected Action Level of 1.0 ppm, fish advisories for acceptable fish tissue concentrations in walleye would be achieved in 1 to 14 years.

The SWAC value in OU 2 will be 0.61 ppm. Implementation of the selected alternative in OU 1 and OU 2 will result in PCB concentrations within acceptable risk ranges over time. The selected remedy does not pose unacceptable short-term risk.

14.2 Compliance with ARARs

Section 121(d) of CERCLA requires that Superfund remedial actions meet ARARs. The selected remedy will comply with the ARARs listed in Table 31.

14.2.1 Potential Chemical-Specific ARARs

Toxic Substances Control Act (TSCA)
TSCA establishes requirements for the handling, storage, and disposal of PCB-containing materials equal to or greater than 50 ppm. TSCA is an ARAR at the Site with respect to any PCB-containing materials with PCB concentrations equal to or greater than 50 ppm that are removed from the Site.

Clean Water Act
Federal surface water quality standards are adopted under Section 304 of the Clean Water Act where a state has not adopted standards. These federal standards, if any, are ARARs for point discharges to the River. Related to these standards are the federal ambient water quality criteria. These criteria are non-enforceable guidelines that identify chemical levels for surface

waters and generally may be related to a variety of assumptions such as use of a surface water body as a water supply. These criteria may be TBCs for this Site.

Ground-water Quality Standards
State ground-water quality standards for various substances are set forth in chapter NR 140, Wisconsin Administrative Code (WAC). In general, sections NR 140.24 and NR 140.26 require preventive action limits (PALs) to be achieved to the extent it is technically and economically feasible to do so. In the remediation context, the NR 140 groundwater quality standards are to be achieved within a reasonable timeframe. Natural attenuation is allowed as a remedial method where source control activities have been undertaken and where groundwater quality standards will be achieved within a reasonable period of time. The ground-water quality standards constitute an ARAR.

Soil Cleanup Standards
The State of Wisconsin has adopted generic, site-specific, and performance-based soil cleanup standards. These regulations allow the party conducting the remedial action to select which approach to apply. The generic soil standards are divided into those necessary to protect the ground-water quality and those necessary to prevent unacceptable, direct contact exposure. Generic soil standards, based on conservative default values and assumptions, have been adopted only for a few substances, none of which are relevant to the Site. Site-specific soil standards depend upon a variety of factors, including local soil conditions, depth to groundwater, type of chemical, access restrictions, and current and future use of the property. These site-specific soils standards also may be adjusted based on an assessment of the site-specific risk presented by the chemical constituents of concern. With respect to the Site, the soil standards constitute an ARAR.

Surface Water Quality Standards
The State of Wisconsin has promulgated water quality standards that are based on two components: 1) use designation for the water body; and, 2) water quality criteria. These standards, designations, and criteria are set forth in chapters NR 102 to NR 105, WAC. The state also has rules for applying the water quality standards when establishing water-quality-based effluent limits (chapters NR 106 and NR 207, WAC). The state water quality standards are used in making water management decisions and controlling municipal, business, land development, and agricultural activities (section NR 102.04, WAC). In the remediation context, surface water quality standards are applicable to point source discharges that may be part of the remedial action. Further, to the extent that the remedial work is conducted in or near a water body, such work is to be conducted so as to prevent or minimize an exceedance of a water quality criterion (in chapters NR 102 to 105, WAC).

As recognized in the WDNR's sediment guidance (1995), the water quality standards are goals to be used in guiding the development of the sediment remediation work. As a goal, but not a legal requirement, the water quality standards as applied to the remediation of sediment contamination constitute a TBC.

In addition, the NCP states that, in establishing Remedial Action Objectives (RAOs), water quality criteria established under the Clean Water Act (WQSs in Wisconsin), shall be attained where "relevant and appropriate under the circumstances of the release." 40 CFR 300.430(e)(2)(I)(E).

