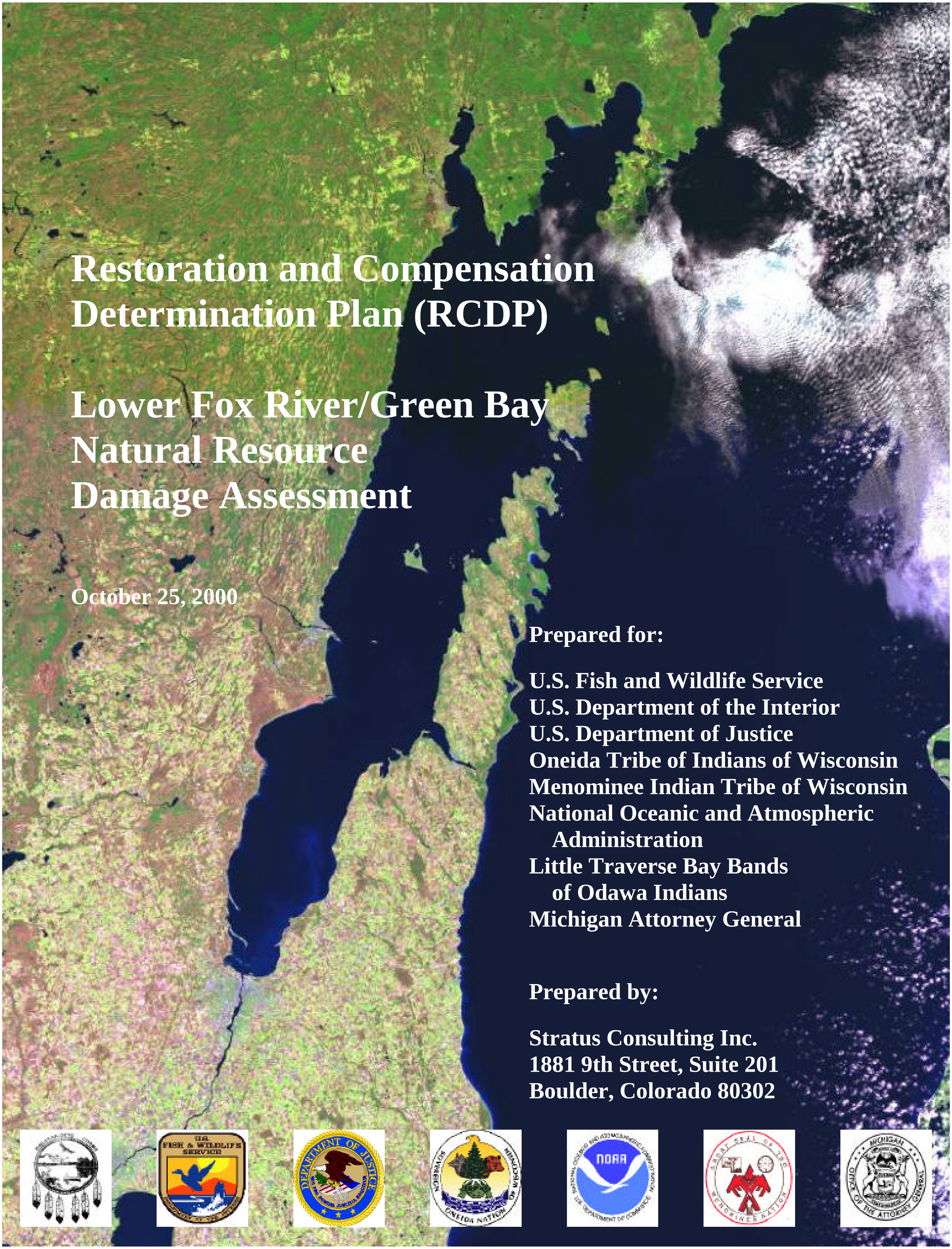


Restoration and Compensation Determination Plan (RCDP)

Lower Fox River/Green Bay Natural Resource Damage Assessment

October 25, 2000

Prepared for:

U.S. Fish and Wildlife Service
U.S. Department of the Interior
U.S. Department of Justice
Oneida Tribe of Indians of Wisconsin
Menominee Indian Tribe of Wisconsin
National Oceanic and Atmospheric Administration
Little Traverse Bay Bands of Odawa Indians
Michigan Attorney General

Prepared by:

Stratus Consulting Inc.
1881 9th Street, Suite 201
Boulder, Colorado 80302

Restoration and Compensation Determination Plan (RCDP)

Lower Fox River/Green Bay Natural Resource Damage Assessment

Prepared for:

U.S. Fish and Wildlife Service
U.S. Department of the Interior
U.S. Department of Justice
Oneida Tribe of Indians of Wisconsin
Menominee Indian Tribe of Wisconsin
National Oceanic and Atmospheric Administration
Little Traverse Bay Bands of Odawa Indians
Michigan Attorney General

Prepared by:

Stratus Consulting Inc.
1881 9th Street, Suite 201
Boulder, CO 80302
(303) 381-8000

October 25, 2000

William F. Hartwig
U.S. Fish and Wildlife Service, Regional Director and Authorized Official

Contents

Acronyms

CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
FCA	fish consumption advisory
FRG	Fox River Group
GBMBS	Green Bay Mass Balance Study
GLWQC	Great Lakes Water Quality Guidance
IGP	Intergovernmental Partnership
iRCDP	initial restoration and compensation determination plan
MITW	Menominee Indian Tribe of Wisconsin
MOA	Memorandum of Agreement
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRDA	natural resource damage assessment
OTIW	Oneida Tribe of Indians of Wisconsin
RCDP	Restoration and Compensation Determination Plan
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
WCA	waterfowl consumption advisory
WDNR	Wisconsin Department of Natural Resources

Figures

Tables

1. Introduction and Summary

1.1 Introduction

The Department of the Interior (Department) acting through the U.S. Fish and Wildlife Service (the Service), the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, the Menominee Indian Tribe of Wisconsin (MITW), the Oneida Tribe of Indians of Wisconsin (OTIW), the Michigan Attorney General, and the Little Traverse Bay Bands of Odawa Indians (collectively, the Co-trustees)[1] are conducting an assessment of natural resource damages (known as a natural resource damage assessment, or NRDA) that have resulted from releases of PCBs to the Lower Fox River/Green Bay ecosystem. Section 107 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, more commonly known as the federal “Superfund” law) [42 U.S.C. § 9607], Section 311 of the Federal Water Pollution Control Act (CWA, commonly known as the Clean Water Act) [33 U.S.C. § 1321], and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 CFR Part 300] provide authority to the Co-trustees to seek such damages.

The Co-trustees’ NRDA follows an administrative process that is outlined in federal regulations at 43 CFR Part 11 (Department regulations). The objective of this NRDA process is to compensate the public, through environmental restoration, for losses to natural resources that have been caused by releases of PCBs into the environment. The results of this administrative process are contained in a series of planning and decision documents that have been published for public review. The Department completed a Preassessment Screen and Determination in May 1994 (U.S. FWS, 1994), which concluded that there was sufficient information to proceed with an NRDA for the Lower Fox River and Green Bay Environment. In August 1996, the Co-trustees published for public comment an assessment plan (U.S. FWS and Hagler Bailly Consulting, 1996) for the Lower Fox River and Green Bay Environment. This plan provided

1. These agencies are referred to as natural resource “Co-trustees” because they have agreed to work together to perform a single, comprehensive, joint natural resource damage assessment with the aim of restoring natural resources that have been injured as a result of releases of PCBs. The Wisconsin Department of Natural Resources (WDNR) declined a 1993 invitation to conduct a joint NRDA and entered into an agreement in 1997 to conduct a separate assessment led by the Fox River Group (FRG) of paper mills. However, in 2000 the WDNR entered a joint assessment plan addendum with the Co-trustees designed to merge compatible parts of the FRG-led NRDA with the Co-trustees’ NRDA, and WDNR subsequently has endorsed parts of the Co-trustees’ NRDA (U.S. FWS, 2000; WDNR, 2000). The Co-trustees have also invited other state and tribal agencies in Michigan to join the Fox River and Green Bay NRDA because much of Green Bay is in Michigan waters, Fox River PCBs contaminate natural resources that routinely cross between Wisconsin and Michigan, and many opportunities for environmental restoration in and around Green Bay are in Michigan.

information on which natural resources would be assessed for injuries, the Co-trustees' authority for conducting the assessment, and coordination among Co-trustees. In addition, the assessment plan confirmed water, sediment, fish, and wildlife exposure to PCBs, discussed the recovery period for natural resources exposed to PCBs, and outlined pathway and injury assessment approaches, damage determination methodologies, and quality assurance measures. The Co-trustees published for public comment three addenda to the assessment plan. The first (U.S. FWS and Hagler Bailly Services, 1997) outlined additional approaches that the Co-trustees would use, including additional detail on injury studies of walleye, waterfowl, tree swallows, and Forster's terns; assessment of transportation service interruptions due to injured sediments; and assessment of injuries and damages specific to the Oneida Tribe. The second addendum (U.S. FWS and Hagler Bailly Services, 1998) was an initial restoration and compensation determination plan (iRCDP), which provided an overview of the restoration planning and damage determination process. In particular, the iRCDP described criteria for determining project acceptability, project focus, project implementation, and project benefits; the process for ranking and scaling projects (including the total value equivalency economic assessment); and the process and methodologies for determining compensable values, including the recreational fishing damages economic assessment. The third addendum (U.S. FWS, 2000) set forth a process that could result in a unified NRDA acceptable to both the Co-trustees and the WDNR.

In addition to these planning and decision documents, specific results and findings of the Co-trustees' NRDA were published for public review in a series of reports addressing PCB transport pathways, natural resource injuries, and economic damage determinations (U.S. FWS and Stratus Consulting, 1998, 1999a, 1999b, 1999c, 1999d, 1999e, 1999f).

This Restoration and Compensation Determination Plan (RCDP) represents the next phase of the NRDA process. In it, the Co-trustees present their planned approach for restoring injured natural resources and compensating the public for losses caused by releases of PCBs. As such, the RCDP ties together the Co-trustees' previous injury determinations, completes the economic valuation of damages, and presents an evaluation of the type and scale of environmental restoration required to make the public whole. The public is afforded an opportunity to comment on the RCDP, and the Co-trustees will respond to those comments in the Report of Assessment.[2]

In addition to providing for the recovery of natural resource damages, the Superfund Law provides for cleanup of the environment by federal and state response agencies in order to address ongoing risks to human health and the environment. The U.S. Environmental Protection Agency (EPA) has proposed the site for inclusion on the National Priorities List (NPL) of Superfund sites, and EPA and WDNR currently are performing a Remedial Investigation/

2. If, as a result of public comments, the Co-trustees make substantive changes to their restoration and compensation approach, the RCDP may be revised and finalized in a subsequent public release document.

Feasibility Study (RI/FS) to evaluate possible cleanup activities. The culmination of this ongoing process will be the publication of a Record of Decision (ROD) by EPA in which the EPA's decisions regarding remedial actions for the site will be documented.

As described in the Co-trustees' iRCDP (U.S. FWS and Hagler Bailly Services, 1998), final assessment of natural resource damages is dependent on the results of the RI/FS process because the potential for restoration and the nature and extent of future damages will depend on the extent of PCB cleanup undertaken by the response agencies. Therefore, the final natural resource damage claim will be calculated after EPA has issued the ROD for the site. After publication of the ROD, the Co-trustees will issue a report of assessment [43 CFR § 11.90] that will make any necessary updates to previous determinations, will summarize and respond to comments provided on the assessment plan and addenda, and will result in a claim, on behalf of the public, for a sum certain, which is a definitive damage claim.[3] Once a damages award has been determined, the Co-trustees will develop a detailed restoration plan (the post-award restoration plan) for public comment that will provide a detailed description of the Co-trustees' restoration measures, including descriptions of the specific projects that will be undertaken to restore, rehabilitate, replace, or acquire natural resources and thereby compensate the public for harm caused by PCBs.

The RCDP is organized as follows: the remainder of Chapter 1 presents a summary of the Co-trustees' Restoration and Compensation Determination Plan. Chapter 2 presents a summary of the Co-Trustees' determination and quantification of injuries to natural resources in the Lower Fox River/Green Bay ecosystem. Chapter 3 describes the Co-trustees' selected restoration and compensation determination approach. Chapter 4 provides a summary of the Co-trustees' planning and coordination activities. Finally, detailed descriptions of key elements of the Co-trustees' restoration and compensation determination are provided in technical appendices to this RCDP.

3. A final damage claim for the Fox River/Green Bay site cannot be completed until EPA and WDNR's response actions have been selected because of the relationship between the extent of site cleanup undertaken by the response agencies and total natural resource damages. As was discussed in the iRCDP, the quicker and more complete the remedy or cleanup, the less the total harm to the environment that must be addressed through restoration. At sites like the Lower Fox River and Green Bay Environment, where decades of harm have already occurred and where even the best available remedies will not compensate the public for past harm, restoration activities are necessary to compensate the public for losses incurred. In addition, even the most aggressive cleanup in the river cannot prevent further harm in Green Bay, where most of the PCBs released by Fox River paper mills now reside, and injuries will continue in the Fox River for some time in the future. The final claim for damages therefore will require evaluation of the extent and timing of site cleanup and the rate of recovery of natural resources to baseline conditions.

1.2 Summary of Co-Trustees' RCDP for the Lower Fox River/Green Bay NRDA

The Co-trustees' natural resource damage assessment includes three primary elements: injury determination, injury quantification, and damage determination [43 CFR § 11.60(b)]. The Co-trustees have previously completed the first two elements, which yielded the following determinations for the Fox River/Green Bay natural resource damage assessment: PCB Pathway Determination (August 1999), Injuries to Surface Water Resources (November 1999), Injuries to Fishery Resources (November 1999), and Injuries to Avian Resources (May 1999).

This RCDP, along with the iRCDP published in September 1998 and the Recreational Fishing Damages Determination published in November 1999, describes the activities that constitute the third element of the assessment — damage determination. Under the Department's regulations, damage determination includes four primary trustee activities: development of a reasonable number of possible alternatives for restoration, rehabilitation, replacement, and/or acquisition of equivalent resources; selection of the most appropriate alternative; identification of methods for estimating the costs of the restoration alternative selected; and identification of methods for determining the compensable value of the services lost to the public associated with the selected alternative [43 CFR §§ 11.80, 11.82-11.83]. These activities serve as a blueprint for producing the final natural resource damage claim, which comprises the cost of restoration to baseline of the natural resources and the services they provide, the compensable value of services lost until baseline is achieved, and the Co-trustees' reasonable assessment costs [42 U.S.C. § 9607(a)(4)(C), 43 CFR § 11.80(b)].

To select a preferred restoration alternative, the Co-trustees compiled and analyzed a list of more than 600 potential projects, in light of the factors set out in 43 CFR § 11.82(d) and decision-making criteria published in the iRCDP. In addition, the Co-trustees conducted a total value equivalency study (Appendix A) to help determine the types and scale of restoration projects that would be necessary to restore the natural resources to baseline, as measured by the value of the services they provide, and to compensate for any ongoing and future losses of services. CERCLA prohibits natural resource trustees from any double recovery for natural resource damages [42 U.S.C. § 9607(f)(1)]. To avoid double counting between the value of restoration projects and compensable values measured in the recreational fishing study, the Co-trustees propose to use the recreational fishing study for past damages only, and costs of restoration for future damages only.

In selecting their preferred restoration alternative, the Co-trustees rejected the no-action/natural recovery alternative. Under this alternative, no further actions would be undertaken to restore natural resources. In addition, the Co-trustees rejected a PCB removal alternative because PCB removal is currently being evaluated by EPA and WDNR as part of the ongoing RI/FS.

Instead, the Co-trustees' preferred restoration alternative focuses on performing resource-based restoration actions to improve the environmental health of the Lower Fox River and Green Bay Environment and thereby compensate for losses resulting from PCB injuries. The Co-trustees' restoration plan for the NRDA will involve a mix of actions designed to provide ecological and social benefits. A central element of the Co-trustees' restoration approach is ensuring that the restoration addresses the full geographic and ecological scope of the injuries to natural resources. Therefore, in developing their final restoration plan, the Co-trustees will ensure that restoration activities:

- address the entire Lower Fox River and Green Bay Environment, from Little Lake Butte des Morts in the south to the Bays des Noc in the north

- encompass the unique range of habitats in the Green Bay region, including the aquatic habitat of the bay itself, the coastal wetlands on the west shore, the rich riverine habitats that connect to the bay, and the valuable ecological habitats of the Door Peninsula and the Bays des Noc

- provide for long-term recovery, protection, and enhancement of the unique natural resource endowment of the Lower Fox River and Green Bay Environment

- consider human uses of the natural environment to provide for ongoing and long-term active and passive uses of Green Bay natural resources.

The specific restoration actions that constitute the Co-trustees' preferred alternative include wetland preservation, wetland restoration, and reduction of nonpoint source runoff loads into the bay from cropland through conservation tillage and installation of vegetated buffer strips along streams. These actions will provide valuable environmental benefits that will compensate for the injuries caused by PCBs:

- Wetlands provide valuable habitat for many fish and bird species. They are highly productive areas, and help reduce wave erosion, contain nonpoint source runoff, and recycle nutrients. Many fish species of Green Bay rely on coastal wetlands for breeding and rearing, including yellow perch, northern pike, and largemouth bass, as well as shiners and minnows, which are essential prey items for many birds and larger fish. Many bird species also rely on wetlands for breeding and feeding, such as herons, rails, eagles, and terns. Coastal, riparian, and near-shore wetlands historically were an integral component of the habitat and wildlife diversity of the Green Bay area. However, most of the wetlands around Green Bay have been drained or filled, making preserving the remaining wetlands an important priority. Actions to preserve and restore wetlands thus can improve the environmental quality of the Lower Fox River and Green Bay

Environment to compensate for the ecological and human use of service losses caused by PCB injuries.

- Nonpoint source runoff pollution into Green Bay can stimulate the growth of blue-green algae, which causes the periodic algae blooms in inner Green Bay. The blue-green algae also contribute to low oxygen conditions (when the algae die), making the water less habitable for some native fish species and more hospitable to species such as carp, which can survive in low-oxygen waters. Blue-green algae contribute little to the aquatic food chain of the bay, and can release a chemical when they die that can irritate people's skin and eyes on contact. The decreased light penetration in the bay caused by runoff limits the growth of submerged aquatic vegetation that provides important habitat for fish and waterfowl, and can also reduce the feeding success of sight-feeding fish such as sport fish like walleye and northern pike. Reducing nonpoint source runoff pollution can improve the quality of the Lower Fox River and Green Bay Environment, thereby compensating for the decrease in environmental quality caused by PCBs.

- Runoff control through vegetated buffer strips and conservation tillage practices also provides some habitat services for wildlife. The streambank stabilization caused by the roots of the vegetation used in buffer strips helps to maintain stream geometry, thereby enhancing neighboring stream habitat for fish and macroinvertebrates. The vegetative cover of the buffer strip can provide wildlife nesting and feeding habitat, and can serve as connecting corridors that enable wildlife to move safely from one habitat to another. Conservation tillage can provide cover for birds and small mammals and higher quality habitat for soil invertebrates (which, in turn, are fed upon by small mammals and birds).

In addition, the Co-trustees also included consideration of improvements to existing recreational facility improvements as a component of the restoration. The scale of the environmental restoration projects necessary to compensate the public for injuries to natural resources of the river and bay was determined through a total value equivalency study. The value to the public of the improvement in the environment that will be attained through wetland preservation, wetland restoration, and nonpoint source pollution reductions is balanced with the value of the resources and services lost to the public because of the PCB injuries.

Table 1.1 summarizes the past compensable values (from the recreational fishing damages assessment) and the estimated costs of restoration to address present and future PCB injuries. The restoration costs shown in Table 1.1 are illustrative only, for the amount of restoration required depends on the level of PCB cleanup that will be conducted by the response agencies. In addition, different possible mixes of restoration projects are possible, and the composition of the mix affects the total restoration cost. The Co-trustees prefer a mixture of project types so that the full range of ecological service types lost because of PCB injuries are restored and the public's values and attitudes toward restoration of Lower Fox River and Green Bay Environment resources are adequately addressed. Furthermore, a mix of project types allows for the flexibility necessary to actually implement a restoration plan. The final mix of restoration projects will be determined in the Co-trustees' post-award restoration plan.

Table 1.1. Potential damages under different remediation scenarios[a] (millions of dollars, 2000 present value).

Remediation scenario	Past interim damages (recreational fishing losses)	Present and future damages (restoration costs)[b]	Total
Intensive PCB cleanup (baseline achieved in 20 years)	$65	$111-191	$176-256
Intermediate PCB cleanup (baseline achieved in 40 years)	$65	$158-268	$223-333

a. Table does not include the reasonable and necessary costs of conducting the assessment, which will be included in the final claim.

b. Values are from illustrative mixes of restoration project types and are not intended to necessarily represent the costs that will be used in the final claim. See Section 3.2.9.

2. Natural Resource Injuries

The purpose of the natural resource damage assessment is to establish restoration of and compensation for natural resources that have been injured as a result of releases of hazardous substances. Therefore, restoration and compensation planning relies on the Co-trustees' assessment of natural resource injuries in the Lower Fox River and Green Bay Environment. The results of the injury assessment are presented in a series of reports that have been released previously to the public:

- Fish Consumption Advisories in the Lower Fox River/Green Bay Assessment Area (U.S. FWS and Stratus Consulting, 1998)
- Association between PCBs, Liver Lesions, and Biomarker Responses in Adult Walleye (*Stizostedium vitreum vitreum*) Collected from Green Bay, Wisconsin. (U.S. FWS and Stratus Consulting, 1999a)
- Injuries to Avian Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment (U.S. FWS and Stratus Consulting, 1999b)
- Injuries to Fishery Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment (U.S. FWS and Stratus Consulting, 1999c)
- Injuries to Surface Water Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment (U.S. FWS and Stratus Consulting, 1999d)
- PCB Pathway Determination for the Lower Fox River/Green Bay Natural Resource Damage Assessment (U.S. FWS and Stratus Consulting, 1999e).

Each of the above reports is available at the Service's Lower Fox River/Green Bay NRDA website at http://www.fws.gov/r3pao/nrda/index.html and has been presented at public meetings (see Appendix B). Moreover, the results of these injury determinations have been accepted by the WDNR and adopted as the basis for joint restoration planning pursuant to the Third Addendum to the Assessment Plan for the Lower Fox River/Green Bay NRDA (WDNR, 2000). This chapter establishes the foundation for the Co-trustees' restoration and compensation determination by providing a brief summary of the results of the injury phase of the NRDA. This summary is based on the above-cited reports.

2.1 Natural Resources of the Lower Fox River and Green Bay Environment

As part of the larger Lake Michigan and Great Lakes ecoregion (Figure 2.1), the Lower Fox River and Green Bay form a unique and important ecosystem. The terrestrial, wetland, and aquatic habitats of the Lower Fox River and Green Bay Environment assessment area (Figure 2.2) support a wide diversity of birds, fish, and mammals, including many rare, threatened, and endangered species. The health of the ecosystem and the quality of its ecological habitats are vital to the invertebrates, plants, fish, and wildlife of the area. Human use services of these resources, such as recreational fishing, boating, and swimming, and tribal cultural uses, also depend on the health and quality of the Lower Fox River and Green Bay Environment.

Figure 2.1. The Great Lakes Basin, and location of Green Bay.

Figure 2.2. The Lower Fox River and Green Bay Environment assessment area.

The assessment area contains diverse aquatic habitats that include riverine, near-shore, and open water habitats. Riverine habitats are found in the Lower Fox River and in tributaries to Green Bay. The warm, shallow waters typical of shorelines and of Lower Green Bay support warm water fish such as white bass (Bertrand et al., 1976; Brazner, 1997). Sandbars and estuaries, vital spawning and nursery habitats for many fish species such as yellow perch and northern pike (Brazner, 1997), characterize the western and southern shores of Green Bay, whereas rocky steep shorelines are typical of the eastern shore. Cold, deep waters characterize the open waters of outer Green Bay, generally defined as the section of the bay north of Chambers Island. These waters support cold-water fish such as trout and salmon (Bertrand et al., 1976).

This diversity of habitats supports a diversity of fish species at different trophic levels (University of Wisconsin-Green Bay, 1993). Small forage fish, including alewives, gizzard shad, and spottail shiners, feed on insects, zooplankton, and bottom-dwelling invertebrates and occupy nearshore habitats where aquatic vegetation provides cover and forage. These forage fish provide an important trophic link between zooplankton and game fish such as walleye, northern pike, trout and salmon. Bottom feeders such as channel catfish provide another trophic link between bottom-dwelling invertebrates and higher level predators (University of Wisconsin-Green Bay, 1993).

The fishery resource, one of the most productive in the Great Lakes, is of central importance to the Green Bay food web because it provides food for the region's many piscivorous (i.e., fish-eating) birds and mammals (U.S. EPA and Environment Canada, 1995). Birds and mammals that depend on the fishery resource for food include bald eagles, terns, herons, ducks, double-crested cormorants, otter, and mink (Linscombe et al., 1982; Toweill and Tabor, 1982; Allen et al., 1987). Nationally significant fish stocks of the area, as classified by the Great Lakes Fish and Wildlife Restoration Act (16 U.S.C. 941), include lake trout, yellow perch, lake sturgeon, and walleye (U.S. FWS and Stratus Consulting, 1999c).

Situated on one of the major bird migration routes in North America, the Mississippi Flyway, the Lower Fox River and Green Bay Environment provides essential habitat for large populations of breeding and migratory birds (Temple and Cary, 1987; Erdman and Jacobs, 1991; Robbins, 1991; U.S. FWS and Stratus Consulting, 1999b). Over 250 bird species have been recorded in the five Wisconsin counties immediately adjacent to the bay and river (Temple and Cary, 1987), and 91 bird species have been recorded in the townships adjacent to the Michigan Green Bay shore (Brewer et al., 1991). At least 16 species listed by either the State of Wisconsin, the State of Michigan, or the federal government as threatened or endangered are found in the assessment area, including bald eagle, peregrine falcon, great egret, and Caspian and Forster's terns (U.S. FWS and Stratus Consulting, 1999b).

The assessment area is located within a transitional zone where plant communities typical of both colder and warmer climates converge (Curtis, 1959). Thus, upper Green Bay is characterized by conifer forests whereas lower Green Bay and the Lower Fox River are characterized by hardwood forests, resulting in the occurrence in the assessment area of species typical of both habitats (U.S. FWS and Stratus Consulting, 1999b). The wetlands located along the bay provide key habitat for migratory and nesting birds, and the small uninhabited islands of Green Bay provide nesting sites for large colonies of breeding waterbirds such as terns and herons, free from human disturbance and mammalian predators. Because of its comparatively undeveloped nature and the quality and extent of its habitats, the assessment area supports more diverse bird communities than are found elsewhere in the Great Lakes region (U.S. FWS and Stratus Consulting, 1999b).

Human uses of the Green Bay/Lower Fox River resources include waterfowl hunting; recreational, commercial, and sustenance fishing; and tribal cultural uses (U.S. FWS and Stratus Consulting, 1999b, 1999c). During the fall influx of migratory ducks and geese, the waterfowl in and around Green Bay are intensively hunted and comprise an important recreational resource (K. Stromborg, U.S. Fish and Wildlife Service, personal communication, 1998).

The avian and fishery resources of the Lower Fox River/Green Bay ecosystem are vital food sources and are of great cultural significance to the Oneida and Menominee nations (U.S. FWS and Stratus Consulting, 1999b, 1999c). After the Oneida people were relocated from New York to the reservation near the city of Green Bay, they obtained most of their meat from local game, including waterfowl, turkey, and other small game. In addition, the local birds, including the bald eagle, play an important spiritual role in the lives of the Oneida and Menominee people (U.S. FWS and Stratus Consulting, 1999b). The fishery resource is also an integral part of the Oneida and Menominee tribal cultures. For the Oneida people, the annual fish migrations were historically a focus for cultural events and community gatherings, and also provided a means of income supplementation (U.S. FWS and Stratus Consulting, 1999c). Similarly, the lake sturgeon was historically an important source of food for the Menominee people, and it is a spiritual being in the creation of the Menominee and remains a strong cultural and spiritual symbol (D. Cox and R. Wilson, Menominee Indian Tribe, personal communication, October 2000).

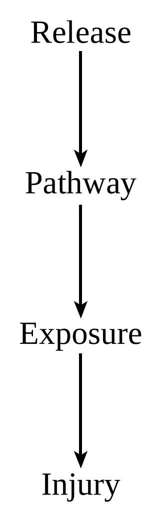


Figure 2.3. The natural resource injury chain of events.

2.2 Injury Determination

Figure 2.3 shows the chain of events that has resulted in injuries to natural resources. Injuries to natural resources were evaluated pursuant to the Department's regulations at 43 CFR Part 11, as described in the

Assessment Plan (61 FR 43,558) and three addenda to the Assessment Plan (62 FR 67,888; 63 FR 43,558; and 65 FR 33,823), and in individual injury reports. Considerable amounts of data were available for the site, including data collected as part of the Green Bay Mass Balance Study (GBMBS), Wisconsin and Michigan State fish and wildlife contaminant monitoring databases, and field data collected by numerous university and government researchers. These data were supplemented by the Co-trustees with several focused injury studies (Table 2.1). Because of the size and the diversity of the assessment area, evaluation of injuries to every species was not feasible. Instead, the Co-trustees focused the injury assessment on selected representative resources and injury categories (Table 2.2).

Table 2.1. Supplemental data collected for the Co-trustees' injury assessment.[a]

Fish	Birds
PCB exposure data (lake trout, brown trout, walleye)	PCB exposure data in eggs (Forster's tern, common tern, tree swallow)
Fish health data (lake trout, brown trout, walleye)	PCB exposure data in waterfowl (lesser scaup, mallard, greater scaup, bufflehead, common goldeneye ruddy duck, common merganser, red-breasted merganser, tree swallows)
Fish reproduction data (lake trout)	
PCB toxicity data (lake trout)	

a. These studies are described in the Assessment Plan and Addendum for the Lower Fox River/Green Bay NRDA (U.S. FWS and Hagler Bailly Consulting, 1996; U.S. FWS and Hagler Bailly Services, 1997).

2.2.1 PCB releases

Starting in the mid-1950s, Lower Fox River paper companies and associated waste treatment facilities released PCBs to the Lower Fox River (U.S. FWS and Stratus Consulting, 1999e). These releases comprised byproducts of a process that made, converted, or recycled carbonless copy paper containing PCBs. Multiple Lower Fox River paper companies contributed to the releases, including Appleton Coated Paper, PH Glatfelter — Bergstrom Division (formerly Bergstrom Paper), Wisconsin Tissue Mills, Fort James Green Bay West Mill (formerly Fort Howard), and other secondary fiber producers. In addition, releases occurred from Arrowhead Park landfill and the City of Appleton and Neenah-Menasha POTWs, all of which handled wastes received from the paper companies (U.S. FWS and Stratus Consulting, 1999e). A schematic diagram that illustrates the flow and releases of PCBs associated with NCR paper production is provided as Figure 2.4.

Table 2.2. Injury assessment approach.

Natural resource	Injury definitions evaluated	Representative species or matrix evaluated	Biological effects evaluated (where relevant)	Evaluation approach	NRDA injury determination reports
Birds	Adverse changes in viability [43 CFR § 11.62(f)(1)(i)]	Forster's tern	Reduced hatching success; embryonic deformities; behavioral effects	Evaluate existing studies to determine whether the biological resource has undergone any of the adverse changes in viability that are specified in the NRDA regulations as causing injury[a]; evaluate cause of any adverse effects observed	U.S. FWS and Stratus Consulting, 1999b
		Common tern	Reduced hatching success; embryonic deformities		
		Caspian tern	Embryonic deformities; behavioral abnormalities		
		Double-crested cormorant	Reduced hatching success; embryonic/chick deformities		
		Black-crowned night heron	Physical deformations		
		Tree swallow	Reduced breeding success		
		Red-breasted merganser	Reduced breeding success		
		Bald eagle	Reduced breeding productivity		
	FDA exceedences [43 CFR § 11.62(f)(1)(ii)]	Waterfowl (ducks and geese)	NA	Compare tissue concentrations to FDA tolerance	
	Consumption advisory exceedences [43 CFR § 11.62(f)(1)(iii)]	Waterfowl (ducks and geese)	NA	Evaluate State advisory programs	

Table 2.2. Injury assessment approach (cont.).

Natural resource	Injury definitions evaluated	Representative species or matrix evaluated	Biological effects evaluated (where relevant)	Evaluation approach	NRDA injury determination reports
Fish	Adverse changes in viability [43 CFR § 11.62(f)(1)(i)]	Walleye	Fish health (cancer, disease, physiological malfunction, deformation)	Collect supplemental data to determine whether fish have undergone any of the adverse changes in viability that are specified in the NRDA regulations as causing injury[a]; evaluate cause of any adverse effects observed	U.S. FWS and Stratus Consulting, 1999a
		Brown trout	Fish health (cancer, physiological malfunction, deformation)		U.S. FWS and Stratus Consulting, 1999c
		Lake trout	Fish reproduction (embryomortality and deformities); fish health (cancer, physiological malfunction, deformation)		
	FDA exceedences [43 CFR § 11.62(f)(1)(ii)]	Species with available data	NA	Compare tissue concentrations to FDA tolerance	U.S. FWS and Stratus Consulting, 1998
	Consumption advisory exceedences [43 CFR § 11.62(f)(1)(iii)]	Species with available data	NA	Evaluate State advisory programs	U.S. FWS and Stratus Consulting, 1999c
Surface water	Water quality exceedences [43 CFR § 11.62(b)(1)(iii)]	Lower Fox River and Green Bay surface water	NA	Compare surface water PCB concentrations to applicable criteria	U.S. FWS and Stratus Consulting, 1999d
	Injury to biological resources exposed to surface water resource [43 CFR § 11.62(b)(1)(v)]	Species evaluated in assessment of injuries to avian and fishery resources	NA	Determine whether avian and fishery resources have been injured as a result of exposure to PCBs in surface water and sediments	U.S. FWS and Stratus Consulting, 1999b U.S. FWS and Stratus Consulting, 1999c

a. The adverse viability changes addressed in the NRDA regulations are death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations.

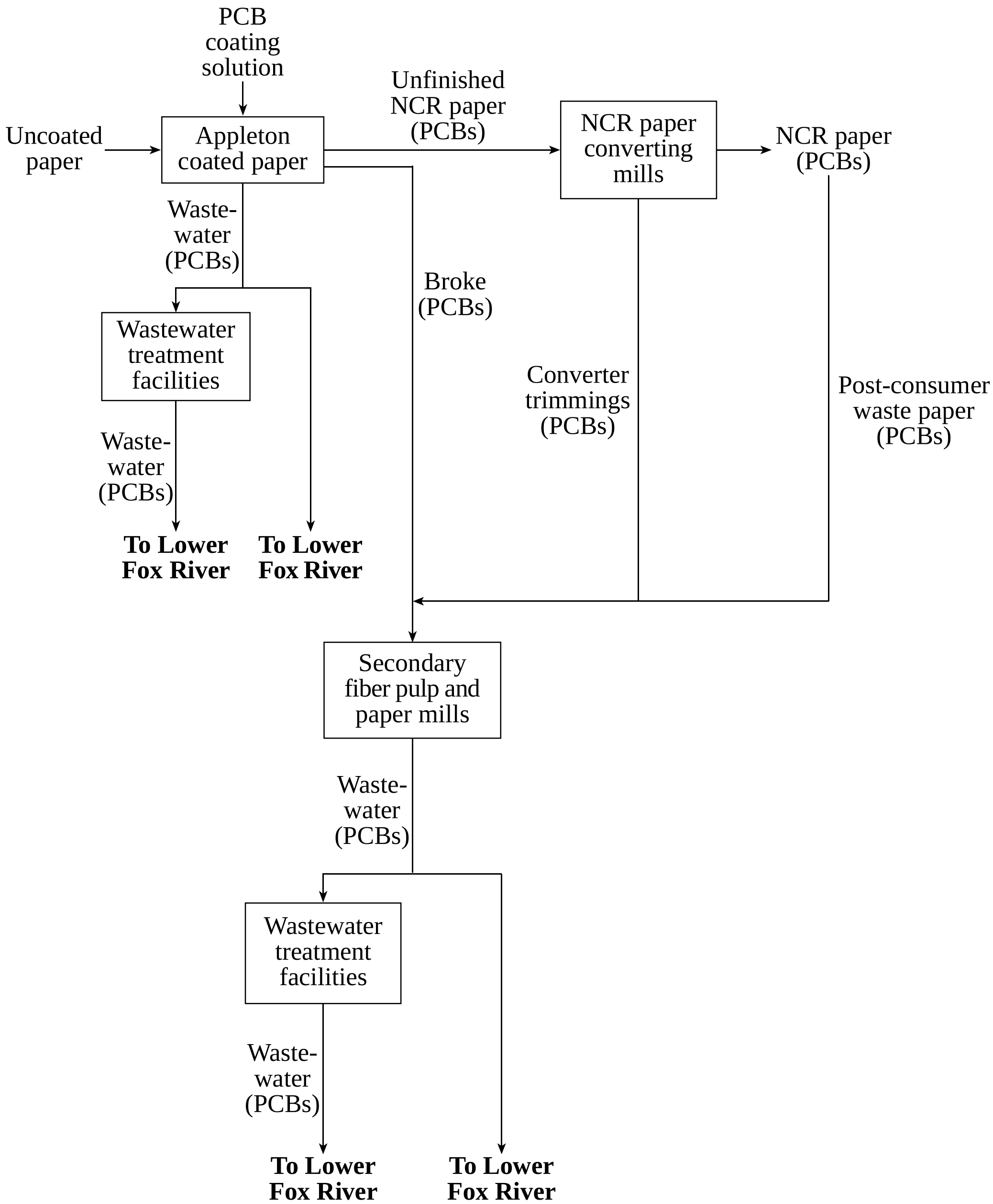


Figure 2.4. Schematic diagram for PCB releases to the Lower Fox River.

The PCB releases began in 1954, when commercial production of a carbonless copy paper called NCR paper that contained PCBs began. The PCBs were applied in a coating solution to paper stock at Appleton Coated Paper Company in Appleton, Wisconsin from 1954 to about April 1971. Coated papers were sold to paper converters who manufactured the finished product. During and after this period, Appleton Coated Paper discharged process wastewater to the City of Appleton sewage system for disposal (U.S. FWS and Stratus Consulting, 1999e).

During preparation of the NCR paper, there were losses of coating solution containing PCBs as well as coated side trimmings, off-grade paper, and waste paper generated during paper machine breaks. Collectively, these paper losses are called "broke." The broke, which contained approximately 3.4% PCBs by weight, was sold to waste paper brokers and to secondary fiber pulp and paper mills, where it was processed with other waste papers to make secondary fiber pulp and paper products (U.S. FWS and Stratus Consulting, 1999e).

PCB releases to the Lower Fox River therefore came from many paper company related sources (Figure 2.4). The majority of PCB releases from paper companies were associated with losses of PCBs from paper coating operations and from recycling of NCR paper broke, followed by recycling of NCR paper converter trim and finally by processing of post-consumer waste paper containing NCR paper. Loss of PCB emulsions occurred during the paper coating process, primarily at Appleton Coated Paper. Secondary fiber mills that processed NCR paper broke and other PCB-containing waste papers and that are estimated to have had the largest PCB releases are Fort James Green Bay West Mill in the City of Green Bay, PH Glatfelter — Bergstrom Division in Neenah, and Wisconsin Tissue Mills in Neenah. Other important PCB releases were discharges from the City of Appleton sewerage system and wastewater treatment plant, which received wastewater from Appleton Coated Paper; releases from the Neenah-Menasha wastewater treatment plant, which received wastewater discharges from Wisconsin Tissue and other secondary fiber mills; and releases from the Arrowhead Park landfill, which received waste products from PH Glatfelter (U.S. FWS and Stratus Consulting, 1999e).

WDNR (1999a) has estimated the total amount of PCBs released to the Lower Fox River between the mid-1950s and 1997 as approximately 300,000 kg (660,000 lb). Direct PCB releases to the Lower Fox River began in the 1950s, increased through the 1960s, peaked in 1969, and dropped sharply after 1971. Nevertheless, the Lower Fox River continues to be the dominant source of PCBs entering Green Bay (Figure 2.5). Although the use of

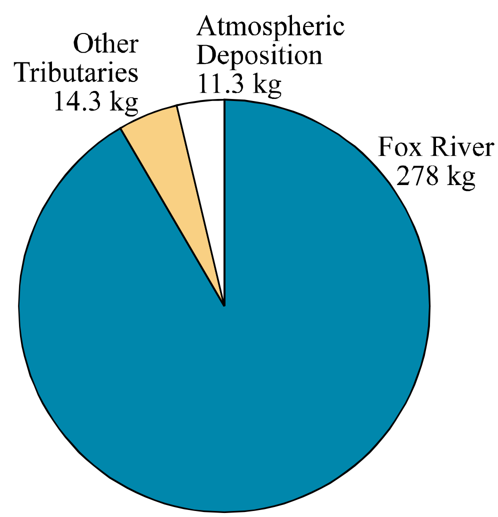


Figure 2.5. PCB loadings into Green Bay, 1989. Data from DePinto et al. (1994).

PCBs in the production of NCR paper ceased in 1971, NCR paper broke and converter trim containing PCBs remained in the recycled fiber stream for several years, and releases are expected to have occurred for years after production of NCR paper ceased. Furthermore, PCBs continue to be released into the environment through surface water and sediment transport processes. An estimated 39,400 to 47,300 kg of PCBs (13-16% of the total released) remain in bed sediment throughout the Lower Fox River (WDNR, 1999b).

2.2.2 Pathways

The movement and distribution of PCBs in Green Bay is determined by the water current patterns in the bay, and where PCB-contaminated sediment settles to the bay floor (U.S. FWS and Stratus Consulting, 1999e). Figure 2.6 illustrates the general movement of PCBs from release points in the Lower Fox River throughout Green Bay. PCBs enter the food chain when they are taken up by benthic invertebrates and phytoplankton, which serve as food for higher trophic level fish.

Figure 2.6. The movement of PCBs from the Lower Fox River throughout Green Bay. Water circulation patterns in the river and bay determine the movement of the PCBs.

Surface water, sediment, and air pathways

PCBs released from paper company facilities into the Lower Fox River are carried downstream and into Green Bay, dissolved in the water column and adsorbed to suspended sediment particles. This is illustrated in Figure 2.7, which shows that PCB concentrations and loads measured between 1989 and 1995 in the Lower Fox River are lowest upstream of the paper companies and highest downstream of the paper companies.

Once PCBs enter Green Bay in surface water and sediments of the Lower Fox River, they are carried by the water currents that circulate through the bay. Green Bay water circulation is complex but has an overall counterclockwise pattern. It is controlled by factors such as surface water elevation changes induced by wind and barometric pressure, wind speed and direction,

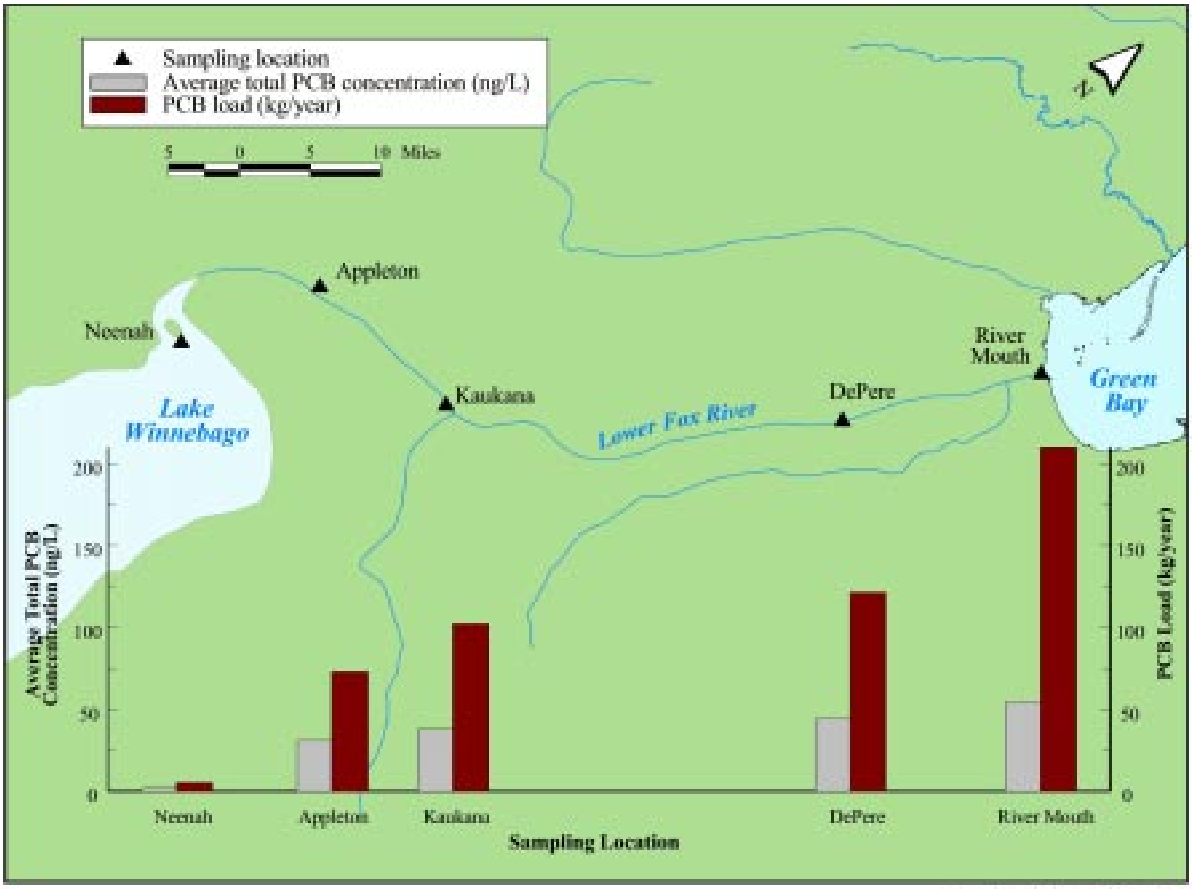


Figure 2.7. PCB concentrations and loads in the Lower Fox River. Concentrations and loads are lowest at Neenah, which is upstream of paper company facilities, and increase downstream of paper companies starting at Appleton. Data for Neenah, Appleton, Kaukana, and DePere are from Steur et al. (1995). Data for River Mouth are from ThermoRetec Consulting and Natural Resource Technology (1999).

river discharge, upwelling of the thermocline in Lake Michigan, thermal and density gradients between the bay and Lake Michigan, ice cover, and the Coriolis effect.

The Lower Fox River is the dominant tributary to Green Bay, and the Lower Fox River plume can be tracked within the bay. The Lower Fox River plume moves up the bay along the eastern shore for 20-40 km under the influences of both prevailing southwesterly winds and the Coriolis effect. Mixing of water is limited in the southernmost portion of the bay. Although water movement between the inner and outer bay and between Green Bay and Lake Michigan is complex, net water movement between these areas is from the inner to the outer bay and from the outer bay to Lake Michigan. Overall exchange is very high, providing a mechanism by which

PCBs are transported from the inner bay to the outer bay and from Green Bay into Lake Michigan (U.S. FWS and Stratus Consulting, 1999e).

Most of the PCB-laden sediment from the Lower Fox River is deposited in inner Green Bay, especially along the eastern half, where the Lower Fox River plume is directed by the bay water currents. Sediment that has been deposited can be re-entrained and transported. Approximately 10% to 33% of the inner bay tributary sediment load (the majority of which is from the Lower Fox River) is resuspended and transported to the outer bay, along with the PCBs carried within the sediments. The Green Bay Mass Balance Study (GBMBS), a comprehensive modeling effort of the movement of PCBs in and out of the Green Bay system, found an annual net estimated transfer of 122 kg of PCBs from Green Bay to Lake Michigan for 1989 (U.S. FWS and Stratus Consulting, 1999e).

PCB congener patterns in outer Green Bay are consistent with the transport and weathering of PCBs from the Lower Fox River and are inconsistent with the transport and weathering of Lake Michigan PCBs. Therefore, the Lower Fox River rather than Lake Michigan is the dominant source of the PCBs in outer Green Bay (U.S. FWS and Stratus Consulting, 1999c).

Biotic pathways

As illustrated in Figure 2.8, PCBs can enter the aquatic food chain from contaminated surface water and sediment via uptake by phytoplankton and benthic invertebrates. PCBs that accumulate in phytoplankton are passed on to zooplankton, which consume phytoplankton. Forage fish (e.g., rainbow smelt, gizzard shad, and alewife) take up PCBs by consuming zooplankton, and in turn serve as a PCB pathway to predator fish such as walleye and brown trout. Similarly, PCBs that enter the food chain via benthic invertebrates are transferred to benthic feeding fish such as catfish. This food chain pathway is therefore the dominant PCB pathway for top-level fish predators in the Lower Fox River and Green Bay Environment (U.S. FWS and Stratus Consulting, 1999e).