WDNR and EPA have determined that WQSs, while relevant to sediment clean up RAOs, are not appropriate for direct application at this time. Calculating a site-specific sediment quality standard from a WQS using current scientific methods such as equilibrium partitioning is very uncertain. Moreover, the EPA 's 1996 Superfund PCB clean up guidance directly addresses sediment clean up targets using water quality criteria. The guidance suggests using equilibrium partitioning to develop a sediment criteria and then compare it to risk based clean up numbers for establishing an RAO. If the guidance considered a derived sediment quality number to be an ARAR, it would be directly applied to each alternative as a threshold criteria. Therefore, WQSs are not ARARs and are not a threshold criteria for selecting an alternative for the Site.

14.2.2 Potential Action- and Location-Specific ARARs

Wisconsin Statutes Chapter 30

Chapter 30 of the Wisconsin Statutes requires permits for work performed in navigable waterways, or on or near the bank of such a waterway. For remediation that is conducted under CERCLA, only the substantive provisions set forth in Chapter 30 (but not the procedural requirements for obtaining a permit) must be satisfied. In general, the substantive provisions address minimizing any adverse effects on the waterway that may result from the work. This includes chapter NR 116, Wisconsin's Floodplain Management Program. The substantive provisions are action-specific ARARs.

Section 10 - Rivers and Harbors Act; Section 404

Clean Water Act. Section 404 of the Clean Water Act requires approval from the USACE for discharges of dredged or fill material into waters of the United States, and Section 10 of the Rivers and Harbors Act requires approval from the USACE for dredging and filling work performed in navigable waters of the United States. As the Fox River is a water of the United States, these statutes might implicate action-specific ARARs for dredging/filling work that may be conducted in the River. Under the Fish and Wildlife Coordination Act, the USACE must coordinate with the Fish and Wildlife Service regarding minimization of effects from such work. The work would be subject to the substantive environmental law aspects of permits under these statutes, which would be ARARs. Permits are not required for remediation that is implemented under the authority of CERCLA.

Floodplain and Wetland Regulations and Executive Orders 11988 and 11990

The requirements of 40 CFR § 264.18 (b) and Executive Order 11988, Protection of Flood Plains, are relevant and appropriate to action on the Site. Executive Order 11990 (Protection of Wetlands) is an applicable requirement if there are any wetlands present in the areas to be remediated.

National Historic Preservation Action (NHPA), 16 U.S.C. 470 et seq

The National Historic Preservation Act (NHPA) provides protections for historic properties (cultural resources) on or eligible for inclusion on the National Historic Register of Historic Places (see 36 CFR Part 800). In selecting a remedial alternative, adverse effects to such properties are to be avoided. If any portion of the Site is on or eligible for the National Historical Register, the NHPA requirements would be ARARs.

Endangered Species

Both State and Federal law have statutory provisions that are intended to protect threatened or endangered species [i.e., Endangered Species Act (Federal) and Fish and Game (State)]. In general, these laws require a determination as to whether any such species (and its related habitat) reside within the area where an activity under review by governmental authority may take place. If the species is present and may be adversely affected by the selected activity, where the adverse effect cannot be prevented, the selected action may proceed. If threatened or endangered species exist in certain areas of the Fox River, these laws may constitute an action-specific ARAR. At the Site, the queen snake as well as several plant species were noted by WDNR to be endangered/rare resources occurring within or near the Site.

Management of PCBs and Products Containing PCBs
Wisconsin regulations (i.e., Chapter NR 157, WAC, "Management of PCBs and Products Containing PCBs" that was adopted pursuant to section 299.45. Wisconsin Statutes) which establish procedures for the storage, collection, transport, and disposal of PCB-containing materials also apply to remedial actions taken at the Site.

Solid Waste Management Statutes and Rules (Chapter 289, Wisconsin Statutes and chapters NR 500-520 & NR 600-685, WAC) establish standards that apply to the collection, transportation, storage and disposal of solid and hazardous waste.