Because PCBs accumulate in biota and biomagnify up the food chain, the dietary pathway also is the primary route by which birds and piscivorous mammals are exposed. Of the birds that nest and feed on and near the assessment area, piscivorous species (i.e., those that consume fish) such as Forster's and Caspian terns and predatory species (i.e., those that consume other birds) such as bald eagles are the most highly exposed to PCBs, since their food items are the most highly contaminated with PCBs. Waterfowl such as mallards also contain elevated PCB concentrations, most likely as a result of exposure to sediment, surface water, phytoplankton, and zooplankton contaminated with PCBs (U.S. FWS and Stratus Consulting, 1999e).

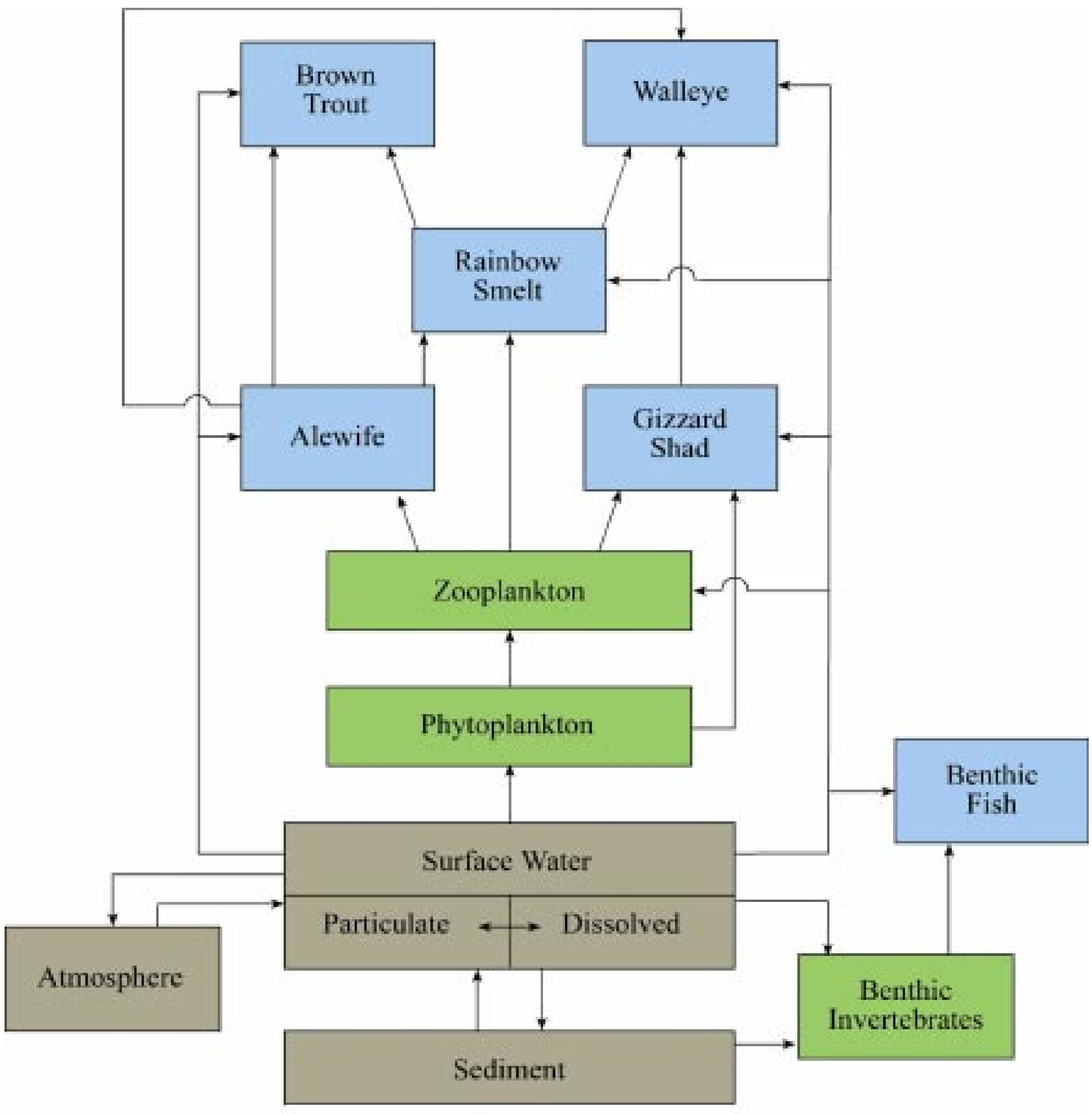


Figure 2.8. PCB pathways in Lower Fox River and Green Bay Environment. Abiotic media are in brown, primary producers and invertebrates are in green, and fish species are in blue.

Fish and birds exposed to PCBs in the Lower Fox River and Green Bay Environment that migrate to other areas serve as PCB pathways by transporting PCBs to other areas. Several fish species, including northern pike, walleye, smallmouth bass, yellow perch, and lake sturgeon, have been documented to migrate between Green Bay and its tributaries. Fish migration has also been documented between Green Bay and Lake Michigan and within Green Bay itself. This migration of contaminated biota may serve as a particularly important transport pathway for natural resources on the Reservation of the Oneida Tribe of Indians of Wisconsin (U.S. FWS and Stratus Consulting, 1999e).

The release and transport of PCBs has resulted in elevated PCB exposure in natural resources throughout Green Bay. Furthermore, the spatial and temporal distributions of PCB concentrations in these media are consistent with the Lower Fox River as the source of the PCBs.

Surface water and sediment

Figure 2.9 shows elevated PCB concentrations in Green Bay sediment. Data were collected in 1989-1990 as part of the GBMBS. PCB concentrations are higher in the inner bay than in the outer bay, and concentrations in the inner bay are highest along the eastern shore, where Green Bay circulation patterns carry contaminated water and sediment discharged from the Lower Fox River.

Fish

Elevated concentrations of PCBs have been found in all of the components of the aquatic food web, including surface water, sediment, plankton, and forage fish (see Figure 2.8). PCB accumulation has been documented in over 45 fish species at all trophic levels and from all Lower Fox River/Green Bay habitats, including coastal wetlands, coastal beaches, near-shore areas, and open water habitat. Because of biomagnification of PCBs in the food chain, PCB concentrations in predatory fish such as walleye and brown trout tend to be higher than concentrations in forage fish (U.S. FWS and Stratus Consulting, 1999c).

Fish PCB concentrations vary spatially throughout the bay. PCB concentrations tend to be highest in the Lower Fox River and along the eastern shore of the inner bay, as shown in Figure 2.10, consistent with the Lower Fox River as the source of the PCBs and the patterns seen in sediment and surface water. PCB concentrations in fish were highest in the 1970s, declined through the late 1970s and mid 1980s, and have reached a state of much slower decline since the mid to late 1980s.(U.S. FWS and Stratus Consulting, 1999c).

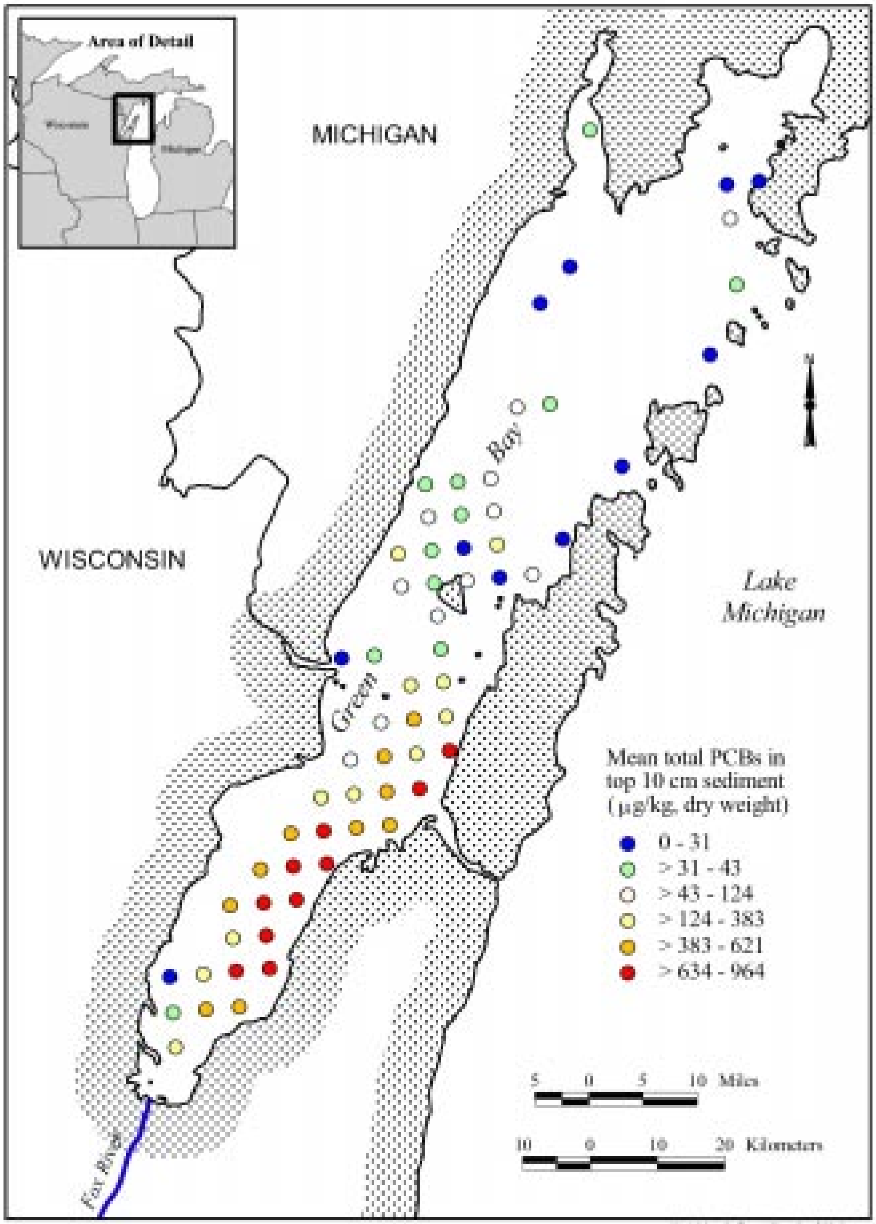


Figure 2.9. **Mean total PCB concentrations in the top 10 cm of Green Bay sediment, 1989.** Each symbol represents a single sediment sampling location. Sediment for PCB analysis was collected only from locations with soft sediment

Source: GBMBS data from the WDNR sponsored database at http://www.ecochem.net/FoxRiverDatabaseWeb/default.asp, downloaded July 1999, as cited in U.S. FWS and Stratus Consulting (1999e).

Birds

PCBs have been measured in the eggs, adults, or chicks of over 25 bird species collected throughout the Lower Fox River/Green Bay ecosystem. These species include birds from all trophic levels, including waterfowl and predatory species, and PCB concentrations in assessment area birds are consistently higher than concentrations in reference area birds. For example, mean assessment area PCB concentrations are up to approximately eight times greater than reference area concentrations for double-crested cormorant, black-crowned night heron, and bald eagle. PCB concentrations in other species are two to fives times greater in the assessment area than in reference areas. (U.S. FWS and Stratus Consulting, 1999b).

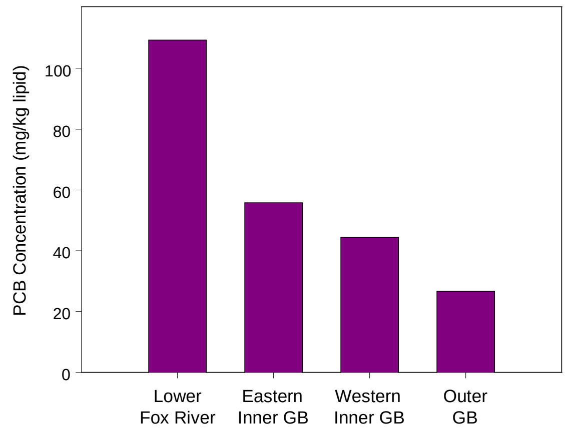


Figure 2.10. Decreases in walleye PCB concentrations with distance from PCB sources, 1989-1990.

Temporal trends of PCB concentrations in Big Sister Island herring gull eggs collected from 1971 to 1997 are shown in Figure 2.11. PCB concentrations in Lower Fox River/Green Bay herring gull eggs were highest in the 1970s, when the herring gull PCBs concentrations were first measured, and declined through the mid-1980s after the PCB releases from Lower Fox River paper companies ceased. Since the mid-1980s, concentrations have stabilized or are declining at a much slower rate than previously (U.S. FWS and Stratus Consulting, 1999b).

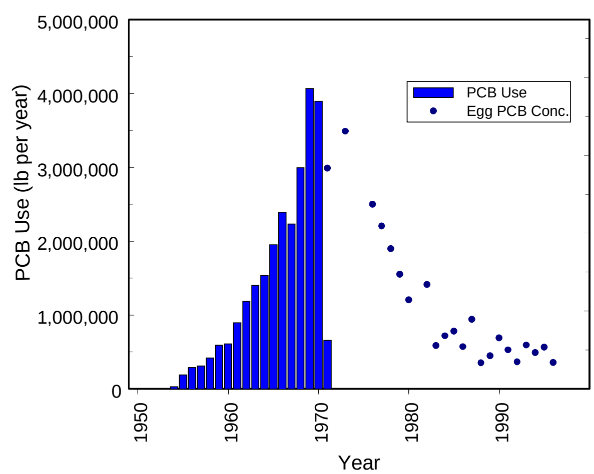


Figure 2.11. Temporal trend in PCB use in NCR paper and PCB concentrations in Green Bay herring gull eggs. Source: U.S. FWS and Stratus Consulting (1999b).

2.2.3 Injury

The Department's regulations provide definitions of injury for natural resources. Injury to natural resources of the Lower Fox River/Green Bay was evaluated pursuant to these definitions (see Table 2.2).

Surface water resources

PCB concentrations in surface water consistently have exceeded, and continue to exceed, the U.S. EPA's Great Lakes Water Quality Guidance (GLWQC) value and the State of Wisconsin surface water quality standard of 0.12 ng/L for PCBs (U.S. FWS and Stratus Consulting, 1999d). These exceedences represent a *per se* injury according to the Department's NRDA regulations [43 CFR § 11.62(b)(1)(iii)]. Figure 2.12 compares average PCB concentrations measured in the assessment area to the injury threshold. PCB concentrations measured in every sample from every Lower Fox River location in three separate studies (GBMBS; Lake Michigan Mass Balance Study; and Blasland, Bouck & Lee data) exceed the 0.12 ng/L injury threshold. The lowest concentrations measured in these studies are consistently an order of magnitude higher than the injury threshold. Furthermore, as summarized in the following sections, fish in the assessment area are injured as a result of their exposure to PCBs in the surface water resource.

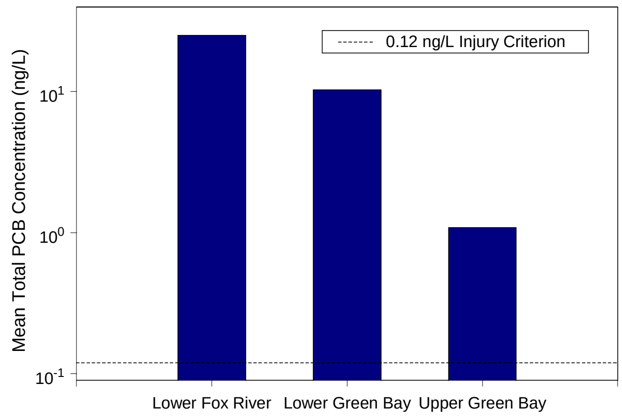


Figure 2.12. PCB concentrations in surface water compared to the 0.12 ng/L injury criterion. Source: U.S. FWS and Stratus Consulting (1999d).

Fishery resources

Fishery resources in the Lower Fox River/Green Bay are injured because of PCB fish consumption advisories, exceedences of FDA tolerances for PCBs, and adverse biological effects to walleye.

Fish consumption advisories and FDA exceedences

Wisconsin and Michigan have issued fish consumption advisories for the Lower Fox River and Green Bay Environment since 1976 and 1977, respectively, and continue to issue advisories

(U.S. FWS and Stratus Consulting, 1998, 1999c). Therefore, fish are injured according to the Department's NRDA regulations [43 CFR § 11.62(f)(1)(iii)]. Advisories have been issued by Wisconsin for 15 species in the Lower Fox River and by Wisconsin or Michigan for more than 20 species in Green Bay and northern Lake Michigan. The species, spatial and temporal extent, and degree of fish consumption advisory injuries for Lower Fox River/Green Bay fish are summarized in Tables 2.3 and 2.4. Advisories for carp, brown trout, lake trout, and rainbow trout have continued since the inception of the advisory program, and many other species, including walleye, chinook salmon, splake, white bass, and coho salmon, have been under advisories for the last 10 or more years. (U.S. FWS and Stratus Consulting, 1998, 1999c).

Table 2.3. Summary of fish species in the Lower Fox River for which PCB consumption advisories have been issued by Wisconsin, 1976-1999.

	1976-1977	1978-1983[a]	1984-1986	1987-1994	1995-1996	1997-1999
Black crappie		•				•
Bluegill		•				•
Bullhead		•		•	•	
Carp	•	•	•	•	•	•
Channel catfish		•		•	•	•
Drum		•		•	•	
Northern pike		•	•	•	•	•
Rock bass		•				•
Sheepshead		•				•
Smallmouth bass		•				•
Walleye		•	•	•	•	•
White bass		•	•	•	•	•
White perch		•				•
White sucker		•		•	•	•
Yellow perch		•				•

• = Consumption advisory (either "no consumption" or "limit consumption") issued. A blank cell means no advisory was issued.

a. From 1978 to 1983, a "limit consumption" advisory was issued for all species in the Lower Fox River.

Source: U.S. FWS and Stratus Consulting (1999c).

Exceedences of the FDA tolerance level for PCBs in edible fish tissue have been documented since 1971 in Green Bay and since 1975 in the Lower Fox River. This also constitutes an injury to fishery resources [43 CFR § 11.62(f)(1)(ii)]. The spatial extent of the exceedences of the FDA tolerance level in edible fish tissue includes all of the Lower Fox River and Green Bay. The FDA tolerance was exceeded in 13 species in the Lower Fox River and 23 species in Green Bay.

Table 2.4. Summary of fish species in Green Bay for which PCB consumption advisories have been issued by Wisconsin or Michigan, 1976-1999.

	1976-1977	1978-1983	1984-1986	1987-1994	1995-1996	1997	1998	1999
Brook trout	•	•	•	•	•	•		
Brown trout	•	•	•	•	•	•	•	•
Bullheads		•						
Burbot								
Carp	•	•	•	•	•		•	•
Catfish		•	•			•	•	•
Chinook salmon	•	•	•	•	•	•	•	•
Coho salmon	•	•	•					
Lake trout	•	•	•			•	•	•
Lake whitefish			•					
Longnose sucker								•
Northern pike			•	•	•	•	•	•
Rainbow trout	•	•	•	•	•	•	•	•
Smallmouth bass			•			•	•	•
Splake				•	•	•	•	•
Sturgeon				•	•	•	•	•
Walleye			•	•	•	•	•	•
White bass			•	•	•	•	•	•
White perch						•	•	•
White sucker			•	•		•	•	•
Whitefish		•				•	•	•
Yellow perch						•	•	•

• = Consumption advisory (either "no consumption" or "limit consumption") issued. A blank cell means no advisory was issued.

Note: The table excludes advisories issued by Michigan for mercury only.

Source: U.S. FWS and Stratus Consulting (1999c).

Adverse health effects

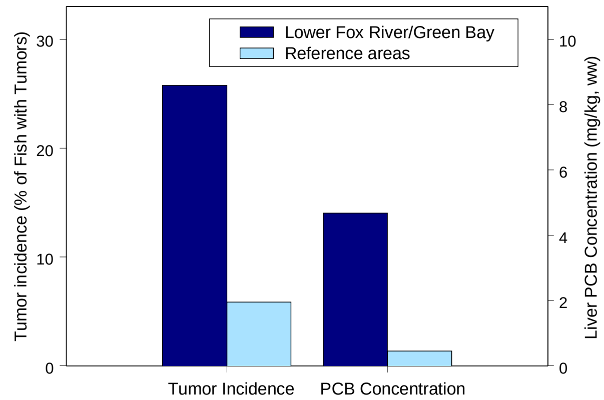


Figure 2.13. Incidence of liver tumors or pre-tumors and liver PCB concentration in walleye. Source: U.S. FWS and Stratus Consulting (1999c).

In 1996 and 1997, the Service conducted a study of health effects on Lower Fox River/Green Bay walleye (see U.S. FWS and Stratus Consulting, 1999c). Health parameters assessed included liver tumors and pre-tumors, immunological responses, infections, and physiological responses. Lower Fox River/Green Bay walleye were found to be injured as a result of increased incidence of liver tumors and pre-tumors. Of the assessment area fish aged 5-8 years (the only age bracket for which sufficient data from both assessment and reference areas are available for comparison), 26% had liver tumors or pre-tumors compared with 6% of reference area fish. Assessment area fish also had higher concentrations of PCBs in the liver. The mean total PCB concentration across all assessment area sampling locations was 4.56 µg/g (sd = 2.62), compared to 0.460 µg/g (sd = 0.60) in reference areas (Figure 2.13).

The Co-trustees also conducted studies on brown trout health and the reproductive failure of lake trout populations in Green Bay and Lake Michigan. Brown trout were analyzed for various health endpoints, including cancer and physiological malfunction. The lake trout investigation included laboratory analysis of the interactions of thiamine, PCBs, and other dioxin-like compounds in causing lake trout embryomortality. Based on these investigations, the Co-trustees concluded that currently available evidence does not support a determination of biological injury to these species (other than consumption advisories).

Avian resources

Waterfowl in the Lower Fox River/Green Bay ecosystem are injured as a result of waterfowl consumption advisories and exceedences of FDA tolerances for PCBs, and Forster's terns, common terns, double-crested cormorants, and bald eagles have suffered adverse toxicological as a result of exposure to PCBs (U.S. FWS and Stratus Consulting, 1999b).

Waterfowl consumption advisory injuries

A consumption advisory for mallards from the Lower Fox River and inner Green Bay was issued by the WDNR and the Wisconsin Division of Health in 1987 and remains in effect. Waterfowl in the Lower Fox River and inner Green Bay are also injured as a result of PCB accumulation in edible bird tissues in excess of the FDA tolerance [43 CFR § 11.62(f)(1)(ii); 43 CFR § 11.62(f)(1)(iii)]. Figure 2.14 shows the areas covered by the consumption advisory. Among waterfowl samples collected by the Service in 1997, PCB concentrations exceeded the FDA tolerance in 8 of 10 mallards and in 18 of 38 diving ducks, including samples of scaup, common goldeneye, bufflehead, red-breasted merganser, and ruddy duck.

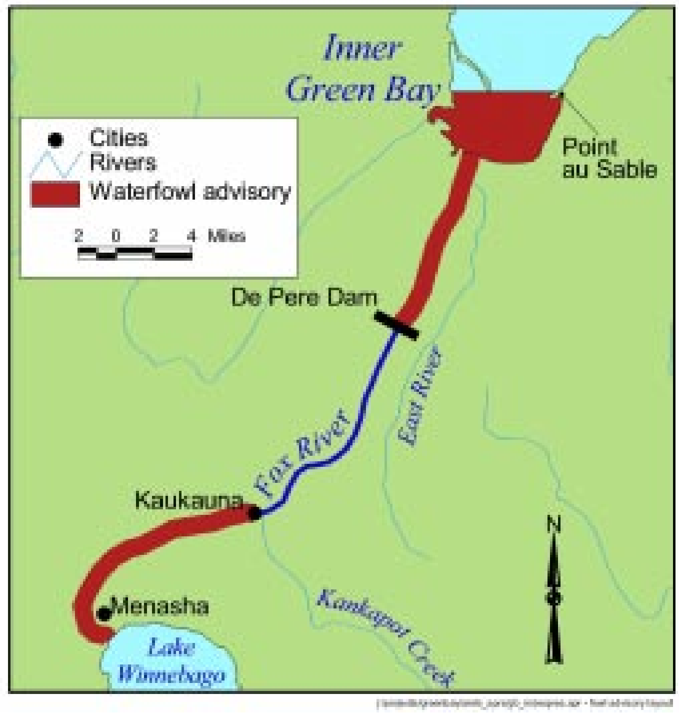


Figure 2.14. Areas covered by the Wisconsin waterfowl consumption advisory.

Adverse health effects

Forster’s terns, common terns, double-crested cormorants, and bald eagles have suffered adverse toxicological effects that were most likely a result of PCB exposure in the assessment area. Numerous studies have been conducted on the adverse effects to Green Bay birds resulting from exposure to and accumulation of PCBs. Although some of the studies were inconclusive, many of the species evaluated have been injured according to the Department’s regulations [43 CFR § 11.62(f)(1)(iii)] as a result of exposure to PCBs. The available data and thereby the Co-trustees’ evaluation are limited to only a small subset of the Lower Fox River and Green Bay bird species.

Terns are colonially-nesting birds that consume fish as a large portion of their diet. Tern species that nest in Green Bay are common tern, Forster’s tern, and Caspian Tern, all of which are listed as endangered species by the State of Wisconsin. Green Bay Forster’s terns have been documented to have embryonic deformities, skeletal deformities, edema, and reduced reproductive rates resulting from exposure to PCBs (U.S. FWS and Stratus Consulting, 1999b).

Figure 2.15 compares the hatching success and egg PCB concentrations of Forster's terns from Green Bay and reference areas. Common terns in Green Bay have suffered from increased deformity rates compared to reference area terns, as shown in Figure 2.16, and may have also had reduced hatching success. Although field studies on Caspian terns are not as conclusive, one study found reduced reproduction and higher rates of deformities in Green Bay Caspian terns relative to terns from reference locations.

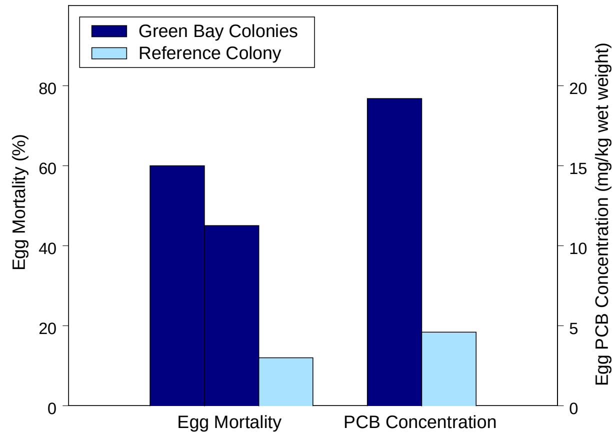


Figure 2.15. Egg mortality and PCB concentrations in Forster's terns. Source: U.S. FWS and Stratus Consulting (1999b).

PCBs have also most likely caused reduced reproductive success and embryonic deformities in Green Bay double-crested cormorants (U.S. FWS and Stratus Consulting, 1999b). Bill deformity rates among cormorant embryos and nestlings in the assessment area are higher than background rates, but the evidence for other types of deformities such as edema and hemorrhaging is not as conclusive. The deformities are believed to be caused by PCBs. Available evidence suggests that both PCBs and DDE have contributed to reduced hatching observed among Green Bay cormorants (U.S. FWS and Stratus Consulting, 1999b).

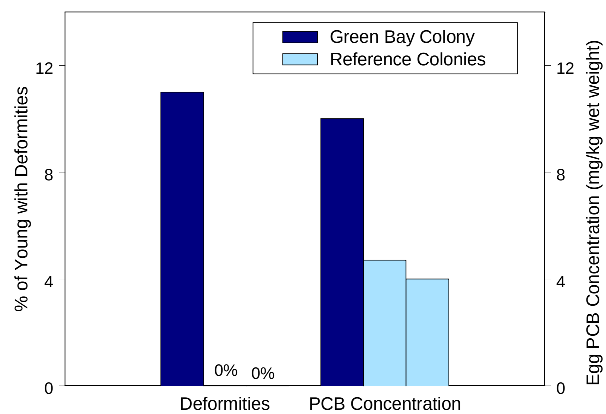


Figure 2.16. Incidence of deformities among Common tern embryos/hatchlings and egg PCB concentrations. Source: U.S. FWS and Stratus Consulting, 1999b.

Bald eagle populations in Green Bay have been studied extensively (U.S. FWS and Stratus Consulting, 1999b). PCB concentrations in bald eagle eggs and chick plasma from Green Bay are significantly higher than those in eggs and chicks from reference areas, and reproductive productivity among Green Bay bald eagles was significantly reduced relative to reference area eagles from 1974 until at least the mid-1990s. Figure 2.17 shows that reproductive productivity is reduced in bald eagles from Green Bay compared to bald eagles from inland Wisconsin. Both PCBs and DDE have most likely contributed to the reduced productivity (U.S. FWS and Stratus Consulting, 1999b).

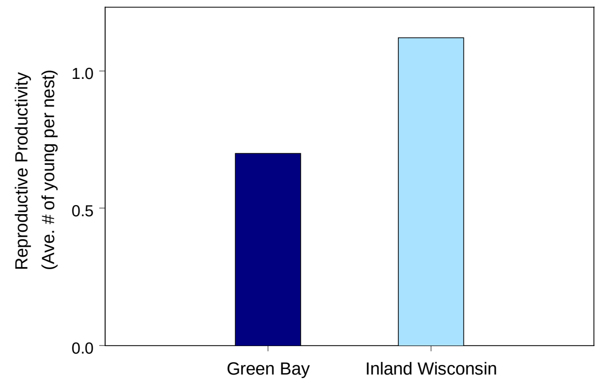


Figure 2.17. Bald eagle productivity. Source: U.S. FWS and Stratus Consulting (1999b).

Other avian species evaluated for injuries were black-crowned night heron, tree swallow, and red-breasted merganser. Although Green Bay black-crowned night herons have suffered from higher rates of deformities, the available data does not support the conclusion that PCBs caused the deformities. The Co-trustees found no evidence that tree swallows or red-breasted mergansers in the assessment area have suffered adverse health or reproductive effects from exposure to PCBs.

2.2.4 Conclusions

Releases of PCBs have resulted in injuries to natural resources throughout the Lower Fox River/Green Bay ecosystem. Table 2.5 summarizes the natural resource injuries in the assessment area and shows that the spatial extent of injuries encompasses all regions and habitats of the Lower Fox River and Green Bay. Natural resource injuries have been documented in aquatic and shoreline habitats throughout the assessment area. Injury to aquatic habitats of Green Bay tributaries, Little and Big Bays de Noc, and Lake Michigan has also occurred through fish consumption advisories in these locations. Natural resource injuries most likely began occurring as early as the mid-1950s, when PCBs were first released from Lower Fox River paper companies, although data on PCB concentrations in the environment were not available until the 1970s. Injuries to fishery, avian, and surface water resources continue to the present, because the environmentally persistent PCBs continue to be recycled through the sediments, surface water, and all levels of the diverse Lower Fox River/Green Bay food web.

Table 2.5. Summary of natural resource injuries.

		Lower Fox River		Inner and outer Green Bay		Other aquatic habitats		
Resource		Aquatic habitat	Shoreline habitat	Aquatic habitat (near shore and open water)	Shoreline habitat (wetlands, shores, and islands)	Green Bay tributaries[a]	Little and Big Bays de Noc	Lake Michigan[b]
Surface water resource (includes sediment)		Water quality criteria/standard exceedences	-	Water quality criteria/standard exceedences	-			
Fishery resource	Forage fish	FCAs,[c] exceedence of FDA tolerance level	-	FCAs,[c] exceedence of FDA tolerance level	-	FCAs[c]	FCAs[c]	FCAs[c]
	Game fish	Walleye tumors, FCAs,[c] exceedence of FDA tolerance level		Walleye tumors, FCAs,[c] exceedence of FDA tolerance level	-	FCAs[c]	FCAs[c]	FCAs[c]
Avian resource	Piscivorous birds	-		-	Forster's tern reproduction and deformities, common tern reproduction, cormorant reproduction	-	-	-
	Omnivorous birds	-	Bald eagle reproduction	-	Bald eagle reproduction	-	-	-
	Waterfowl	WCAs,[d] exceedence of FDA tolerance level		WCAs,[d] exceedence of FDA tolerance level				

a. Includes Duck Creek, Oconto River, Peshtigo River, Menominee River, Cedar River, and other tributaries.

b. Includes Lake Michigan north of Frankfurt, Michigan, and Wisconsin waters of Lake Michigan and its tributaries up to the first dam, including the Root River, Milwaukee River, Sheboygan River, Manitowoc River, and Kewaunee River.

c. FCA = Fish consumption advisory.

d. WCA = Waterfowl consumption advisory.

- = Not Applicable

2.3 Injury Quantification

2.3.1 Purpose and quantification approach

The previous section of this chapter presented a summary of natural resource injuries to the Lower Fox River/Green Bay ecosystem. This section summarizes the quantification of those injuries.

The purpose of injury quantification is for use “in determining the appropriate amount of compensation” in a damage assessment [43 CFR § 11.70(b)]. Quantification can be expressed in terms of the extent to which the natural resource has been injured [43 CFR § 11.71(b)(1)] or by directly measuring changes in services[1] provided by natural resources when:

- the change in the services from baseline can be demonstrated to have resulted from the injury to the natural resource
- the extent of change in the services resulting from the injury can be measured without also calculating the extent of change in the resource
- the services to be measured are anticipated to provide a better indication of damages caused by the injury than would direct quantification of the injury itself [43 CFR § 11.71(f)].

The Co-trustees have quantified injuries to natural resources both in terms of direct quantification of the extent of injury to natural resources themselves, and in terms of quantification of human services.

Extent of injury to natural resources

Quantification of the extent of injury to natural resources includes the spatial and temporal extent of injury as well as the degree to which natural resources were injured. Section 3.2 and the individual injury reports cited in that section provide detailed information on the extent of injury.

Surface water resources have been injured throughout the Lower Fox River, from Little Lake Butte des Morts to the mouth and throughout the entire waters of Green Bay. Injuries to surface water resources continue to the present.

1. “Services” are the physical and biological functions performed by natural resources, including the human uses of those functions [43 CFR § 11.14 (nn)].

Fishery resource injuries include fish consumption advisory injuries and physiological impairments to walleye. The extent of fish consumption advisory injuries is presented in U.S. FWS and Stratus Consulting (1998). Fish consumption advisories are in place throughout the Lower Fox River and Green Bay. Physiological impairments to walleye are described as the frequency of impairments in Lower Fox River/Green Bay walleye relative to reference locations. Liver pre-tumors and tumors occurred in 26% of assessment area fish aged 5-8 years, the only age range with sufficient data for comparison, compared to 6% of reference area fish. This difference was more dramatic in females, with 34% of assessment area females having liver tumors or pre-tumors versus 7% of reference area females. Although physiological impairment injuries were observed throughout the Lower Fox River and Green Bay and were observed in both 1996 and 1997, the full spatial and temporal extent of these injuries is not known with specificity.

Injuries to bird resources include both waterfowl consumption advisory injuries and biological injuries. Waterfowl consumption advisories injuries are present in the Lower Fox River. Adverse health effects, including reduced reproduction and physical deformities, have been documented in several piscivorous species such as bald eagle and Forster's tern in the Lower Fox River and Green Bay Environment. Injuries to bald eagles, which nest along the length of the western shore and on the northern shore of Green Bay, were documented on a bay-wide basis. Injuries to colonial nesting birds were found in nesting sites throughout Green Bay, primarily on islands and other sites located along the eastern and southern shorelines.

Baseline conditions

Baseline conditions are those conditions that would be expected to occur in the assessment area absent the releases of PCBs [43 CFR § 11.14(e)]. Baseline conditions are reflected by conditions observed in reference or control areas, and by consideration of conditions in the Fox River/Green Bay ecosystem without PCBs. The baseline condition for natural resources in the assessment area has been determined by the Co-trustees to be as follows:

- Surface water resources would not exceed water quality criteria and standards for PCBs and would not serve as a PCB transport or exposure pathway to other resources.
- Sediment resources would not contain elevated concentrations of PCBs and therefore would not act as a PCB transport or exposure pathway to other resources.
- Fish would not be contaminated with PCBs and fish consumption advisories would be eliminated; FDA tolerances for PCBs would not be exceeded.
- Walleye would have substantially lower levels of liver tumors and pre-tumors, consistent with those observed at reference locations.

- Waterfowl would not be contaminated with PCBs and, as a result, consumption advisories would be eliminated.

- Bird reproduction and health would not be impaired as a result of exposure to PCBs and would be similar to reference levels.

Direct quantification of services

As described in greater detail in Chapter 3, the Co-trustees used the direct quantification of services approach [43 CFR § 11.71(f)] as the primary injury quantification method in scaling the preferred restoration alternative. The direct quantification of services approach involved the application of a total value equivalency study to establish the scale of restoration actions necessary to provide equivalent natural resource services to the public as compensation for injuries to natural resources. The total value equivalency approach, described in Section 3.2.4, therefore represents a direct measure of services lost by the public.

2.3.2 Resource recoverability

Another aspect of the injury quantification phase is the resource recoverability analysis, which involves estimating the time needed for injured natural resources to recover to baseline levels [43 CFR § 11.73(a)]. The analysis includes determination of the recovery period if no restoration actions beyond response actions are conducted [43 CFR § 11.73(a)]. The length of time required for resources to return to baseline is an important component of the restoration plan described in Chapter 3, because the amount of restoration required is dependent in part on how long recovery would take absent any restoration beyond the response action. This resource recoverability analysis considers resource recoverability under response actions ranging from no further action to the intensive cleanup of PCB-contaminated sediments.

PCBs are persistent in the environment, and once released into a waterbody have a strong affinity for sediment (Erickson, 1997). The dominant mechanism of PCB loss from the Lower Fox River and Green Bay Environment, as well as other similar aquatic systems, is sediment burial (DePinto et al., 1994). PCBs can also be lost through volatilization and transport via air currents or through water flow into Lake Michigan, but the mass of PCBs removed from the system via these processes is much smaller than the mass of PCBs in the sediment (DePinto, 1994). Similarly, although PCBs can be degraded by microbial communities under some environmental conditions (see, e.g., Brown and Wagner, 1990; Flanagan and May, 1993), microbial degradation is much slower for PCBs than for most other organic compounds (Erickson, 1997). Evidence suggests that degradation of PCBs in sediment slows dramatically below approximately 30 mg/kg (U.S. EPA, 1997), which is well above the PCB concentration in sediments throughout Green Bay and most of the Lower Fox River. Detailed measurements of PCB dechlorination in the Hudson River, a site contaminated with PCBs similar to those in the Lower Fox River and Green Bay, show that PCB degradation has reduced the mass of PCBs present in the river sediment by less than 10%, and that the remaining PCBs will most likely not be significantly further degraded (U.S. EPA, 1997).

As PCBs adhered to sediment particles become deposited on the bottom of the river or bay, they can become covered with cleaner sediment that enters the system. However, PCBs buried in sediment can be periodically re-released through sediment erosion, such as can occur during storm events. Evidence suggests that the sediment bed of the Lower Fox River shifts dramatically over small spatial and temporal scales, exposing sediment in some areas and depositing new sediment over others (WDNR, 1999c). Thus, although sediment burial is the primary long-term loss mechanism of PCBs, some buried PCBs may still be accessible, resulting in periodic increases in biota exposure to PCBs.

An examination of the past rate of PCB decline in the Lower Fox River and Green Bay Environment can provide insight into the future rates of decline that can be expected if no sediment remediation occurs. Concentrations measured in birds, fish, and sediment (via sediment cores) are consistently highest in the early 1970s (although there are no fish or bird tissue data prior to this time period) and have declined since then, coinciding with decreases in PCB releases from paper company facilities (U.S. FWS and Stratus Consulting, 1999e). However, the rate of decline has not been constant in all environmental media since the early 1970s. An analysis of PCB temporal trends in Green Bay fish conducted by the Co-trustees shows the following (U.S. FWS and Stratus Consulting, 1999e):

- PCB concentrations show a stronger and more consistent decline in forage fish (e.g., yellow perch and perhaps alewife) than in predator fish (walleye and brown trout). Possible explanations for this difference include shifts in walleye and brown trout diet over time, and increased “lag time” for the reductions in PCBs to be detectable in the longer lived predatory species.

- PCB concentration declines in fish are more prominent in inner Green Bay than in outer Green Bay. A possible explanation for this trend is that the signal of decreased PCB loadings from the Lower Fox River may take longer to reach the portions of the bay that are farther from the river.

- Except in the innermost portion of the bay, PCB concentrations do not show a decline between 1989 and 1996. This conclusion is based on a comparison of fish PCB data from the same fish species collected in similar locations and analyzed using similar methods.

Thus the rate of PCB decline in the Lower Fox River and Green Bay Environment appears to be slowing. Detailed studies of PCB concentrations in Lake Michigan fish (for which much more data are available than for Green Bay alone) show a similar temporal pattern of higher rates of decrease in the late 1970s and early 1980s, and much lower rates of decrease since then (Stow et al., 1995; Stow et al., 1999). These results are also consistent with a recent analysis conducted as part of the RI/FS, which concluded that trends in fish PCB concentrations in the Lower Fox River and inner Green Bay are highly variable, and that future trends cannot be predicted reliably (Mountain Whisper Light Statistical Consulting and ThermoRetec Consulting, 2000). Given the evidence for a decreasing rate of PCB decline, along with uncertainties regarding how the Lower Fox River and Green Bay Environment will respond to large storm events or other unusual processes in the future, it is not likely that the PCB declines observed in the 1970s and 1980s, immediately after PCB releases were dramatically reduced, will continue into the future.

Therefore, if no or limited sediment PCB cleanup actions are conducted, the time required for resource recovery to baseline is expected to be very long. PCB fate and transport models developed as part of the Green Bay Mass Balance Study indicate that absent PCB cleanup, the natural recovery period for the Lower Fox River and Green Bay Environment is 90 to 100 years or more (Patterson et al., 1994; WDNR and Bureau of Watershed Management, 1997).

Response actions are likely to reduce the resource recovery time. Removal of PCB-contaminated sediments can rapidly reduce PCB concentrations in the river and decrease PCB loadings carried by the river into Green Bay. However, given the large mass of PCBs already in Green Bay, response actions focused on the Lower Fox River cannot directly address recoverability of bay resources, but can only reduce the amount of new PCBs being contributed to the bay. The Green Bay Mass Balance Study models indicate that even under intensive remediation of PCB-contaminated sediments in the Lower Fox River, recovery will take 20 years or more for the Lower Fox River and much longer for Green Bay as a whole (WDNR and Bureau of Watershed Management, 1997).

Once the response action remedy is selected, the Co-trustees will conduct a final resource recoverability analysis as part of developing the final claim. The magnitude of the final claim depends on the scale of resource restoration required, and the restoration scale is dependent in part on the length of time required for recovery following the response action. To determine the post-remedy recovery period, the Co-trustees will evaluate relevant information from the RI/FS, such as an alternative-specific risk assessment of residual injuries, any mass balance modeling results, or the evaluation of the long-term effectiveness of the selected remedy. The Co-trustees may also review or evaluate similar or other PCB fate and transport models that are available for predicting future PCB concentrations in the Lower Fox River and Green Bay Environment under different cleanup scenarios. Under even an intensive PCB cleanup scenario, the recovery period is not expected to be less than 20 years for Lower Fox River resources and somewhat longer for Green Bay resources. Recovery periods under lesser amounts of PCB cleanup will be longer, with periods under a no action cleanup alternative being 100 years or more.

3. Restoration and Compensable Value Determination

Chapter 2 described the natural resource injuries in the Lower Fox River and Green Bay Environment that have resulted from Lower Fox River PCB releases. This section of the RCDP describes the approach and results of the Co-trustees' determination of the restoration and compensable value damages necessary to address the natural resource injuries.

3.1 Overview of Restoration and Compensable Value Determination Approach

As described in the iRCDP, a damage determination is intended to establish the amount of money to be sought in compensation for injuries to natural resources resulting from a . . . release of a hazardous substance [43 CFR § 11.80 (b)]. The measure of damages is defined as *restoration costs* plus, at the discretion of the Co-trustees, *compensable values for interim losses* [43 CFR § 11.80 (b)].

Restoration can be accomplished by restoring or rehabilitating resources or by replacing or acquiring the equivalent of the injured natural resources and their service flows. Restoration should be distinguished from *remediation* or *response actions* being considered by the U.S. EPA and the WDNR pursuant to CERCLA or the NCP. The cost of the response action is not included in a damage claim.

Compensable values include the value of lost public use of the services provided by the injured resources [43 CFR § 11.83 (c)(1)]. Under CERCLA, the compensable values for interim services lost to the public (interim losses) accrue from the time of discharge or release or 1980, whichever is later, until restoration is complete [see 43 CFR § 11.80 (b)]. Under the CWA, damages accrue from 1976 [33 U.S.C. § 1321(f)(5)].

The Co-trustees' selected restoration and compensation determination (RCD) approach involves two components:

1. *Recreational fishing damages determination.* This component involves determining monetary damages from injuries to fishery resources associated with the imposition of fish consumption advisories (FCAs) as a result of PCB contamination. The recreational fishing damages are the compensable values for the loss of recreational fishing services to the public. Other natural resource injuries and service losses are not included in this

component of the Co-trustees' damage assessment. A detailed description of the recreational fishing damage determination is presented in Section 3.3.

2. *Restoration planning and cost analysis.* This component involves selecting a preferred alternative for restoration of natural resources and estimating costs associated with implementing the preferred alternative. The restoration planning analysis addresses multiple natural resource injuries and service losses, rather than focusing solely on recreational fishing. Section 3.2 describes in detail the restoration determination approach employed by the Co-trustees, and the results.

In applying this approach, the Co-trustees have decided to apply the recreational fishing damages determination to quantifying compensable values for past interim loss damages, whereas the restoration planning analysis is applied to current and future losses. This approach is designed to avoid double counting of damages. Double counting can occur when damages have been counted more than once in the assessment [43 CFR §11.84 (c)(1)]. Because the two components of the RCD approach, compensable values and restoration, address different, nonoverlapping time periods, the Co-trustees' assessment avoids double counting. Another aspect of avoiding double counting is ensuring that any beneficial effects of response actions are taken into consideration by the Co-trustees [43 CFR §11.84 (c)(2)]. As noted in the iRCDP, response actions undertaken by the WDNR, U.S. EPA, and the responsible parties are likely to benefit natural resources and improve natural resource services. The Co-trustees have accounted for the potential effects of response actions by incorporating natural resource recovery rates into the restoration alternatives scaling approach, as described in greater detail in Section 3.2.5. To the extent that response actions result in more rapid recovery of natural resources, restoration actions are more limited; to the extent that recovery is more protracted, the scale of restoration actions is increased. Moreover, the scale of restoration measures will not be finalized until after selection of a final remediation plan for the Fox River basin and publication of a Record of Decision by WDNR and the U.S. EPA.

3.2 Restoration Determination

3.2.1 Restoration plan overview

As discussed in greater detail below, the Co-trustees' restoration plan will involve several component actions. These component actions include a mix of wetland restoration and wetland preservation to protect and enhance important habitats for fish, birds, and other natural resources, and farmland conservation tillage and vegetated buffer strip installation to reduce nonpoint source runoff into Green Bay and thereby improve water and habitat quality. These actions will improve the environmental quality and ecological and human use services of the Lower Fox

River and Green Bay Environment and thereby will accelerate the return to baseline services and compensate for the PCB injuries from now until the injuries no longer occur.

In addition to the above actions that address acceleration of the return to baseline and future compensable values, past compensable value damages (associated with the recreational fishing damages, as described in Section 3.3) will also be used for restoration activities. However, the compensable value damages will not be applied to achieve the restoration that addresses future injuries. Instead, past compensable value damages will be used to provide: (1) enhancement of recreational fishing opportunities, (2) additional restoration actions consistent with the Co-trustees' stated restoration objectives, and (3) funding for any future proposals for additional restoration actions, consistent with overall restoration planning objectives. Thus, restoration will be funded by both the recovered costs to restore resources (which includes acceleration of the return to baseline and future compensable values) and the recovered past compensable value damages.

A central element of the Co-trustees' conceptual restoration plan is ensuring that the overall plan addresses the full geographic and ecological scope of the injuries to natural resources. Therefore, in developing their final restoration plan, the Co-trustees will ensure that restoration activities:

- address the entire Fox River/Green Bay region, from Little Lake Butte des Morts in the south to the Bay des Nocs in the north

- encompass the unique range of habitats in the Green Bay region, including the aquatic habitat of the bay itself, the coastal wetlands on the west shore to the rich riverine habitats that connect to the bay, and the valuable ecological habitats of the Door Peninsula and the Bays des Noc

- provide for long-term recovery, protection, and enhancement of the unique natural resource endowment of the Green Bay ecosystem

- consider human uses of the natural environment to provide for ongoing and long-term active and passive uses of Green Bay natural resources.