It is not expected that federal Resource Conservation and Recover Act (RCRA) or state regulations governing hazardous waste management will be applicable at this Site.

TSCA – Disposal Approval
TSCA regulations for the disposal of PCB remediation waste (40 CFR 761.61) are applicable to the selection of the clean up alternative for remediation of PCBs in sediments at the Lower Fox River Site, and to the disposal of removed sediments at a State licensed landfill. These regulations provide cleanup and disposal options for PCB remediation waste. The three options include self-implementing, performance-based and risk-based disposal approvals. The risk-based disposal approval option is allowed if it will not pose an unreasonable risk of injury to health and the environment.

The current situation in the Lower Fox River, as identified in RA conducted as part of the RI/FS, is that PCB contaminated sediment pose an unacceptable level of risk in the River at this time. Remediation of PCB contaminated sediment via the selected remedy will reduce risks to human health and the environment.

Sediments removed from the Fox River may contain PCBs equal to or greater than 50 ppm. PCB sediment with concentrations less than 50 ppm will be managed as a solid waste in accordance with statutes and rules governing the disposal of solid waste in Wisconsin. PCB sediment with concentrations equal to or greater than 50 ppm will be managed in accordance with the Toxic Substances Control Act of 1976 (Appendix E of the Feasibility Study). Presently TSCA compliance would be achieved through the extension of the January 24, 1995 approval issued by EPA to WDNR pursuant 40 CFR 761.60(a)(5) under the authority of TSCA. This TSCA approval, granted by EPA Region 5, states that the disposal of PCB-contaminated sediment with concentrations equal to or greater than 50 ppm into an NR 500, WAC landfill that is also in compliance with the conditions of the TSCA approval, provides adequate protection to human health and the environment as required by 40 CFR 761.60(a)(5); and, will provide the same level of protection required by EPA, Region 5 and therefore is no less restrictive than TSCA. However, should other administrative rules pertaining to disposal under TSCA in effect at the time that TSCA compliance decisions are made for the Fox River sediment, then compliance with those rules will be achieved.

14.2.3 Additional To Be Considered Information

Section 303(d), Clean Water Act
Under Section 303(d) of the Federal Clean Water Act, states are required, on a periodic basis, to submit lists of "impaired waterways" to EPA. In December 1996, WDNR submitted its first list of impaired waters under Section 303(d). The Fox River was included on the initial list. WDNR has taken no further action with respect to the listing, nor has it developed a total maximum daily load (TMDL) for the River. Currently, a State-wide watershed committee is advising WDNR on the steps to be taken in this process, and the listing process is being reviewed by the

Wisconsin Natural Resources Board. The listing of the Fox River under Section 303(d) is a TBC.

Great Lakes Water Quality Initiative, Part 132, Appendix E
The Great Lakes Water Quality Initiative set forth guidance to the states bordering the Great Lakes regarding their wastewater discharge programs. For remedial actions, the guidance states that any remedial action involving discharges should, in general, minimize any lowering of water quality to the extent practicable. The concepts of the guidance have been incorporated into chapters NR102 to NR 106, WAC. The Great Lakes Water Quality Initiative constitutes a TBC.

Sediment Remediation Implementation Guidance
Part of the Strategic Directions Report of WDNR approved by Secretary Meyer in 1995 addressed the sediment remediation approach to be followed by WDNR. This approach includes meeting water quality standards as a goal of sediment remediation projects. In developing a remedial approach, the guidance calls for use of a complete risk management process in consideration of on-site and off-site environmental effects, technological feasibility, and costs. The guidance constitutes a TBC.

Great Lakes Water Quality Agreement
The Great Lakes Water Quality Agreement calls for the identification of "Areas of Concern" in ports, harbors, and River mouths around the Great Lakes. Remedial goals to improve water quality are to be established in conjunction with the local community. In the case of the Fox River, a Remedial Action Plan (RAP) has been prepared and finalized. The RAP lists a series of recommendations ranging from addressing contaminated sediments to controlling non-point source runoff. This RAP is a TBC.