The restoration plan described here was developed using the following steps, as described in the following sections. First, three fundamental restoration alternatives were identified and considered. The Co-trustees then selected their preferred alternative. The preferred alternative was then further clarified with the identification of a set of component actions that constitute the preferred alternative. The methods for scaling the components, estimating the benefits and costs of the components, and combining the components into a single, coherent plan were then developed.

3.2.2 Restoration alternatives considered by the Co-trustees

The following three overall restoration alternatives were considered by the Co-trustees:

1. *No Action-Natural Recovery.* This alternative must be considered by the Co-trustees [43 CFR §11.84 (c)(2)]. The No Action alternative assumed that no restoration, replacement, acquisition, or resource enhancement activities would be undertaken.

2. *PCB Cleanup.* The PCB Cleanup alternative includes actions involving removal of PCBs from the Lower Fox River and Green Bay Environment. PCB removal was considered because (1) PCB removal from sediments will speed recovery of natural resources and their services to baseline (Patterson et al., 1994), and (2) PCB declines in Green Bay fish and wildlife have slowed from the 1980s to present (Stow et al., 1995; U.S. FWS and Stratus Consulting, 1999e; Mountain Whisper Light Statistical Consulting and ThermoRetec Consulting, 2000), suggesting that natural recovery alone will not sufficiently address PCB injuries to natural resources.

3. *Resource-Based Restoration Projects to Provide Enhanced Ecosystem Services.* The Resource-Based Restoration alternative involves restoration projects that would not directly remove PCBs from the system but would, rather, provide enhanced ecosystem services as compensation for losses caused by PCBs. Resource-based restoration projects include activities such as wetland restoration or preservation, which would provide habitat for fish and wildlife species; nonpoint source runoff control, which would improve water quality, aquatic habitat, and human recreational services; and direct resource restoration projects, such as projects designed to improve bald eagle reproduction.

3.2.3 Selection of the preferred alternative

Co-trustees' evaluation and selection of the preferred alternative relied on factors identified in the Department's NRDA regulations [43 CFR §11.84(d)]:

1. technical feasibility
2. the relationship of the costs of the alternative to the expected benefits
3. cost-effectiveness
4. the results of actual or planned response actions
5. the potential for additional injury resulting from the proposed actions
6. the natural recovery period
7. ability of the resources to recover with or without alternative actions
8. potential effects of the action on human health and safety

9. consistency with relevant federal, state, and tribal policies
10. compliance with applicable federal, state, and tribal laws.

This section of the RCDP summarizes the Co-trustees' selection of the preferred restoration alternative.

No Action-Natural Recovery. The No Action alternative was not selected by the Co-trustees as their preferred alternative. Although the No Action alternative is technically feasible, would not cause incremental injuries, would not impose incremental effects on human health and safety, and is consistent with applicable laws, the Co-trustees rejected the No Action alternative for the following reasons:

- It would not restore injured natural resources or compensate the public for current, ongoing natural resource injuries.

- Estimates of natural recovery periods, without additional remediation, are 90 to 100 years or more (Patterson et al., 1994; WDNR and Bureau of Watershed Management, 1997, 1997). Even under intensive remediation scenarios, natural resource injuries are projected to continue for some 20 years in the Lower Fox River and inner Green Bay, and much longer for Green Bay as a whole (WDNR and Bureau of Watershed Management, 1997). Therefore, the No Action alternative does not adequately compensate the public for natural resource injuries and offers no public benefits.

PCB Cleanup. As noted previously, the WDNR and U.S. EPA are currently engaged in performing a Remedial Investigation/Feasibility Study (RI/FS) for the Lower Fox River and Green Bay. At this time, the Co-trustees' evaluation of restoration alternatives assumes that the response agencies will adequately address PCB cleanup. Criteria used by the response agencies to select remedial alternatives under CERCLA include technical feasibility, cost-effectiveness, effects on human health and safety, and compliance with relevant laws (U.S. EPA, 1988). The Co-trustees anticipate that further PCB removal, beyond that selected as part of the CERCLA response, is unlikely to pass the NRDA's feasibility and cost-effectiveness criteria and therefore would be unnecessary and inappropriate. For example, the cost to dredge the estimated 465 million cubic yards of Green Bay sediment estimated to be contaminated with PCBs above a concentration of 50 µg/kg (ThermoRetec Consulting and Natural Resource Technology, 2000) is approximately $111 billion, based on an average cost for remedial dredging projects of $238 per cubic yard (Cushing, 1999). Therefore, the Co-trustees do not intend to pursue the PCB removal alternative at this time. However, the Co-trustees wish to emphasize that this alternative will be reexamined following publication of the Record of Decision by WDNR and the U.S. EPA. To the extent that the Co-trustees believe that insufficient PCB removal is being conducted, the Co-trustees may reconsider PCB removal and/or immobilization actions.

Resource-Based Restoration. Resource-Based Restoration actions were determined by the Co-trustees to be the preferred alternative. Such restoration actions are known to be technically feasible, can provide beneficial natural resource services, are more cost-effective than either No Action or additional PCB removal (beyond that performed by response agencies), will not cause additional injury, can provide enhanced natural resource services to compensate for ongoing service losses, and can be designed in compliance with applicable laws and policies. However, the Co-trustees note that many different types of actions can be implemented within this alternative. Therefore, to further ensure compliance with NRDA evaluation criteria [43 CFR § 11.84 (d)], the Co-trustees engaged in additional, detailed evaluation of individual resource restoration approaches and projects in an iterative manner. This more detailed evaluation is presented in the following sections.

3.2.4 Development of the preferred alternative

Having selected Resource-Based Restoration as the preferred alternative, the Co-trustees then worked to define the specific types of projects that would constitute the preferred alternative. The process used by the Co-trustees to develop the types of projects that constitute the preferred alternative takes into account the following two facts:

- An extensive amount of resource-based restoration planning has already been conducted for the Green Bay area by a variety of government agencies and private organizations. Cumulatively, these planning efforts reflect the types of restoration projects, if not the actual projects, that best address the stresses and resulting impacts that the resources of the Lower Fox River and Green Bay are under. Thus, these previous planning efforts provide the Co-trustees with a foundation for evaluating the resource-based restoration needs of the area.

- The NRDA restoration planning objectives and limitations are likely to be different than those of the previous planning processes. Therefore, the Co-trustees will apply NRDA criteria and factors specified in the NRDA rule to the extensive planning work already conducted by other parties.

Figure 3.1 summarizes the process used by the Co-trustees to identify the types of preferred restoration projects. First, a database of restoration projects proposed by various government and private agencies was constructed. Second, projects that did not meet minimum NRDA acceptability criteria established by the Co-trustees were removed from further consideration. Third, the remaining individual projects in the database were grouped into categories of similar projects based on their goals and methods. The project categories were then scored against Co-trustee ranking criteria. The subsequent relative ranking of projects by their score produced a final set of restoration project types that constitute the preferred alternative: restoring selected

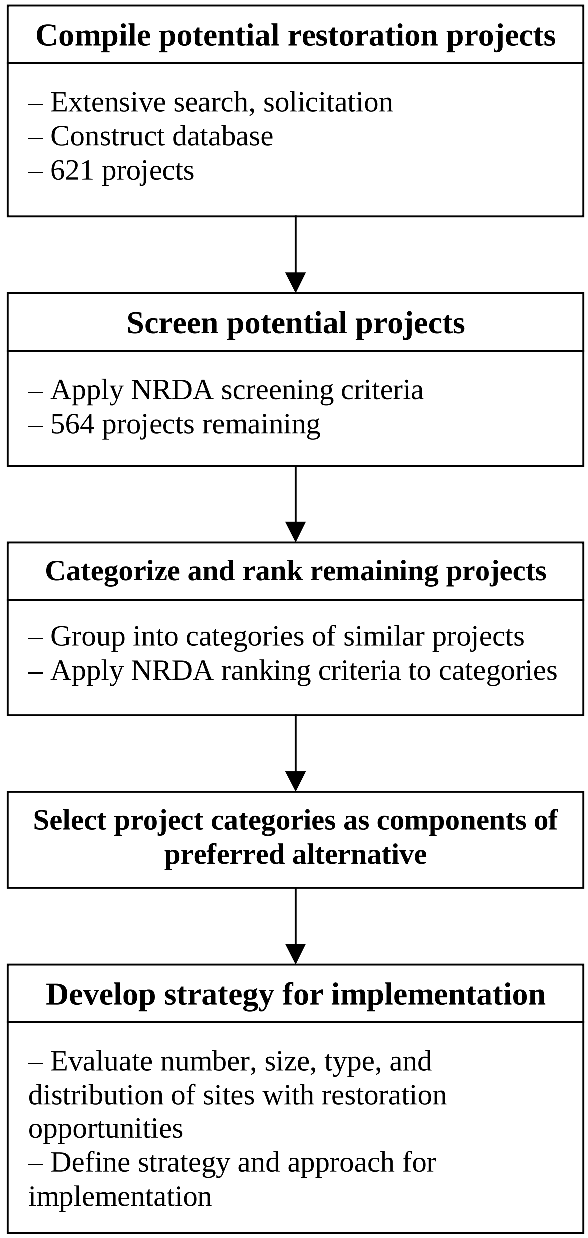


Figure 3.1. Process used by the Co-trustees to define the types of projects that comprise the preferred restoration alternative.

lost wetlands around Green Bay; preserving selected existing wetlands; and reducing nonpoint source pollution into Green Bay through both installing vegetated buffer strips along streams in agricultural areas and inducing farmers to adopt tillage practices that reduce erosion. These types of restoration actions can improve the quality of the Lower Fox River and Green Bay Environment to compensate for the losses caused by PCB injuries, as described in Section 3.2.6. Finally, the Co-trustees developed a strategy for implementing the selected project types that is based on the type, number, size, and distribution of sites that provide opportunities for restoration.

Step 1: Compiling potential restoration projects

The Co-trustees conducted an extensive search to identify the results of restoration and resource planning efforts by other organizations for the Lower Fox River and Green Bay. This search identified documents ranging in scope and level of specificity from very detailed city and county parks and recreation plans to the more general proposals in regional development, land conservation, and resource management plans. Table 3.1 presents the published sources from which projects were obtained. Of the published sources identified in this search, the *Lower Green Bay Remedial Action Plan for the Lower Fox River and Lower Green Bay Area of Concern* (WDNR, 1988) and the *Green Bay Habitat Restoration Workshop: Summary 1994.* (Author unknown, 1994) stand out because of the number of projects they include, the expertise of those involved in developing the projects, and their focus on addressing problems that affect the entire Green Bay ecosystem.

Table 3.1. Document sources of potential restoration project proposals used in the Co-trustees' projects database.

Document	Author (year)
Final Project Summaries of the Habitat Restoration Workgroup	Habitat Restoration Workgroup (1997a)
Green Bay Habitat Restoration Workshop: Summary 1994	Author unknown (1994)
Lower Green Bay Remedial Action Plan for the Lower Fox River and Lower Green Bay Area of Concern	WDNR (1988)
Menominee Reservation Lake Sturgeon Management Plan	Author unknown (1995)
Potential Habitat Restoration Projects Reviews	Habitat Restoration Workgroup (1997b)

The Habitat Restoration Workgroup, which was assembled by the WDNR, also was an important source of restoration projects for the database developed by the Co-trustees. The Habitat Restoration Workgroup consisted of natural resource experts from several different agencies such as the WDNR, the Green Bay Metropolitan Sewerage District, the City of Green Bay, the University of Wisconsin — Green Bay, and the Menominee and Oneida Indian Tribes who were knowledgeable about natural resources and potential restoration actions in the Lower Fox River and Green Bay. Throughout its meetings in 1997 and 1998, the group developed and updated lists of potential restoration project proposals that were intended to provide the basis for the selection of restoration projects.

In addition to its project lists, the Habitat Restoration Workgroup produced a collection of potential restoration project written reviews. The reviews were prepared by the individual members of the workgroup to summarize projects from the lists. These reviews also provided members of the workgroup with the opportunity to present projects that had not yet been incorporated into the groupwide project lists and that the members felt should be considered. The projects described in the individual reviews and those in the project lists were both incorporated in the project database developed by the Co-trustees.

Restoration project proposals were also actively solicited by the Co-trustees from organizations. A list of the organizations that were contacted for potential restoration projects is presented in Table 3.2.

Table 3.2. Organizations contacted for potential restoration project proposals.

Brown County Land Conservation Department	Oconto County Office of Land Conservation
Brown County Park Department	Oneida Tribe of Indians of Wisconsin
Clean Water Action Council	Outagamie County Land Conservation Department
Fox River Group of paper companies	University of Wisconsin – Green Bay
Fox-Wolf Basin 2000	U.S. Army Corps of Engineers
Menominee Tribe of Wisconsin	U.S. Fish and Wildlife Service
Michigan Department of Environmental Quality	Winnebago County Land Conservation Department
The Nature Conservancy	Wisconsin Department of Natural Resources
Northeast Wisconsin Land Trust	Wisconsin Waterfowl Association

Each restoration project was entered into a database designed to simplify the tracking and categorizing of the projects. After removing duplicate records, the database contained 621 distinct potential restoration projects. The database, which is included in Appendix C, includes information such as the project description, location, what the project would attempt to achieve, how the project would achieve it, and the source(s) of information for the project. This database of projects served as the starting point for the Co-trustees' subsequent restoration planning steps.

Step 2: Screening the projects database

In the second step, the projects in the database were screened against acceptability criteria that projects must pass for them to be considered further in the NRDA planning process. These criteria, which were published in the iRCDP, were developed by the Co-trustees to aid in eliminating those projects that are clearly inconsistent with the requirements of the NRDA. In essence, the acceptability criteria stipulate that a restoration project must comply with all applicable laws and regulations, address resources or services at least broadly connected to those injured by PCBs, and be technically feasible to implement.

Table 3.3 shows the results of the project screening step. In comparing each project against each criterion, projects were assumed to meet the criterion unless the available information clearly indicated otherwise. Therefore, if available project information was not sufficient to determine whether it met a criterion, it was assumed that it did. These projects were classified as either "pass/more information," which means the available information suggests that the project passes but more information is needed to determine with certainty, or "more information," which means that no information is available to determine if the project passes. This approach was taken to ensure that the projects retained for further consideration encompass the full range of potentially applicable projects. Furthermore, additional information can be gathered on the projects in later steps to eliminate those projects that do not meet the criteria.

A total of 93 projects were removed from further consideration (Table 3.3). Examples of the types of projects that were eliminated in this step include:

- projects that are primarily evaluations or investigations rather than actual improvements in resources or services
- projects that enhance recreational activities that are not related to natural resources (e.g., creating historical parks, restoring band shells)
- improvements to sports parks (e.g., municipal golf courses, ball fields)
- public education programs
- controlling pollution point sources such as industrial discharges or landfill leakage.[1]

---

1. Controlling pollution point sources was screened out from further consideration because it did not meet the criterion of complying with all applicable laws and regulations. Since controlling pollution point sources falls under the purview of other state or federal regulatory programs, it is considered inconsistent with these programs for the NRDA to conduct such actions.

Table 3.3. Results of screening the full project list against the acceptability criteria.

	Projects receiving score	
Possible project evaluation scores	**Number**	**Percentage**
Pass	318	51%
Pass/more information	111	18%
More information	99	16%
Fail	93	15%

Step 3: Ranking potential restoration projects

The next step was to rank potential restoration projects against the remaining Co-trustee criteria for the NRDA. As described in detail below, the ranking procedure resulted in four types of restoration projects: (1) wetland restoration, (2) wetland preservation, (3) installing vegetated buffer strips along farmlands and (4) inducing changes in agricultural practices. The latter two project types are intended to reduce nonpoint source pollution into Green Bay. The Co-trustees also selected a unique category of projects that provide resources or services of cultural importance to Indian tribes.

The Co-trustees developed criteria to evaluate and rank potential restoration projects and published the criteria in the iRCDP. The criteria were grouped into three categories that reflect the aspects of the projects that the criteria evaluate: “focus” criteria, which evaluate project objectives; “implementation” criteria, which evaluate project methods; and “benefits” criteria, which evaluate the types and characteristics of the benefits the projects aim to achieve. These criteria reflect the Co-trustee requirements and priorities for NRDA restoration, as well as the criteria for selecting the preferred alternative specified in the Department’s NRDA regulations [43 CFR §11.84(d)]. The purpose of the criteria is to provide a means of ranking potential restoration projects against each other by considering the objectives and requirements of the NRDA restoration planning process.

Rather than apply the ranking criteria to each individual project, the criteria were applied to categories of projects that were similar in their objectives, methods, and benefits provided. Projects were grouped into one of 15 project categories, which are listed in Table 3.4. In addition, the 15 project categories all fall within one of three broad types of projects: nonpoint source pollution control, habitat/species programs, and recreational facilities improvements. No other types of projects passed the screening step. The Co-trustees evaluated the 15 project categories and concluded that they adequately encompass the range of projects that the NRDA planning process should consider.

Table 3.4. Project categories and numbers of projects in each category in the project database.

Project category	Number of projects in database
Nonpoint source pollution reduction	
Restore riparian habitat as buffer strips	22
Improve agricultural practices	13
Stabilize eroding streambanks	35
Improve animal waste handling practices	11
Control urban nonpoint source pollution	11
Habitat/species programs	
Restore wetlands	29
Restore island habitat	6
Preserve wetlands	41
Create artificial fish habitat	7
Create artificial bird habitat	2
Rare/endangered species programs	11
Remove shoreline rip-rap, seawalls	3
Exotic species control	5
Recreational facilities	
Create or improve parks and trails	278
Improve recreational fishing access	96

In this step the Co-trustees used a subset of the available ranking criteria to rank the project categories, for some of the ranking criteria are best applied to individual projects rather than project categories. For example, the degree to which a restoration project achieves environmental equity and justice is best evaluated at the individual project level rather than at the project category level. Similarly, since costs are dependent in part on the specific aspects of a project, cost comparisons will be addressed later at the individual project level. The following five criteria (from those listed in the iRCDP) were used to rank the project categories against one another:

- *Restores habitat on-site.* This criterion evaluates the degree to which the project restores habitat in the Lower Fox River and Green Bay Environment, including on tribal lands. This criterion incorporates a preference for projects that address natural habitat over those that address only the services provided by habitat. This criterion was identified as a higher priority criterion in the iRCDP.

- *Benefits can be scaled to PCB injuries and can be measured.* For a project to provide benefits that can be scaled to PCB injuries, it must provide benefits that can be both predicted and related to PCB injuries and services losses. As described in Section 3.2.5, the Co-trustees' total value equivalency study provides a means of comparing nonpoint source runoff, habitat, and recreational facility benefits to PCB injuries. Thus, this criterion primarily evaluates the degree to which the benefits are predictable. This is a higher priority criterion.

- *Provides a broad scope of benefits to a wide area or population.* Project categories may differ in their tendencies to provide a range of benefits over a wide area or population. Those that are focused on a limited set of benefits to a limited area or population are less preferred. This is a higher priority criterion.

- *Has a high probability of success.* Projects that use reliable, proven methods are preferred over those that rely on experimental, untested methods. Other factors that can affect project success, such as validity of assumptions inherent in the project approach, are also considered. This is a medium priority criterion.

- *Maximizes the time over which benefits accrue.* Projects that provide long-term benefits that begin immediately after project implementation are preferred. In applying this criterion, we assume that any operations and maintenance activities required for long-term success will be conducted. This is a lower priority criterion.

These five criteria were applied to the 15 restoration categories using the following system. The degree to which a restoration category met each criterion was assigned a score of high, medium, or low, which were assigned point values of 5, 3, and 0 points. These point values were multiplied by a weighting factor of 5 for higher priority criteria, 3 for medium priority criteria, and 1 for lower priority criteria. For example, a restoration category that scores medium on a higher priority criterion would be assigned a score of 15 points for that criterion (3 x 5). Each project category's priority-weighted criterion scores were then summed to produce an overall project category score. These scores were used only as an indication of project categories relative rankings, and do not necessarily represent a quantitative means of comparing the desirability of different categories. For example, a project category that scores 90 points is not necessarily twice as preferred as a project category that scores 45 points.

Table 3.5 shows the results of the ranking process. Appendix D describes the scoring and ranking methods used. The total score for each project category is used to rank the projects from highest to lowest. Both installation of farmland buffer strips and wetland restoration scored high for every criterion and are the highest ranked project categories. The next highest category is reducing nonpoint source pollution through improving agricultural practices, followed by

Table 3.5. Summary projects scoring.

Project category	Relative ranking
Buffer strip installation	1
Wetland restoration	1
Agricultural practice improvements	3
Wetland preservation	4
Streambank stabilization	5
Island habitat restoration	5
Shoreline softening	7
Exotic species control	8
Animal waste handling improvements	9
Urban nonpoint source control	9
Rare/endangered spp. programs	11
Waterfront parks or trails	12
Recreational fishing access improvements	12
Fish artificial habitat creation	14
Bird artificial habitat creation	14

wetland preservation. The bottom ranking projects are artificial habitat creation for birds and fish and new or improved parks, trails, or recreational fishing access.

Conclusion: Selection of restoration project types for the preferred alternative

Based on the analysis described above, the Co-trustees selected four types of projects to constitute the preferred alternative: wetland restoration, wetland preservation, vegetated buffer strip installation, and improvements in agricultural practices to reduce nonpoint source pollution. The next section describes how the Co-trustees determined the scales of these components that are required for restoration, and the subsequent section provides a more complete description of these four project types.

The ecological and human use services of the Lower Fox River and Green Bay Environment will be enhanced and improved through these restoration actions. Wetlands are a vital component of the area's ecosystem, and provide valuable breeding and feeding habitat for many fish, birds, and other organisms. Reducing nonpoint source pollution will improve the water quality of Green Bay, making it a much better habitat for fish and birds. Therefore, these restoration actions can compensate the public for the losses associated with the PCB injuries to natural resources.

The Co-trustees also included a different type of project that addresses a different type of benefit: restoration/preservation of specific areas or resources that have significant cultural value to the Indian tribes in the area. Examples of these types of projects may include the following:

- The preservation of the property associated with nine gathering sites historically used by Oneida tribal members for fishing and ceremonies along Duck Creek.

- The restoration of wild rice beds in selected areas. This action would be beneficial to the culture of the Menominee Tribe, and it would accomplish important ecological goals identified by the preferred alternatives in the RCDP. Rice beds also provide excellent buffer strips, protection to shoreline banks, and would aid in wetland restoration projects.

- Continued efforts toward management and restoration of lake sturgeon. Lake sturgeon are integrally important as a focus of cultural activity for the tribes.

These and other similar projects may be included as a distinct type of restoration action to specifically address the loss of cultural services that has been experienced by the tribes as a result of PCB injuries. Therefore, as part of the Co-trustees' post-award restoration plan, individual projects will be evaluated for their tribal cultural importance, and the preservation of such sites may be considered as a "credit" toward the preservation/restoration of wetlands or other natural areas.

3.2.5 Scaling the preferred alternative

Restoration scaling refers to determining the amount of the preferred restoration alternative that is required to compensate the public for injuries to natural resources. The scaling of restoration actions under the preferred alternative is supported by a total value equivalency (TVE) study. The TVE study also addresses the scaling of improvements in regional park facilities, since such actions have been proposed by various organizations around the bay. A summary of the TVE report is presented here, and the full report is included as Appendix A.

The TVE study supports restoration planning in two ways. First, the study explicitly obtains public input regarding the priorities and values for alternatives types of restoration projects, which aids the Co-trustees in evaluating the benefits of alternatives [43 CFR § 11.82(d)(2)] and ensures that there is public input on the selection of alternatives [43 CFR § 11.90]. Second, the study provides value-based methods to determine the appropriate scale of restoration actions.

For a large share of the PCB-caused service flow losses in the assessment area, particularly within Green Bay, where most of the PCBs have come to be located, providing restoration with the same or very similar services may not be technically feasible (i.e., the Co-trustees may be unable to find or develop resources that are sufficiently extensive to be developed in sufficient quantities), is undesirable (e.g., increasing the population of fish or birds that may continue to experience injuries from PCB exposure), or may be too expensive. Therefore, it is preferable to select restoration actions that provide resources and services of a similar but different type or quality than those injured. In these cases, value-based scaling methods provide a basis for selecting and scaling restoration activities.

Value-to-value scaling is used in the TVE study to scale restoration projects that provide services similar to, but not the same as, those lost.[2] Scaling is computed such that the value of the services gained through restoration equals the value of PCB-caused losses. Value is measured by the utility (benefits or satisfaction) that people derive from all active and passive uses of the resources. Dollar measures of value are not required for value-to-value scaling.

In the TVE study, the Co-trustees focus on restoring all human use losses, including active use losses related to well-identified active, and often on-site, resource uses such as recreational fishing, and passive use losses arising from services individuals receive from resources apart from their own readily identified and measured active uses.

Certain active use losses may be cost-effectively and readily individually measured and valued, as the Co-trustees have done for recreational fishing active use losses (U.S. FWS and Stratus Consulting, 1999f). However, focusing solely on these losses omits consideration of other potentially significant losses, thus understating the services to be restored. The TVE study is a total value assessment because it cost effectively addresses most or all PCB-caused service flow losses, including but not limited to recreational fishing and other recreational losses such as waterfowl hunting and wildlife viewing; casual or indirect losses such as reduced enjoyment while driving or walking by or working near a site, and when hearing about, reading about, or seeing photographs of a site; and option and bequest losses tied to preserving resource services for future use for oneself or for others.

Value-to-cost scaling can be used to select the type and scale of restoration projects such that their cost equals the value of the lost services. This is the same as computing compensable values [CFR 43 § 11.83-11.84] and applying the recovered damages to selected restoration projects [43 CFR § 11.93 (b)]. This study supports the selection of the mix and scale of restoration projects once damages are recovered by identifying project preferences and the relative value of alternative mixes of projects. While not the primary focus, the study can provide a measure of

2. See also 15 CFR § 990.53(d) for additional discussion of value-based scaling concepts and methods.

compensable values for interim losses from 2000 until services are returned to baseline using a willingness-to-pay (WTP) measure [43 CFR §11.83(c)(2)].[3,4]

TVE approach

Survey of preferences and values

To obtain public preferences and values, a survey was conducted with residents of 10 Wisconsin counties surrounding the Wisconsin waters of Green Bay. The survey focused on four types of natural resource restoration programs for the Green Bay area that were selected because the majority of proposed natural resource restoration actions for the Green Bay area fall into one of these groups. The action levels for each program were selected reflecting relevant options and responses from respondents in survey focus groups and pretests.

1. *Restore wetlands* near the waters of Green Bay. Wetlands restoration will provide increased spawning and nursery habitat and increased food for a wide variety of fish, birds, and other wildlife. This provides wildlife services similar to, but not the same as, those injured by PCBs. Priorities and values for restoration of wetlands can also be applied as an indicator of the priorities and values for other habitat enhancement projects. Restoration levels range from taking no action up to a 20% increase in wetlands within five miles of Green Bay within Wisconsin (although restoration could also take place in Michigan).

2. *Reduce runoff* that contributes to pollution of the waters of Green Bay. Controlling runoff improves water quality by lessening algae growth and improving water clarity, especially in the lower bay. This improves aquatic vegetation and habitat for fish and some birds and improves recreation. The runoff control in this case provides similar, but not the same, services as those injured by PCBs. The runoff control levels considered range from no change in the amount of runoff up to a 50% reduction, reflected by changes in water quality measures.

3. *Enhance outdoor recreation* in counties surrounding Green Bay. Enhanced recreation includes increasing facilities at existing parks such as adding picnic grounds, boat ramps, and biking and hiking trails, and development of new parks. These facilities provide

---

3. Compensable values include "the value of lost public use of the services provided by the injured resources, plus lost nonuse values such as existence and bequest values" [43 CFR § 11.83(c)(1)].

4. The values provided in this study could also be used to support value-to-value scaling of the compensable values for the total interim recreational fishing losses (U.S. FWS and Stratus Consulting, 1999f) to the value of the restoration programs addressed herein.

recreation services, although not the same as those lost as a result of the presence of PCBs. The levels of recreation enhancements considered range from no improvements up to a 10% increase in facilities at existing parks and a 10% increase in new park acreage.

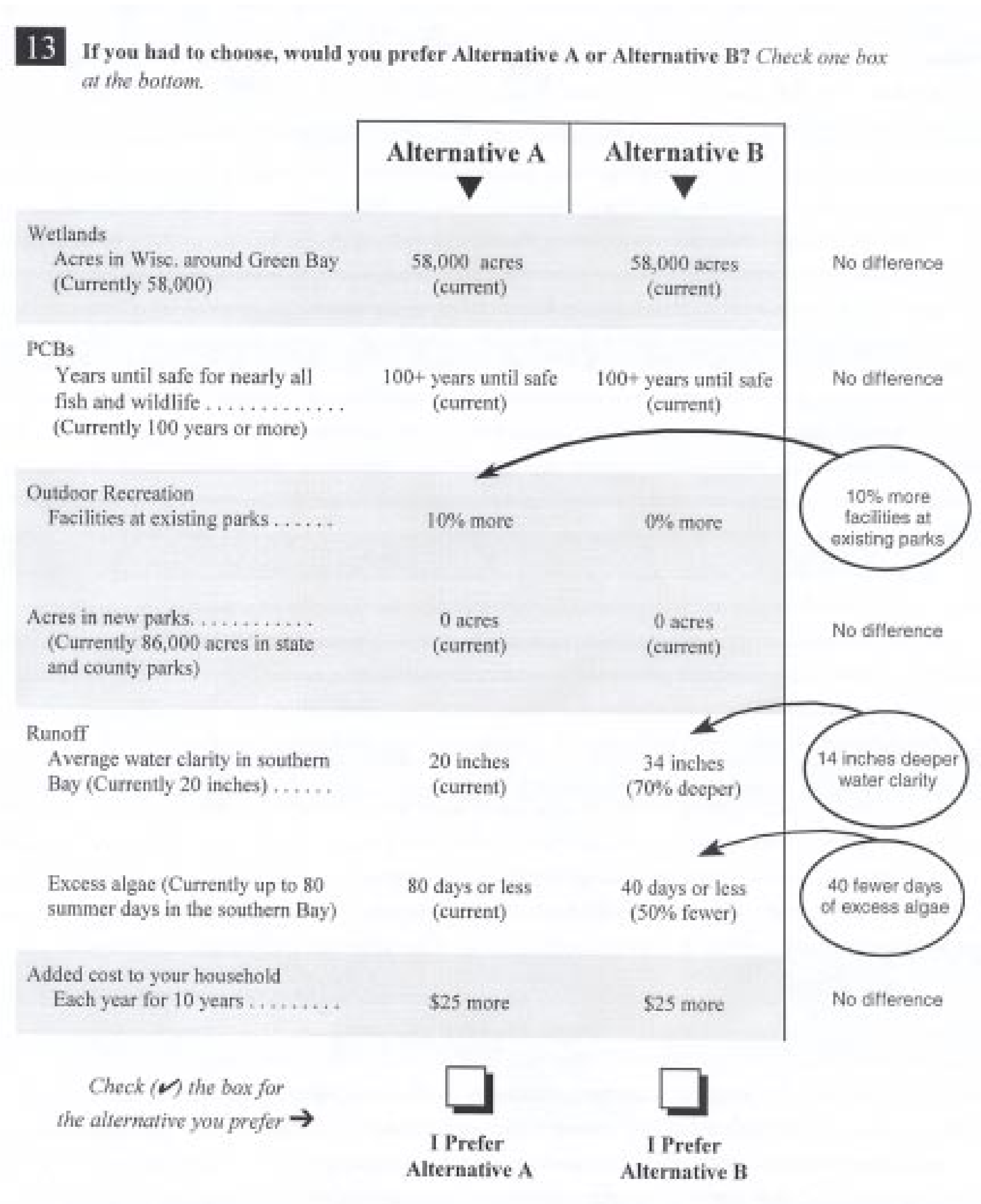
4. *Remediate PCBs* in the sediments of the assessment area. Removing PCBs will reduce the number of years until FCAs and the injuries to wildlife are eliminated. The levels of removal considered result in the number of years until PCBs are at safe levels (i.e., a return to baseline conditions) ranging from 100 years (no additional removal) to 20 years with intensive remediation.

The TVE study supports restoration planning by providing a large-scale perspective of public preferences across alternative types of restoration programs, and providing a method to scale programs that provide equivalent value to the service flow losses. The study was not intended to provide a selection of individual projects such as specific wetland acres or specific recreational facilities. That task is left to the Co-trustees and regional planners who have a detailed knowledge of needs, technical effectiveness, and cost-effectiveness and will be undertaken as part of the post-award restoration plan.

The survey describes each of the four natural resource restoration programs and asks a variety of questions to elicit preferences about the programs and the program levels. Next, the survey includes six stated preference choice questions, where respondents state their preferences by choosing which of two alternatives (A or B) they prefer, where each alternative has a specified level for each of the four restoration programs.

Figure 3.2 provides an illustration of the choice questions presented to respondents. In this question, respondents are making a choice between enhanced outdoor recreational facilities at existing parks versus increased levels of runoff control. By varying the program mixes and levels across questions and examining the choices made, mathematical methods (knows as random utility models) are used to determine how much of one kind of restoration has equivalent value to different amounts of other kinds of restoration.

The alternatives, and the choice between alternatives, are designed to reflect realistic and meaningful options for natural resource management in the study area. To present realistic choices, each of the alternatives includes a dollar cost to the household associated with the alternative. The dollar values presented differ across choice pair, and across survey versions, which allows for calculation of the public’s WTP for the value of PCB-caused losses, or compensable values (see Appendix A), and for the natural resource enhancements considered.



13 **If you had to choose, would you prefer Alternative A or Alternative B?** *Check one box at the bottom.*

	Alternative A ▼	Alternative B ▼	
Wetlands Acres in Wisc. around Green Bay (Currently 58,000)	58,000 acres (current)	58,000 acres (current)	No difference
PCBs Years until safe for nearly all fish and wildlife . . . . (Currently 100 years or more)	100+ years until safe (current)	100+ years until safe (current)	No difference
Outdoor Recreation Facilities at existing parks	10% more	0% more	10% more facilities at existing parks
Acres in new parks. . . . . (Currently 86,000 acres in state and county parks)	0 acres (current)	0 acres (current)	No difference
Runoff Average water clarity in southern Bay (Currently 20 inches)	20 inches (current)	34 inches (70% deeper)	14 inches deeper water clarity
Excess algae (Currently up to 80 summer days in the southern Bay)	80 days or less (current)	40 days or less (50% fewer)	40 fewer days of excess algae
Added cost to your household Each year for 10 years	$25 more	$25 more	No difference
Check (✔) the box for the alternative you prefer →	☐ **I Prefer Alternative A**	☐ **I Prefer Alternative B**	

Figure 3.2. Sample choice question.

The TVE survey was implemented through a mail survey of a stratified random sample of households in 10 counties near Green Bay. Of the 650 eligible respondent households, 470 responded, for a 72% response rate. An evaluation of the sampling plan and responses indicates that any potential sampling and response biases are likely to be small and thus have a minimal impact on the results.

Remediation scenarios

The TVE study determines what level of enhancements in the selected natural resource programs has a value that is equivalent to the value of PCB-caused losses over various time periods for alternative remediation scenarios. Figure 3.3 illustrates how ongoing PCB-caused losses depend on the rate of remediation of services. In the figure, Area A represents past losses experienced before initiation of remediation begins at the site (assumed to be 2000); these losses are not addressed in the TVE study. Area B reflects an assumption of a 10 year period (2000-2009) for remediation actions during which time limited, if any, recovery may occur. Areas C-F are ongoing losses after remediation (if any), depending on the level of remediation. Several scenarios were considered:

1. *Intensive remediation.* This scenario assumes losses continue largely unabated during the remediation period (Area B), then linearly decline to baseline over another 10 years (Area C) for a total of 20 years of ongoing losses. This scenario reflects the Fox River Global Meeting Goal Statement (FRGS-97) by the Fox River Global Meeting Participants (1997), and is similar to the more intensive remedial actions being considered in the RI/FS (ThermoRetec Consulting and Natural Resource Technology, 2000).

2. *Intermediate remediation*. This scenario assumes that losses continue largely unabated during a remediation period (Area B), then linearly decline to baseline over another 30 years (Areas C + D) for a total of 40 years on ongoing losses. This scenario is similar to the intermediate remediation scenarios in the RI/FS.

3. *Little or no additional remediation*. These scenarios consider limited remediation over 10 years (Area B), resulting in declining losses over an additional 60 years (Areas C + D + E) for a 70 year total, or resulting in declining losses over an additional 90 years (Areas C + D + E + F) for a 100 year total.

The TVE study design allows the calculation of the scale of restoration that provides services of equal value to the value of PCB-caused losses within any time period shown in Figure 3.3.

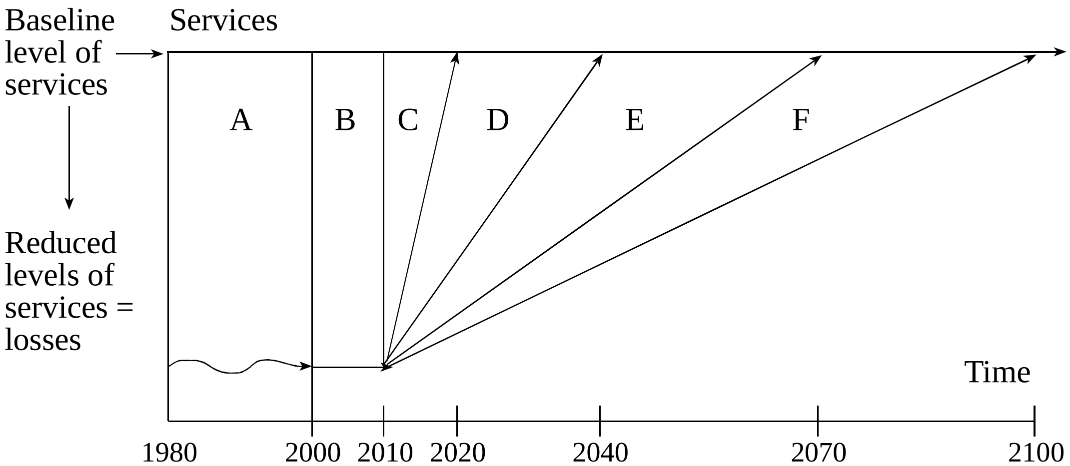


Figure 3.3. Interim losses under alternative time paths for a return to baseline.

Summary of results

Awareness and preferences

Respondents were asked how aware they were of each of the four natural resource topics presented (wetlands, PCBs, outdoor recreation, and runoff control) before receiving the survey. Respondents reported being moderately to highly aware of the topics, with over 80% reporting they were somewhat to very aware of each topic. The literature identifies that higher awareness can be expected to enhance the reliability of responses and to reduce the burden of communication in survey design. High levels of awareness of a topic most likely reflect personal interest in the topics and increased preference for, and values for, natural resource restoration.

Various questions address respondent concerns and preferences for the four programs and the service flow benefits they provide. There is a strong and consistent preference for PCB removal over other natural resource enhancement programs (see Appendix A). Relative to PCB removal, runoff control and wetland enhancements have modest interest and values. Limited interest is expressed in enhancing 120 regional parks, and almost no interest is expressed in adding new regional parks. Table 3.6 summarizes the importance ratings for the benefits from each program. Table 3.7 summarizes preferences in terms of doing and spending less, the same, or more, compared to current levels, for each program in the future.

Table 3.6. Importance of natural resource action benefits (1 = not at all important to 5 = very important).

Benefits[a]	Mean importance ranking (SE of mean)
Remove PCBs to reduce risks to birds, fish, and other wildlife	4.3 (0.05)
Remove PCBs so that it is safe to each fish and waterfowl	4.3 (0.05)
Reduce runoff to improve water clarity	4.0 (0.05)
Increase wetland acreage to support birds, fish, and other wildlife	3.9 (0.05)
Reduce runoff to reduce algae blooms	3.8 (0.05)
Add facilities at existing parks	3.6 (0.05)
Add new parks	3.3 (0.06)

a. Listed in order of mean importance score, not in the order they appear in the survey.

Table 3.7. Preferred actions for natural resource programs.

Natural resource programs[a]	Do less and spend less[b]	Do and spend the same	Do more and spend more
PCB investigations and removal	NA[c]	17%	83%
Runoff reduction	2%	34%	65%
Wetlands maintenance and/or restoration	3%	42%	56%
New facilities at existing parks and/or opening new parks	2%	51%	47%

a. Listed in order of mean importance score, not in the order they appear in the survey.
b. Percentages are adjusted to remove missing responses, which amount to less than 2.4% for all questions and may not sum to 100% due to rounding.
c. Not applicable: “Do less and spend less” was not offered as an option for PCBs.

The reported preferences vary by household characteristics. For example, households report higher importance for the benefits of a program, and interest in doing more and spending more, if they have anglers active in fishing the waters of Green Bay, if they live very near Green Bay, and if they were previously very aware of the natural resource topic.

Scaling restoration

The results of the choice questions, which trade off enhancements in natural resource programs, demonstrate that respondents predominately answer in a manner consistent with our expectations: more enhancements are preferred to fewer enhancements, and lower costs are preferred to higher costs and the trade-offs are consistent with the results in Tables 3.6 and 3.7. These results support the reliability of the results.

The resource trade-off questions are used to scale combinations of resource restoration programs that would provide services that the public considers to be equivalent in value (measured in utility) to eliminating the continuing PCB-caused losses. While the final mix and scale of restoration programs will be determined later, the model presented here provides a basis upon which to scale alternative restoration programs. The composition and costs for alternative restoration programs are discussed in Section 3.2.9.

Table 3.8 provides examples of the scale of sample mixes of restoration projects that provide services with value equal to the ongoing PCB-caused losses for selected scenarios. Each line represents one possible mix of restoration projects. The listed examples are but a few of the infinite number of possible combinations that the Co-trustees and potentially responsible parties could develop to provide services of equal value to the PCB caused losses. The first three lines provide example combinations for the scale of restoration providing services of value equal to the PCB-caused losses from 2000 until a return to baseline if an intensive level of remediation returns services to baseline by 2020:

- a combination of 3,100 acres of wetlands restoration, plus a 10% enhancement in existing park facilities, plus an additional 14 inches of Green Bay water clarity from a runoff control program
- a combination of 5,500 acres of wetlands restoration, plus an 8% increase in existing park facilities, plus an additional 12 inches of Green Bay water clarity from a runoff control program
- 11,000 acres of wetlands restoration, plus an additional 12 inches of Green Bay water clarity from a runoff control program.

The second block provides examples for the 40 year intermediate level of remediation. The third block provides examples of the scale of restoration that provides services of value equal to a

Table 3.8. Compensatory restoration scaling: Illustrative example combinations.

	Example restoration combinations		
Years until clean from PCBs	**Wetland acres**[a]	**Existing park enhancement**	**Runoff control**[b]
PCB remediation scenarios[c]			
Intensive: (0 to 20 years)	3,100	10%	14”/50%
	5,500	8%	12”/45%
	11,000	0%	12”/45%
Intermediate: (0 to 40 years)[d]	24,100	10%	16”/55%
	16,000	20%	16”/55%
Partial restoration:	2,900	2%	4”/25%
(20 to 40 years)	5,000	3%	2”/13%
	2,400	0%	7”/33%

a. Rounded to nearest 100 acres.
b. Additional inches of water clarity/percentage decrease in number of excess algae days.
c. Restoration is for PCB-related losses during the period indicated.
d. Requires extrapolating beyond the range of actions considered for some or all programs.

portion of the PCB-caused losses corresponding to the differences between a 20 and 40 year remediation.

These illustrations do not include additional acres of new parks as a restoration approach because this approach was found to have a near-zero value in the 10 county area. A few key findings emerge as applicable to the ultimate selection and scaling of restoration alternatives within the identified three project types (wetlands, runoff control, and outdoor recreational facilities):

- Wetland (and likely other wildlife habitat) restoration programs and runoff control programs are preferred to, and more highly valued than, programs to enhance outdoor recreation in the assessment area. While specific outdoor recreation enhancements would benefits some residents, the majority of residents indicated limited interest in additional facilities and parks.

- Continued increases in the levels of wetland restoration programs increase benefits, but at a declining rate. That is to say, there are diminishing marginal utility gains as more wetlands are restored. As a result, increased restoration well beyond the levels addressed in the study will most likely result in limited additional benefits to the public.

- The value of PCB-caused losses is so substantially larger than the value of service flow benefits from the restoration programs that it is difficult to generate benefits equivalent in value to the PCB-caused losses with just improvements in one program. For instance, a widespread improvement in regional parks provides services that are equal in value to the value of the first few years of PCB-caused losses, a 20% increase in wetland acres provides services with value equal to about the first seven years of PCB-caused losses, and runoff control that results in an additional 14 inches of water clarity provides services with value equal to about the first 15 years of PCB-caused losses. Therefore, to provide sufficient restoration with value equal to the value of ongoing PCB-caused losses until a return to baseline will most likely require a combination of several programs.

- The restoration combinations presented in Table 3.8 consider up to a 40 year time horizon for eliminating PCB injuries because even the maximum combination of the wetlands, outdoor recreation, and runoff control programs considered do not provide enough service flow benefits to be equivalent to eliminating PCB losses more than 40 years more quickly. To provide services flow benefits for PCB-caused losses beyond 40 years would require additional co-variations on these four natural resource programs.

Comparison to other studies

The TVE study differs from, but necessarily partially overlaps, the Co-trustees' recreational damage determination (U.S. FWS and Stratus Consulting, 1999f) because both include a portion of the recreational fishing losses due to PCB-caused fish consumption advisories. The WTP results of the TVE and recreational fishing studies can be compared for those households with Green Bay anglers in the 10 nearby Wisconsin counties. For this comparison population, the WTP values in this TVE study are comparable to or slightly larger than the WTP values in the recreational fishing study. This is as expected because this study values a larger set of losses than does the recreational fishing study, although for households with Green Bay anglers, fishing losses may well be the dominant component of PCB-caused losses. The comparability of the results supports the estimated magnitude of damages in each study.

The results of the TVE study are also consistent with other existing literature specifically addressing social preferences and values for PCBs and other natural resource management programs in northeastern Wisconsin (see Appendix A). Existing literature consistently identifies that regional residents are aware of and concerned about water pollution issues, and place a high priority and value on cleaning up contaminated water resources. While the existing literature does not address the same scenarios as the TVE study, allowing for differences in the scenarios, the preferences and compensable values from the TVE study are of a magnitude consistent with those in the literature.

3.2.6 Strategies for implementing the preferred alternative

This section describes the Co-trustees' strategies for implementing the different elements of the preferred restoration alternative (wetland restoration, wetland preservation, installation of vegetated buffer strips, and improvements in agricultural practices to reduce nonpoint source runoff). In developing their preferred restoration approach, the Co-trustees have considered issues such as:

- consideration of the approximate number and spatial distribution of sites that provide opportunities for these types of restoration actions
- consideration of the types of wetlands that should be targeted for restoration or preservation, and the potential locations of wetland restoration and improvement actions
- consideration of the specific nature of the actions that would be required to implement different restoration components.

The Co-trustees emphasize that identification of the specific parcels of land that will be restored, enhanced, or acquired, and development of the specific actions that will be undertaken at each of these parcels, will be undertaken as part of the Co-trustees' post-award restoration plan. The strategy presented here provides the general framework within which the more specific work of developing the post-award restoration plan can be conducted. The strategy is intended to provide the flexibility necessary to incorporate the specific issues and constraints that will arise in continued restoration planning and implementation, yet provide enough specificity to allow for public comment on the strategy. In addition, the strategy will be used to help develop the cost estimate for implementing the preferred restoration alternative.

Strategy for wetland restoration and preservation

Background

Wetlands are an integral part of the Green Bay ecosystem. They provide valuable habitat for many plants, birds, fish, and other wildlife that are dependent on wetlands for their survival. They are highly productive areas, and help reduce wave erosion, contain nonpoint source runoff, provide groundwater recharge and discharge, and recycle nutrients. Many fish species of Green Bay rely on coastal wetlands for breeding and rearing, including yellow perch, northern pike, and largemouth bass, as well as shiners and minnows, which are essential prey items for many birds and larger fish. Many bird species also rely on wetlands for breeding and feeding, such as herons, rails, eagles, and terns. Since wetlands provide essential ecological services and habitat for so many fish, bird, and other biota species, preserving and restoring wetlands provides a means of bettering the ecological and human use services of the Lower Fox River and Green Bay Environment and thereby compensate for the losses caused by PCBs.