Fox River Basin Water Quality Management Plan
This plan was developed by WDNR and lists management objectives for improving water quality in the Fox River Basin. The Fox River Basin Water Quality Management Plan is a TBC.

Table 31 Fox River ARARs

Act / Regulation	Citation
Federal Chemical-Specific ARARs	
TSCA	40 CFR 761.60(a)(5)-761.79 and U.S. EPA Disposal Approval
Clean Water Act – Federal Water Quality Standards	40 CFR 131 (if no Wisconsin regulation) and 33 CFR 323
Federal Action-/Location - Specific ARARs	
Fish and Wildlife Coordination Act	16 USC 661 *et seq.* 33 CFR 320-330-Rivers and Harbors Act 40 CFR 6.304
Endangered Species Act	16 USC 1531 *et seq.* 50 CFR 200 50 CFR 402
Rivers and Harbor Act	33 USC 403; 33 CFR 322, 323
National Historic Preservation Act	15 USC 470; *et seq.* 36 CFR Part 800
Floodplain and Wetlands Regs & Executive Orders	40 CFR 264.18 (b) and Executive Order 11988

Act / Regulation	Citation
State Chemical-Specific ARARs	
TSCA-Disposal Approval	U.S. EPA Approval
Surface Water Quality Standards	NR 102, 105 and 207 NR 722.09 1-2
Ground-Water Quality Standards	NR 140
Soil Cleanup Standards	NR 720 and 722
Hazardous Waste Statutes and Rules	NR 600 - 685
State Action- / Location-Specific ARARs	
Management of PCBs and Products Containing PCBs	NR 157
Wisconsin's Floodplain Management Program	NR 116
Solid Waste Management	NR 500-520
Navigable Waters, Harbors, and Navigation	Chapter 30 - Wisconsin Statutes
Fish and Game	Chapter 29.415 - Wisconsin Statutes

14.3 Cost-Effectiveness

WDNR and EPA have determined that the selected remedy is cost effective. Section 300.430 (f)(1)(ii)(D) of the NCP requires that all the alternatives that meet the threshold criteria (protection of human health and the environment and compliance with ARARs) must be evaluated by comparing their effectiveness to the three balancing criteria (long-term effectiveness and permanence, reduction of toxicity, mobility or volume through treatment, and short-term effectiveness). The selected remedies meet these criteria by achieving a permanent protection of human health and the environment at low risk to the public, and provide for overall effectiveness in proportion to their cost.

The Superfund program does not mandate the selection of the least costly cleanup alternative. The least costly effective remedy is not necessarily the remedy that provides the best balance of tradeoffs with respect to the remedy selection criteria nor is it necessarily the least-costly alternative that is both protective of human health and the environment and ARAR-compliant. Cost effectiveness is concerned with the reasonableness of the relationship between the effectiveness afforded by each alternative and its costs compared to other available options.

The total net present worth of the selected remedy for OU 1 and OU 2 is $76.5 million**.**

14.4 Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

WDNR and EPA believe that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for the Fox River Site. The selected remedy does not pose excessive short-term risks. There are no special implementability issues that set the selected remedy apart from the other alternatives evaluated.

14.5 Preference for Treatment as a Principal Element

Based on current information, WDNR and EPA believe that the selected remedy is protective of human health and the environment and utilizes permanent solutions to the maximum extent possible. The remedy, however, does not satisfy the statutory preference for treatment of the hazardous substances present at the Site as a principal element because such treatment was not found to be practical or cost effective.