As part of their restoration planning process, the Co-trustees conducted an in-depth evaluation of the current status of wetlands in the Lower Fox River and Green Bay Environment to assist in development of a wetland restoration and preservation strategy. The analysis was conducted for the Co-trustees by Hey and Associates, a firm with extensive expertise in wetland ecology and restoration in the Great Lakes. The analysis is based on a review of documents and data sources related to wetlands in the area (e.g., the Green Bay Special Wetlands Inventory Study conducted by the Service in 1993), interviews with wetland resource experts from public and private organizations, information obtained from the U.S. Army Corps of Engineers, and a limited field survey of wetlands in the area. The evaluation examined such issues as the spatial distribution of current wetland types and historical wetland losses, the types of wetlands in the area with high ecological values, current and future pressures on wetlands in the area, the effectiveness of current wetland protection programs, and opportunities and methods for preservation and restoration activities. The results of the analysis are summarized here, and the full report on the analysis is included as Appendix E.

Wetlands historically were drained or filled for development as agricultural lands, urban use, or navigation projects, or simply to "reclaim" them. It has been estimated that approximately 90% of the original wetlands in the Green Bay area have been lost (WDNR, 1988). Most of the Green Bay wetlands are along the bay's western shore and comprise primarily emergent marsh, shrub/scrub, or forested habitat. In the Green Bay system, the coastal, floodplain, and headwater wetlands are particularly valuable because they can have substantial impacts on improving water quality and providing valuable habitat for a wide variety of plant and animal species.

In the last few decades, as awareness of the ecological importance of wetlands has increased, so have efforts to maintain the remaining wetlands. The regulatory system now in place requires authorization from the Army Corps of Engineers and compliance with state water quality certification programs and water quality standards for activities such as wetland filling. Additional protection is provided by shoreland-wetland zoning minimum standards, other coastal management requirements, and wetland restoration and preservation incentive programs such as the U.S. Department of Agriculture's "Swampbuster" program. Potential impacts to wetlands typically must be permitted, which usually requires delineation and characterization of the wetland and minimization of impacts. Mitigation is usually required for projects that cause impacts above a certain acreage threshold, typically 0.25 acre. The combined effect of these requirements has been to reduce the extent of wetland loss in the Green Bay ecosystem. Army Corps of Engineers data show that impacts to a total of 168 acres of wetlands were permitted by the Corps from 1991 through 1999 in the five Wisconsin counties that border Green Bay (Appendix E).

However, the current regulations do not prevent all wetland loss. Army Corps of Engineers permits are required only for wetland filling and not for wetland draining or excavation [40 CFR § 232]. Wetlands can be excavated to create ponds as part of residential or industrial development. Wetlands may be drained if draining alone allows for more intensive land uses, or if draining allows for future development of the area when it no longer meets the technical definition of a wetland. Furthermore, many small projects (e.g., culvert crossings, minor fill for driveway or roadway crossings, and dredging for docks) can have substantial indirect effects on wetlands through land use changes and edge disturbances. These types of indirect effects are particularly common along the west shore of Green Bay.

Wetland restoration strategy

Wetland restoration would help replace wetlands that have been lost. The ecological benefits of wetland restoration projects would begin immediately after project completion. Wetland restoration, which seeks to restore wetlands in areas where hydrological alterations have eliminated former wetlands, is generally much more effective than wetland creation, which seeks to create wetlands in areas that were not previously wetlands (Appendix E). Restoration is typically most effective when it is based on re-establishing the hydrological characteristics that had been eliminated (Appendix E). Therefore, the Co-trustees' wetland restoration strategy will target agricultural lands that are converted wetlands. Wetland restoration of agricultural fields typically involve plugging ditches, disrupting drain tile systems, and re-establishing wetland plants (Appendix E).

Agricultural lands in bay coastal areas or in river or stream floodplains are particularly desirable for restoration actions, as are lands that are adjacent to existing large or valuable wetlands. Restoration of these areas would provide particularly valuable wetlands and a significant enhancement of natural resources in the area. A preliminary analysis of land uses, soil types, surface hydrology, and land cover was conducted using a geographic information system (GIS) to help identify the potential amount and distribution of such lands in the Green Bay area. The results of the analysis, which are detailed in Appendix F, show that approximately 125,000 acres of agricultural lands in the counties bordering Green Bay lie on hydric soils and therefore may provide opportunities for wetland restoration. Although not all of these lands have the potential for restoration to wetlands, the analysis indicates that wetland restoration opportunities are plentiful. Areas within floodplains, within coastal areas, or adjacent to valuable natural areas will be targeted by the Co-trustees for restoration to wetlands.

Wetland preservation strategy

Wetland preservation is another important component of the Co-trustees' restoration strategy. Despite the existence of regulations designed to minimize additional wetland loss and impacts, such regulations typically do not address such threats as indirect impacts, cumulative small-scale impacts, surrounding land use changes, or wetland draining. Furthermore, reliance on regulations and policies does not necessarily provide for long-term preservation of valuable wetland habitat. As a result, wetland preservation offers a potentially effective approach for providing long-term ecological benefits in the Green Bay environment.

The Co-trustees' strategy for wetland preservation targets the following types of wetlands:

- *Coastal wetlands*. The Service's detailed survey of Green Bay coastal wetlands defines coastal wetlands as wetlands with water levels that are directly linked to the water level in the bay (U.S. FWS, 1993). These wetlands are important to the water quality and habitat of Green Bay, providing spawning and rearing habitat for fish, nesting and feeding habitat for birds, and many other functions such as wave energy dissipation, groundwater/surface water interaction, and suspended sediment and nutrient retention (Figure 3.4). These wetlands are under threats from the continued development of coastal areas. Of the remaining coastal wetlands, those that are relatively undisturbed or particularly valuable will be targeted for preservation. According to the detailed survey, there are approximately 14,300 acres of relatively undisturbed coastal wetlands and approximately 18,300 acres of disturbed coastal wetlands remaining (U.S. FWS, 1993). Surveys of fish communities show that the undisturbed coastal wetlands of Green Bay support more fish and a more diverse species assemblage than those wetlands that are disturbed (Brazner, 1997).

- *Wetlands in areas closer to more populated areas*. Preservation of wetlands in and around more populated areas can provide the greatest incremental benefit since they are the wetlands most likely to be impacted in the near future, and preserving them can provide direct use services to more people. Wetland preservation in these areas receives considerable attention from local and regional planning commissions. Based on an analysis of population density changes for the 1990s from U.S. Census data, areas of highest population changes are centered on the southern end of Green Bay (Appendix F). A total of approximately 58,600 acres of wetlands are found within the areas that contain the top 50% of population density growth rates, indicating the potential for wetland preservation in these areas. Specific types of wetlands in these areas, such as floodplain wetlands, may be targeted. More detailed delineations of wetlands under immediate or pending development pressure are available from regional, county, and municipal planning departments, and this information will be used by the Co-trustees in developing the post-award restoration plan.

- *Wetlands with high ecological value habitat or that support rare species.* Despite the tremendous loss of wetlands that has occurred around Green Bay, the area still contains wetland habitat of regional significance. Numerous ecologically valuable areas around the bay have been identified for priority conservation efforts. For example, The Nature Conservancy, in conjunction with federal, state, and local governments, nongovernmental organizations, and academic institutions, recently completed a comprehensive, scientifically based analysis of habitats and species within the Great Lakes Ecoregion, which stretches from Minnesota to southern Quebec (The Nature Conservancy, 1999).

Figure 3.4. Coastal wetlands along the western shore of Green Bay between Oak Orchard and Thomas Slough in the southern part of the bay. Photo credit: Ken Stromborg, U.S. Fish and Wildlife Service.

> This evaluation identified "portfolio sites" across the region as the focus of the organization's conservation efforts. A subset of the sites, the "priority portfolio sites," are those sites that are particularly important for conservation efforts because of the rarity or ecological value of the habitat and/or species at the sites. Several portfolio and priority portfolio sites within the Great Lakes Ecoregion are located in the Green Bay area, as shown in Figure 3.5. Many of these areas, which are primarily on the Door Peninsula in Wisconsin, Garden Peninsula in Michigan, and along the western and southern shores of Green Bay, include wetlands, placing them within the scope of the Co-trustees preservation targets (personal communication, M. Grimm, The Nature Conservancy, September 2000). These same general areas were identified as "critical coast wetland problem areas" that require conservation efforts in a study by the U.S. Geological Survey (Shideler, 1992). When the Co-trustees develop the post-award restoration plan, they will coordinate with organizations such as The Nature Conservancy and its partners to make use of the extensive work that has been conducted in identifying those sites in the Green Bay area that have high ecological value.

The primary methods that will be used for wetland preservation are land acquisition and land management for ecological objectives. These methods were identified by The Nature Conservancy and its partners as the most effective tools for wetland preservation. In addition to purchasing targeted wetland areas, land surrounding targeted wetland areas may also be purchased to minimize indirect impacts from adjacent development pressure. The Co-trustees will coordinate with local land conservation agencies and groups in conducting the land purchases, and anticipate that any lands purchased for preservation will be under the ownership of the local agencies or organizations. The Co-trustees emphasize that they are not seeking to be the owners of the lands purchased for preservation if ownership is possible through state or local governments, land trusts, or appropriate nongovernmental organizations. Land easements to allow for land management for ecological objectives may also be used, but easements may not always be successful, and the scope of the easements required for ecological management typically makes the easements nearly as expensive as outright land purchase (B. Bryant, U.S. Fish and Wildlife Service, personal communication, 2000).

In summary, the Co-trustees' strategy for wetland preservation will focus on coordinating with local agencies and organizations in acquiring and managing coastal wetlands, wetlands in areas of higher population growth, and wetlands of high natural quality. A preliminary analysis indicates that potentially tens of thousands of acres of these wetland types are available for preservation. Final selection of specific wetlands that would be preserved in the post-award restoration plan will include consideration of the ecological value of the wetland habitats, ownership/protection opportunities, geographic/ecological diversity, and local/regional planning and citizens' concerns.

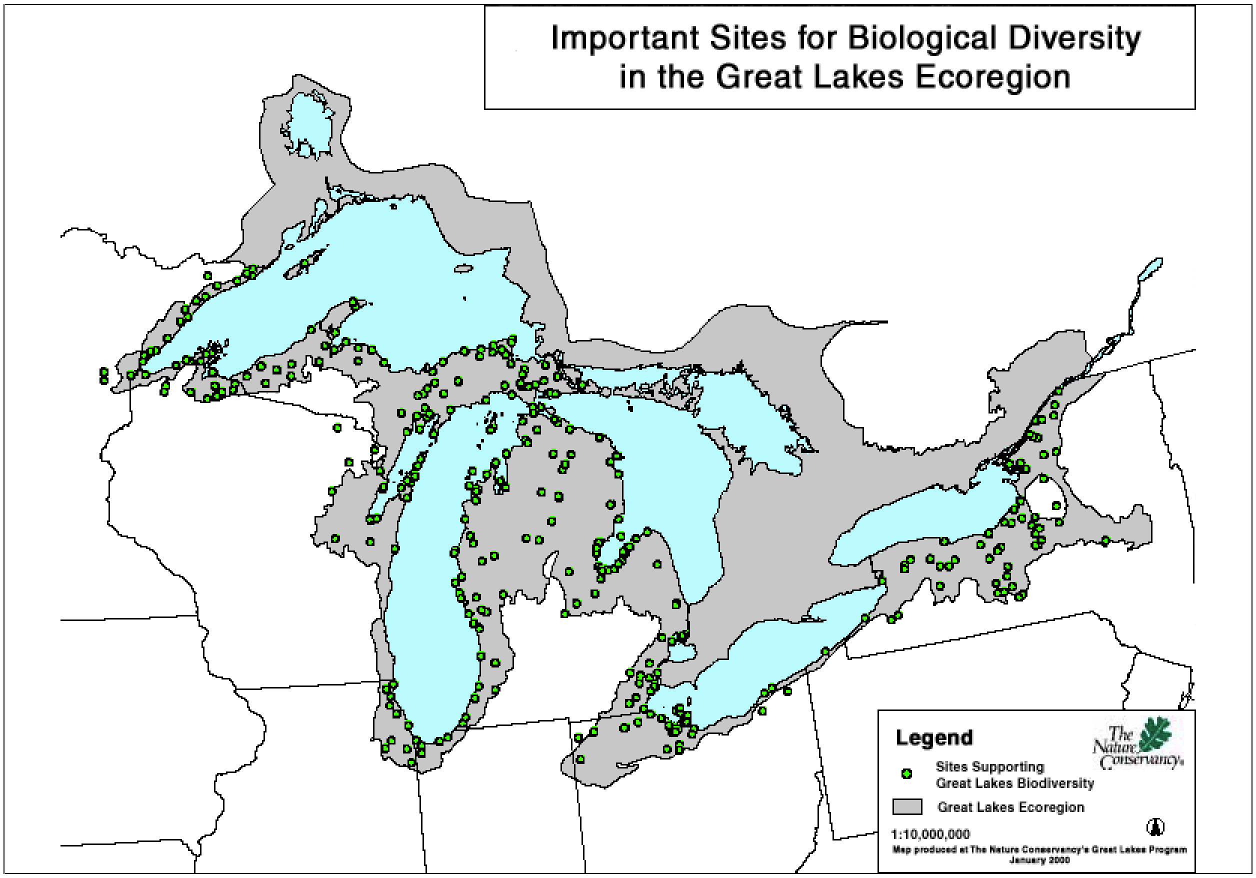


Figure 3.5. Locations of sites within the Great Lakes Ecoregion identified by The Nature Conservancy and its partners as being important for preserving biological diversity in the region. Note the density of sites around Green Bay, including on Door Peninsula and along the northern edge of the bay. Figure courtesy of The Nature Conservancy.

Strategy for a mixture of wetlands preservation and restoration projects

A final component of the Co-trustees' strategy for wetland preservation and restoration is how to combine the different possible actions into an overall restoration approach to estimate benefits and costs. Table 3.9 provides a general framework for how the Co-trustees will combine the different actions that constitute wetland preservation and restoration into an overall wetlands strategy. The final mixes of types of lands preserved, areas restored, and locations addressed will depend on how the wetland restoration and preservation actions are actually implemented in the field. The strategy described here is intended to provide guidance for the post-award restoration

Table 3.9. Co-trustees' general approach toward combining different components of wetlands actions.

Restoration project type	Approach for developing project mixes
Wetland restoration and preservation	3:1 ratio between acres of wetlands preserved and acres of wetlands restored
Wetland preservation	2:2:1 ratio between acres of coastal wetlands, acres of other high-quality wetlands, and acres of wetlands in more populated areas preserved
Coastal upland preservation (to help protect neighboring coastal wetlands)	9:1 ratio between acres of coastal wetlands and acres of coastal uplands preserved

plan, which will be more specific in how the actions will be implemented, and to provide a reasonable basis for estimating the benefits and costs of the actions.

One important aspect of the approach to wetlands actions is the relative emphasis on preservation of existing wetlands versus restoration of former wetlands. Several factors play a role in determining this relationship, including the types and timeframes of the ecological benefits that are likely to be provided by each type of action, the overall net benefits provided by each, the need and opportunities for each, and the degree to which the actions adequately address resource service losses caused by PCB injuries. On the one hand, the ecological services provided through wetland preservation may be greater than those provided by wetland restoration, since wetlands of high ecological services are being selected specifically for preservation. In general, restored wetlands are unlikely to provide this same level of service. Furthermore, the Co-trustees recognize that a sound overall wetland strategy for the Lower Fox River and Green Bay Environment should be based on wetland preservation, for if wetland losses are occurring, restoration without preservation of existing wetlands achieves little net benefit. On the other hand, the actual benefits of wetland preservation will not begin until the point in the future when the wetlands would have been lost had they not been preserved, whereas the benefits of wetland restoration begin much sooner. In addition, only through wetland restoration can the amount of wetlands, and therefore the total ecological benefits provided by wetlands, be increased over current levels. Given these factors, an acreage ratio of wetland preservation to wetland restoration of 3:1 will be used by the Co-trustees as guidance for the post-award restoration plan and for estimating benefits and costs. To compute the scale of benefits provided by wetlands preservation, we use the TVE result of diminishing marginal utility for added wetlands and apply the valuation functional form to wetlands preservation. As a result, the value of preservation of wetland acres at risk is substantially larger than the value of restoration of lost wetland acres, consistent with the Co-trustee preference for preservation.

For wetland preservation, a distribution of acres across the three types of wetlands that the Co-trustees will target for preservation (coastal wetlands, wetlands of high natural quality, and wetlands in more populated areas) must be selected. Based on the availability of the different types of wetlands around Green Bay and the relative importance of the ecological services provided, the Co-trustees will use an acreage ratio of 2:2:1 for coastal wetlands to other wetlands of high natural quality to wetlands in more populated areas as the general target for wetland preservation. In addition, in some cases the preservation of coastal wetlands will include the preservation of adjacent coastal uplands. The Co-trustees will target 1 acre of coastal uplands for preservation for every 9 acres of coastal wetlands that are preserved.

By combining wetland preservation with restoration, the Co-trustees' restoration will provide direct benefits to the fish, bird, and other natural resources of the Lower Fox River and Green Bay Environment that have been injured by PCBs.

Strategy for vegetated buffer strip installation and alterations in land-use practices to reduce nonpoint source runoff

Reducing the loadings of sediment and nutrients into Green Bay has long been the focus of environmental planning efforts in the area. Green Bay is under stress from excess sediment and nutrient loads (WDNR, 1988). High phosphorus loads stimulate the growth of blue-green algae, which causes the periodic algae blooms in inner Green Bay. When the blue-green algae die off, the decomposition process consumes oxygen and produces ammonia, making the water less habitable for some native fish species and more hospitable to species such as carp, which can survive in low-oxygen, high-ammonia waters. Furthermore, zooplankton, which are a primary food source of several fish species in Green Bay, prefer green algae over blue-green algae, so the stimulated algae growth does not fully contribute to the aquatic food chain. The excess algae growth and the total suspended solids (TSS) loads to the bay reduce water clarity and light penetration. Reduced light penetration means that submerged aquatic vegetation, which provides important habitat for many fish and waterfowl species, is unable to grow except in the most shallow waters. The lack of submerged vegetation in the inner bay has been cited as the cause for a decline in waterfowl use of the lower bay during spring and fall migration (WDNR, 1993). Decreased light penetration can also reduce the feeding success of sight-feeding fish such as sport fish like walleye and northern pike. Algae blooms can also reduce recreational services because the blue-green algae release a chemical when they die that can irritate people's skin and eyes on contact, and because of the foul odor produced during die-off.

Overall, these effects combine to reduce both the level and quality of the natural resource service flows provided by the waters of Green Bay. Thus, reducing nonpoint source loads is a means of enhancing natural resources that have been injured by PCBs through improving the ecological habitat and human use services of the bay.

Strategy for improving agricultural practices

Nonpoint source loadings of sediment and nutrients (particularly phosphorus) into Green Bay originate largely from agricultural fields around the bay (WDNR, 1988). For example, in the Duck, Apple, and Ashwaubenon Creek watersheds, approximately 95% of the total sediment load to watershed streams comes from cropland runoff (WDNR et al., 1997). Both Wisconsin and Michigan have well-established programs to improve agricultural practices to reduce nonpoint source pollution from rural areas. These programs have identified Best Management Practices (BMPs) which include cropland management practices that reduce loadings into adjacent streams and waterways. BMPs include actions such as contour farming, stripcropping, cropland protection cover, and conservation tillage. Of these BMPs, the Co-trustees will focus on conservation tillage to represent BMP improvements in cropland management to reduce nonpoint source pollution. Although other BMPs may be targeted as part of the post-award restoration plan, conservation tillage is used here to represent the benefits and costs associated with improvements in agricultural practices to reduce cropland erosion. Conservation tillage programs are a fundamental component of plans and efforts to reduce nonpoint source pollution into Green Bay (WDNR et al., 1993, 1997). Moreover, conservation tillage can provide collateral ecological benefits by providing cover for birds and small mammals and improved habitat quality for soil invertebrates (which, in turn, are fed upon by small mammals and birds).

In conservation tillage (also known as high residue management), tilling before planting is reduced or modified such that at least 30% of the field is covered with residue from previous crops (Figure 3.6). The most complete form is no-till, in which no tilling is conducted before planting. Other forms vary by the tilling practice and amount of residue left on the field. Conservation tillage can reduce TSS and phosphorus loadings from cropland by up to approximately 70% (Appendix G). Conservation tillage is commonly used on farms across the country, and it can provide other direct benefits to farmers such as reduced labor, tractor trips, and fuel consumption (R. Burton, Outagamie Land Conservation Department, personal communication, 2000).

Although programs to encourage or induce farmers to adopt conservation tillage have been in place in several counties around Green Bay for several years, many croplands in the area remain under conventional tillage. For example, 73% of the cornfield acres within the Wisconsin portion of the Green Bay drainage are still under conventional tillage, according to a 1999 survey (see Appendix H). Thus there are many opportunities to expand the existing conservation tillage programs, which exist for only a few of the watersheds.

The strategy for inducing farmers to adopt conservation tillage is to provide incentive payments for converting conventional tillage land to low tillage. This strategy is the same as the strategy that has been employed by county and tribal land conservation departments with success. Typically, incentive payments are required for a limited number of years initially, and once

Figure 3.6. Example of a farm field under conservation tillage practice. Note the crop residue remaining on the field. Photo from http://www.purdue.edu/UNS/html4ever/9802.Evans.notill.html.

farmers have adopted and become accustomed to conservation tillage practices, the need for continuing incentive payments is reduced (R. Burton, Outagamie Land Conservation Department, personal communication, 2000). Education and outreach to farmers are also seen as significant components of a successful conservation tillage program (R. Burton, Outagamie Land Conservation Department, personal communication, 2000).

The Co-trustees will coordinate closely with county and tribal land conservation departments in implementing a program to increase conservation tillage. Some of these departments, particularly those of Brown County, Outagamie County, Winnebago County, and the Oneida Reservation, have active programs already in place. The Co-trustees will work with these departments to make full use of their experience and institutional knowledge. In this way, a conservation tillage program can provide a coordinated and cost-effective means of reducing TSS and phosphorus loadings into Green Bay, thereby improving the ecological and human use services provided by the bay's resources.

Strategy for vegetated buffer strips

In many areas around Green Bay, fields are tilled and planted right up to stream edges, or right across ephemeral drainageways that run through fields. As a result, runoff generated from the fields has a direct route into the stream or drainageway. The installation of buffer strips along streams that run through agricultural areas has been shown to be an effective means of reducing the loadings of sediment and nutrients to streams (Appendix I). These strips can capture sediment and nutrients coming from the fields before they reach the streams, and can reduce erosion of streambanks. Figure 3.7 shows an example of a field before and after installation of a vegetated buffer strip, and Figure 3.8 provides another example of an installed buffer strip.

In addition to reducing nonpoint source pollution loadings from cropland, buffer strips can also provide valuable direct habitat benefits. The streambank stabilization caused by the roots of the vegetation used in the buffer strip helps to decrease the formation of erosion gullies (Kittle, 1999) and to maintain stream geometry, thereby enhancing stream habitat for fish and macroinvertebrates (Gilliam et al., 1997). The vegetative cover of the buffer strip can provide wildlife nesting and feeding habitat (U.S. EPA, 1993). Buffer strips may also provide connecting corridors that enable wildlife to move safely from one habitat to another (NRCS, 2000). These collateral benefits provided by vegetated buffer strips are consistent with the overall Co-trustee restoration criteria and goals.

The Co-trustees' strategy for buffer strip installation is based on the strategy currently being used by the Brown County Land Conservation Department to implement their buffer strip program (W. Hafs, Brown County Land Conservation Department, personal communication, 2000). Brown County pays landowners a fee of $500 per converted acre as an incentive for converting plowed land to buffer strips. Because of Brown County's buffer strip ordinance, the conversion to a buffer strip is perpetual and runs with the land deed (W. Hafs, Brown County Land Conservation Department, personal communication, 2000). Thus the incentive fee acts similarly to the purchase of a land easement from farmers for the areas converted from agriculture to buffer strip. Active restoration is then conducted, which typically consists of planting and maintaining natural vegetation in the strip.

3.2.7 Estimating benefits of the preferred alternative for scaling purposes

As described in Section 3.2.5, scaling the preferred restoration alternative is accomplished through value-to-value equivalency, which determines the level of restoration required to compensate the public for the injuries to natural resources by determining the value to the public of the environmental services gained through restoration. Thus, a key component of the scaling process is estimating the environmental benefits that will be achieved through restoration for use

Figure 3.7. Example of a drainageway before (top) and after (bottom) installation of a vegetated buffer strip. Photo courtesy of William Hafs, Brown County Land Conservation Department.

Figure 3.8. **Example of an installed buffer strip.** Photo courtesy of William Hafs, Brown County Land Conservation Department.

in conjunction with the TVE study results. This section describes how the environmental benefits of the preferred alternative components (wetland restoration, wetland preservation, and nonpoint source pollution control through conservation tillage and vegetated buffer strips) will be estimated for the purposes of restoration action scaling.