14.6 Five-Year Review Requirements

The NCP, at 40 CFR § 300.430(f)(4)(ii), requires a five-year review if the remedial action results in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure. Because this remedy will result in hazardous contaminants remaining on site above levels that allow for unlimited exposure, a statutory review will be conducted within five years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

15. DOCUMENTATION OF SIGNIFICANT CHANGES FROM PREFERRED ALTERNATIVE OF PROPOSED PLAN

To fulfill the requirements of CERCLA 117(b) and NCP [40 CFR § 300.430(f)(5)(iii)(B) and 300.430(f)(3)(ii)(A)], a ROD must document and discuss the reasons for any significant changes made to the Proposed Plan.

The Proposed Plan was released for public comment in October 2001. It identified a PCB sediment clean up target of 1.0 ppm in OU 1 with monitored natural recovery in OU 2.

In the selection of the remedy for OU 1 and OU 2, the WDNR and EPA considered information submitted during the public comment period re-evaluated portions of the proposed alternative.

<u>New Information obtained during the Public Comment Period</u>
WDNR and EPA considered alternative proposals for OU 1 submitted as comments. As a result of consideration of these comments, the following were incorporated into this Record of Decision: 1) If dredging is unable to reduce exposed contaminants PCB concentrations, a sand cover will be employed to further reduce risks, rather than continue with dredging removal operations (Section 13.3); and 2) if it is predicted, based on results from partial completion of dredging OU 1, that concentrations may not sufficiently reduce risks, or if capping is shown to be less costly than complete dredging, then capping may be employed for some areas not yet dredged (Section 13.4).

These proposals may be given further consideration prior to implementation of remedial actions. However if these proposals cause a fundamental change to the alternatives described in this decision (e.g., changing the remedy from removal to containment), then WDNR and EPA would issue a new, revised Proposed Plan and would have a public comment period after which a ROD Amendment would be finalized. If the change is not “fundamental,” but “significant” (e.g., modification of volumes to be removed), then an Explanation of Significant Difference would be issued, and there would be limited public comment.

Response:

Please see our Section B.1.5 of this review. There we describe the difficulty of using distance along the reach.

B.2.1e Models for Variation in PCB Concentration in Space and Time

Comment:

In MWL 2.6, the time trend is modeled as an annual rate of PCB change, with adjustments for spatial variability and depth (separate spatial adjustments within each deposit group and depth interval, and separate depth adjustments within each deposit group). The idea of spatial adjustment of time trends is important but the execution raises questions. Earlier, I commented on the complexity, introduced through the creation of depth intervals and deposit groups, that can sharply reduce the precision of time trend estimates and cloud their interpretability. I also suggested more parsimonious ways to address issues of spatial heterogeneity.

Response:

We addressed this issue in our summary comments (Section B.1.1). There is complexity (perhaps "multiplicity" is a better word) to many spatial units defined by depth and deposit groups. There will also be complexity in a global model that truly reflects local spatial concentrations. Further, the global model would be used to infer concentrations to local spatial units (for the most part this is untestable). The remediation of the River must address discrete spatial units and not the River as a whole or even a reach as a whole.

Comment:

The particular model of Equation 2 in MWL 2.6 is curious in its method for describing spatial location through northing and easting coordinates. Furthermore, the model has no cross-product term that makes it not-invariant to coordinate rotation.

Response:

We used a northing and easting coordinate system (similar to "X and Y coordinates") to indicate locations of samples. We earlier (Section B.1.5) indicated the reason for not including cross-product terms in the model. However, in retrospect, we feel that rotating (per deposit) our rectangular coordinate system to be more in line with the River might have been helpful for some of the deposits.

Comment:

A more natural description would start with a centerline along the River reach. A sample location would then be described through its orthogonal [nearest] projection onto this centerline. The position on the centerline becomes one coordinate of the sample location, and the signed distance to the centerline becomes the second coordinate. With this coordinate system the spatial model coefficients are more readily interpretable and further simplification is possible.

Response:

This has been covered elsewhere, such as in Section B.1.5.

Appendices for this Record of Decision are available by placing a request using the Customized CERCLIS/RODS Report Order Form.

http://www.epa.gov/superfund/sites/phonefax/rods.htm