Estimating benefits of wetland restoration and preservation

The environmental benefits provided by both wetland restoration and wetland preservation will be expressed as acres of wetlands restored or preserved. However, there are two underlying factors that require consideration and may influence the total amount of wetland actions taken: differences in the environmental services provided by different wetlands, and the time span over which the benefits of wetland preservation accrue.

Different wetlands can vary dramatically in the levels of environmental benefits they provide, such as floodwater retention, sediment and nutrient trapping, energy and carbon cycling, and plant and wildlife habitat. The TVE study (Section 3.2.5) is based on the assumption that the types and magnitude of environmental benefits provided by restoration actions are at least similar to those provided by wetlands that exist today or have been lost in the past. Several methods are available for quantifying these services which could be used to provide a metric for comparing the benefits provided by different wetlands. Such methods include those for quantifying functional benefits, such as the U.S. Army Corps of Engineer's hydrogeomorphic classification system (Brinson, 1993); those for quantifying benefits for particular fish or wildlife species, such as the Service's Habitat Evaluation Procedures (U.S. FWS, 1980); and those for quantifying economic benefits (Bardecki, 1998). The Co-trustees may use these or other procedures as part of the post-award restoration plan to assist in identifying specific targets or priorities for wetland restoration or preservation beyond those developed in the previous section. However, at this point in the restoration planning process the Co-trustees are not including a quantitative estimation of wetlands benefits as part of the scaling process, and wetland benefits will be expressed simply as acres restored or preserved. The Co-trustees recognize that restored wetlands may not provide the same level of ecological services as do the wetlands that would be targeted for preservation. This fact is taken into account in how the Co-trustees may combine wetland preservation and restoration in the preferred restoration alternative.

A second factor to consider in estimating the benefits provided by wetland restoration or preservation is the timeframe over which the benefits accrue. The benefits provided by wetland restoration would begin soon after restoration actions are completed. The flow of benefits would follow the development of the restored wetland into a fully functional system, which, if the restoration effort is successful, can take from several years to several decades (D'Avanso, 1990). In contrast, the benefits of wetland preservation do not begin until the time at which the wetland would have been lost or degraded had preservation not taken place. Since the wetlands being preserved already exist, preservation provides additional benefits only if and when the wetland benefits would have been otherwise lost. Estimating the time period over which preservation benefits accrue is difficult given the general success of existing regulation in at least slowing down wetland loss. However, it is probable that many wetlands would not face significant human impacts for decades to come, and certainly at a time much farther into the future than when the benefits of wetland restoration begin. Since benefits that occur in the future are discounted to convert to present-value amounts, this means that a higher quantity of wetland preservation is required than wetland restoration to provide the same level of benefits (assuming that restored wetlands are of equal ecological value). For example, using a discount rate of 3% to convert future to present-value benefits, if it is assumed that wetland restoration benefits begin in 5 years and wetland preservation benefits begin in 20 years, then 15,600 acres of wetland preservation would be required to yield the benefits provided by 10,000 acres of wetland restoration (all other factors being equal).

In conclusion, the benefits of wetland restoration and preservation will be quantified in terms of acres restored or preserved. Measures of wetland benefits may be used as part of the post-award restoration plan to rank or compare different wetlands. Finally, more acres of wetland preservation may be required to provide the same level of benefits as wetland restoration, since the benefits of wetland restoration begin soon after project completion whereas the benefits of preservation do not begin until the time when the wetlands would have been lost or degraded.

Estimating loadings reductions from conservation tillage and buffer strips

The environmental benefits provided by conservation tillage and vegetated buffer strips can be expressed as the estimated reduction in TSS and phosphorus loads to Green Bay. These reductions in loads can also be translated into corresponding increases in water clarity and reductions in algae growth, which are the two parameters used in the TVE study to express the benefits of controlling nonpoint source pollution. A GIS-based modeling approach was used to provide an initial estimate of the reductions in loads that would result from improving tillage practices and installing riparian buffer strips in the Green Bay basin (Appendix H). The approach presented here represents a reasonable and reliable approach for the purposes of the RCDP. In developing the post-award restoration plan, the Co-trustees may work with state and local experts and land conservation personnel to develop alternative approaches that can provide better input into identifying specific parcels of land or restoration actions and more precise estimates of the benefits that can be achieved.

Estimating current loads of TSS and phosphorus to Green Bay

The first step in evaluating the effectiveness of nonpoint source pollution reduction programs is to model the loads of TSS and phosphorus into Green Bay under current land management practices. Estimates of load reductions under altered land management practices (conservation tillage, riparian buffer strips) can then be estimated by altering the model.

A model of current loads was developed for the Co-trustees by Fox Wolf Basin 2000, and is described in detail in Appendix G. The model takes into account such factors as land cover type, soil characteristics, climate, topography, and current tillage practices to estimate loadings to Green Bay from each of the watersheds shown in Figure 3.9. Only watersheds within Wisconsin were included because the GIS data layers for conducting the analysis are only available for Wisconsin, and because the Wisconsin Green Bay tributaries contribute the large majority of the nonpoint pollution loadings into Green Bay. For example, 90% of total organic phosphorus loading into Green Bay in 1989 from major tributaries was from Wisconsin tributaries, compared to just 10% from Michigan tributaries (Fitzpatrick and Myers, 2000).

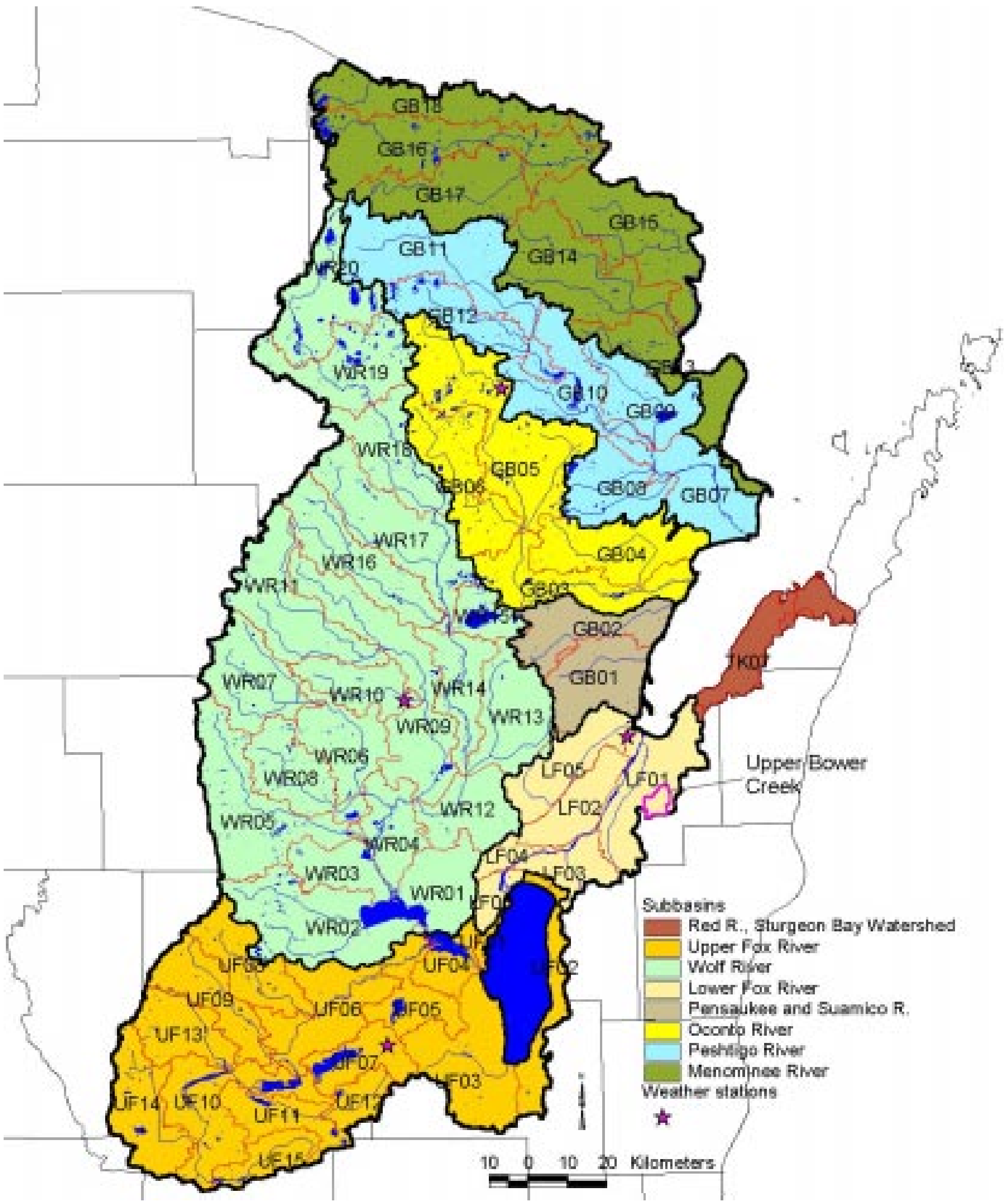


Figure 3.9. Watersheds included in the analysis of TSS and phosphorus loadings to Green Bay.

The results of the analysis of current runoff loads are presented and discussed in detail in Appendix G. Nonpoint source runoff delivers approximately 136,000 metric tons of sediment per year and 643,000 kg of phosphorus per year to Green Bay. The watersheds that produce the highest runoff loadings tend to be those in the Lower Fox River and lower part of the Upper Fox River drainages, such as the East River watershed, the Plum and Kankapot creeks watershed, the Lake Winnebago East watershed, the Fond du Lac River watershed, and the Duck Creek watershed. These results are used as the starting point from which reductions in loadings that result from conservation tillage practices and riparian buffer strips can be estimated.

Estimating reductions in loadings from conservation tillage practices

Appendix H describes the methods used to estimate the reductions in loadings from a basin-wide conservation tillage program. The method is based on the relative effectiveness of different tillage practices to lower the amount of TSS and phosphorus runoff generated from croplands, applied to the acres within each watershed that would fall into cropland tillage categories after implementation of a program to improve tillage practices. The method incorporates an assumption of a less than complete level of farmer participation in the program.

The results are shown in Table 3.10 for phosphorus load reductions under different levels of implementation and for different numbers of watersheds in which a conservation tillage program is enacted (results for TSS reductions are similar). If conservation tillage is adopted within all watersheds and farmer participation is 75%, then approximately 910,000 acres of cropland within the Green Bay basin would be converted from more conventional tillage practices to conservation tillage. This would result in an approximately 26% reduction in phosphorus loads to Green Bay. A slightly higher number of acres converted (997,000) and percent phosphorus load reduction (29%) can be achieved if 85% farmer participation is assumed. By applying conservation tillage practices across watersheds according to the amount of reduction achieved per acre converted, implementation on only 303,000 acres achieves a phosphorus loading reduction of 15%.

Estimating reductions in loadings from installing vegetated buffer strips

Appendix H describes how the loadings reductions from installing vegetated buffer strips along streams are estimated. In general, buffer strips are assumed to be installed in areas that are currently under agricultural production within 15 m of waterways. Buffer strips reduce watershed loadings into Green Bay by both capturing a portion of the loadings in runoff that enter the buffer strip and by generating much less loadings than active agricultural fields. The analysis assumes that buffer strips are effective at capturing only the loadings that are generated within 90 m of the upgradient edge of the strip, since loadings generated from farther away are assumed to reach a buffer strip as channelized flow (Appendix I). For the loadings generated

Table 3.10. Estimated reductions in phosphorus loadings to Green Bay under different implementation levels of conservation tillage.

Acres converted to conservation tillage[a]	**Estimated percent reduction in phosphorus loadings to Green bay**
997,000[b,c]	29.0
910,000[c,d]	26.0
501,000[d]	20.0
303,000[d]	15.0
169,000[d]	10.0

a. Conservation tillage is defined as mulch till or no till/ridge till; total includes corn and soybean crops.

b. Assumes maximum of 85% of lands in conventional till are converted to conservation tillage.

c. Conservation tillage scenario is applied to all Green Bay watersheds.

d. Assumes maximum of 75% of lands in conventional till are converted to conservation tillage.

from within 90 m of buffer strips, buffer strips are assumed to be 35% effective at reducing phosphorus loads (Appendix I).

The estimated reductions in phosphorus loadings to Green Bay under different levels of buffer strip installation are shown in Table 3.11. At levels of implementation that are less than 100%, we assume that buffer strips are installed in only the watersheds where the highest level of reduction is achieved per acre of buffer strip installed. Thus, for example, to achieve 50% of the phosphorus reduction that is achieved at a full implementation level, only 23% of the potential buffer strip acres need be converted. This approach allows for a cost-effective way of combining different levels of buffer strip installation with different levels of conservation tillage programs to achieve a given level of loadings reduction.

Estimating increases in Green Bay water clarity

The Co-trustees' TVE study is based on expressing the benefits of nonpoint source pollution reductions in terms of increases in Green Bay water clarity and reduction in algae. Reductions in nonpoint source loadings to Green Bay are translated to corresponding increases in water clarity using the relationship between phosphorus and water clarity that has been measured in Green Bay (Appendix H). Table 3.12 shows the relationship between percent reduction in phosphorus to Green Bay and number of inches of increased water clarity that will be used to express nonpoint source pollution reduction benefits. The method being used is based on (1) the relationship between phosphorus concentrations and water clarity in Green Bay that has been measured from 1991 through 1997 by the Green Bay Metropolitan Sewerage District, and (2) the

Table 3.11. Percent reductions in phosphorus loadings to Green Bay under different levels of buffer strip implementation.

Acres converted to vegetated buffer strips[a]	Percentage of potential Green Bay watershed acres converted	Estimated percent reduction in phosphorus loads to Green Bay
52,745	100	4.1
32,900	62	3.5
23,900	45	3.0
17,300	33	2.5
12,300	23	2.0
8,500	16	1.5
5,250	10	1.0

a. Assuming that conversion is conducted in the most cost-effective watersheds first.

Source: Appendix H.

Table 3.12. Increases in Green Bay water clarity with reductions in phosphorus loadings.

Percent reduction in phosphorus runoff loadings into Green Bay	Resulting water clarity[a] (inches)
4.0	21.0
8.0	22.0
12.0	23.0
16.0	24.2
20.0	25.3
24.0	26.5
28.0	27.8
32.0	29.1

a. Initially 20 inches.

relationship between changes in Green Bay phosphorus loadings and water concentrations used in the Green Bay Mass Balance Study (Bierman et al., 1992; DePinto et al., 1994; Fitzpatrick and Meyers, 2000; Hydroqual, 1999; LTI Environmental Engineering, 1999). More detailed and comprehensive analyses may be conducted as part of the post-award restoration plan, depending on the scale of nonpoint source pollution reduction programs actually implemented and the need for additional precision.

3.2.8 Costing methods

The final claim for damages that will be prepared by the Co-trustees will include the cost of implementing the preferred restoration alternative as one of its components. This section describes the different cost elements of the preferred restoration alternative.

Each component of the preferred restoration alternative has multiple cost elements. These elements include direct costs (costs that are attributable to the specific restoration action) and indirect costs (costs that cannot be attributed to the actions themselves, such as overhead) [43 CFR §11.83(b)(1)]. The direct and indirect cost elements for each type of restoration action are summarized in Table 3.13.

Table 3.13. Cost elements for each selected restoration action.

	Direct costs						Indirect costs
	Land acquisition/easements						
Restoration action	Land value	Transaction costs	Restoration actions	Project maintenance	Contingency	Monitoring	Co-trustee overhead
Wetland restoration	X	X	X	X	X	X	X
Wetland preservation	X	X				X	X
Conservation tillage practices			X			X	X
Riparian buffer strip installation	X	X	X	X	X	X	X

Table 3.14 lists the different costing methodologies specified in 43 CFR § 11.83(b)(2) that will be used by the Co-trustees for each of the cost elements. The goal of applying the various cost estimating methods is to develop a reasonable estimate of how much it will cost to implement the preferred alternative.

Land acquisition costs

Land acquisition costs include two direct cost components: the land purchase price and the costs associated with planning, negotiating, and conducting the land transaction (transaction costs). Transaction costs are estimated as a percentage of the land acquisition costs. Based on the Service's experience with land acquisition programs, transaction costs are typically 20% of the

Table 3.14. Costing methodologies for the different cost elements.

	Direct costs						Indirect costs
	Land acquisition						
Costing methodology	Land value	Transaction costs	Restoration actions	Project maintenance	Contingency	Monitoring	Co-trustee overhead
Unit methodology	X		X	X			
Standard time data methodology			X				
Factor methodology		X			X	X	
Indirect rate application							X

purchase price (B. Bryant, U.S. FWS — Great Lakes Regional Office: Land Acquisition Supervisor, personal communication, 2000).

The Co-trustees generated a general cost estimate of land prices to derive land value cost estimates for different types of land in the counties surrounding Green Bay. The general cost estimate, produced by Ritter Appraisals, Inc., is based on three sources of information: (1) a detailed review of 1998 and 1999 transaction records and listed prices for parcels greater than 40 acres in the following five counties: Brown, Door, Marinette, Oconto, and Outagamie; (2) 1998 sales summary data organized by land use class from the Wisconsin Department of Revenue; and (3) conversations with local realtors. A copy of the general cost estimate report is included as Appendix J. Although the general land cost estimate was conducted based on data for only five counties in Wisconsin, the counties included in the analysis represent a mix of urban and rural areas that border or are near Green Bay. Therefore, the average land price estimates developed from these five counties are assumed to be representative of the other Wisconsin and Michigan counties where restoration actions may take place.

Land cost estimates were developed on a per acre basis for the following types of land:

- agricultural lands, with separate estimates for lands sold for continued use as agricultural land and for lands sold for diverting use
- wetlands, including separate estimates for inland wetlands, bay/coastal wetlands, and inland wetlands along stream or river waterfronts
- bay coastal uplands and uplands along stream or river waterfronts.

In addition, the general cost estimate includes a qualitative analysis of how factors such as parcel size, road access, and location within a county influence the average land value.

Table 3.15 shows the results of the general cost estimate for the types of lands relevant to the RCDP cost analysis. The results shown are the per acre cost for each type of land, weighted across Green Bay counties by the amount of available land with the potential for restoration or preservation within each county. For example, to obtain the value of $3,000 for agricultural land on hydric soils, the average value within each county was weighted by the acres of agricultural land on hydric soil within that county, relative to the total number of such acres across all the counties. Table 3.15 includes the underlying basis used to calculate the weighted average for each of the land types.

Table 3.15. Estimated overall average land purchase prices based on weighting individual county average prices.

Type of land	Basis for weighting costs across counties	Weighted average cost (per acre)
Agricultural land for restoration to wetlands	Distribution of agricultural land on hydric soils (Appendix F)	$3,000
Coastal wetlands for preservation	Distribution of coastal wetlands (Appendix F)	$1,300
Uplands (as a buffer for coastal wetlands)	Distribution of coastal wetlands (Appendix F)	$1,600
Natural area wetlands for preservation	Distribution of The Nature Conservancy portfolio sites[a]	$1,000
Inland wetlands for preservation around urban areas	Distribution of population density growth (Appendix F)	$1,300

a. Assumed to be 50% in Door County and 50% in Marinette and Delta counties, based on Figure 3.5.

Again, the Co-trustees wish to emphasize that they are not seeking to be the owners of any purchased land, and anticipate that such land would be under the ownership of local land conservation groups and/or agencies.

Active restoration costs

Active restoration costs include costs for restoring wetlands, converting farmland to conservation tillage, and installing vegetated buffer strips. The active restoration costs that will be used in developing the overall cost estimate are shown in Table 3.16. Descriptions are provided below, and details are provided in Appendix K.

Table 3.16. Active restoration costs.

Type of restoration action	Unit cost
Restoration of farmland to wetland	$2,600/acre
Conservation tillage	$90/acre
Riparian buffer strip installation	$240/acre

Source: Appendix K.

Restoring farmland to wetlands typically requires active restoration work such as plugging ditches, destroying drain tile, and seeding or planting wetland plants. The cost estimates for wetland restoration are based on unit cost estimates for the types of activities typically required. An average cost of $2,600 per acre of agricultural land restored to wetlands is used to estimate the direct cost of wetland restoration.

The direct restoration costs for implementing conservation tillage practices include two components: incentive payments to farmers to adopt the new tillage practices, and transaction costs associated with contacting, educating, and negotiating with farmers. Incentive payment costs and transaction costs are based on the current programs of Winnebago and Outagamie counties. Typical total costs for the conservation tillage program are approximately $90 per acre converted to conservation tillage, assuming that four years of performance-based payments are required for farmers to permanently adopt conservation tillage practices.

The cost element estimates for the installation of vegetative buffer strips are based on unit cost estimates from the Brown County Land Conservation Department, which has experience in installing vegetated buffer strips. The types of activities typically required to install buffer strips include removing stones, plowing, harrowing, and seeding. A value of $240 per acre of buffer strip is used to estimate these costs.

Project maintenance costs

Restored wetlands and vegetated buffer strips typically require a limited amount of ongoing maintenance. Restored wetlands typically require activities such as prescribed burning and/or mowing to maintain a dominance of desirable wetland plant species. Assuming that maintenance activities are required every 3 years, $590 per acre is required to fund the maintenance for 25 years (Appendix K).

Vegetated buffer strip maintenance activities generally consist of annual mowing, occasionally reseeding the buffer strip, and filling in gullies and other concentrated flow paths that have developed over time. Assuming that some of these activities (e.g., mowing) are conducted every year and others are conducted every 5 years, $1,100 per acre is required to fund maintenance for 25 years (Appendix K).

Contingency

Contingency costs are included to cover unexpected costs not incorporated in the other cost element estimates. Contingency costs will be estimated as a percentage of the total of the other direct costs and will be applied only to wetland restoration and vegetated buffer strip installation, the activities that require engineering and construction related work. The Co-trustees anticipate using a contingency cost rate of 10%, based on standard contingency rates (U.S. Army Corps of Engineers and U.S. EPA, 2000).

Restoration monitoring

A direct cost element that is associated with all of the components of the preferred restoration alternative is monitoring. The restoration actions that will be conducted by the Co-trustees must be monitored to determine the degree to which the actions achieve the restoration scaling goals. In addition, monitoring will provide ongoing evaluation of any maintenance activities that should be added or modified for the projects to achieve their goals. Monitoring will be conducted according to a monitoring plan developed by the Co-trustees as part of the post-award restoration plan.

Monitoring costs will be estimated as a percentage of the total restoration costs. Based on general experience, the Co-trustees estimate that monitoring costs will be approximately 5% of the total of land value, land transaction, restoration action, and project maintenance costs.

Improvement to park facilities

In addition to the four preferred types of restoration actions (wetland restoration, wetland preservation, conservation tillage, and vegetated buffer strip installation), the Co-trustees have also developed cost estimates for improving existing park facilities in the Green Bay area (Appendix K). Improvements to existing park facilities is one of the types of restoration actions considered in the Co-trustees' TVE assessment and for which scaling measurements are available. Although the results of the TVE assessment demonstrate that improvements to existing parks are not highly valued by the public compared to the other potential restoration actions, cost estimates for park improvements are developed to allow the Co-trustees flexibility in the selection of restoration components.

The cost of improving existing park facilities is estimated based on an incremental increase in the current costs allocated to existing park facilities in the Green Bay area. The current annual budgets for the county Parks and Recreation Departments and the specific state parks in the area were compiled to provide an estimate of current costs for these parks. The results are shown in

Table 3.17. A total of approximately $9.4 million is currently spent annually on county and state park facilities within the area. The cost of improving these parks will be estimated based on a percentage increase in this annual amount spent on the parks. For example, the cost of a 10% improvement in existing park facilities (one of the restoration levels assessed in the TVE study) is estimated as $940,000 annually, not accounting for inflation. Over 25 years this amounts to a total estimated cost of $24.0 million.

Table 3.17. Estimated current average annual costs for county and state parks in the Green Bay area.

Type of park	Estimated annual costs for provision of baseline recreational services (millions 2000$)
County	$7.2
State	$2.2
Total	**$9.4**

Indirect costs

Indirect costs include Co-trustee agency overhead costs associated with implementing the preferred restoration alternative. Indirect costs will be estimated using an indirect cost rate for overhead costs [43 CFR §11.83(b)(1)(iii)]. The Co-trustees will use the standard indirect rates of the Service and the Department for projects of a nature similar to the preferred alternative. The standard indirect rates for the Service and Department are:

- 22% Service overhead for project costs incurred within Region 3 of the Service, which includes Wisconsin and Michigan (Blankenship, 1992)

- 16.84% Department overhead for project costs incurred within the Service's regions (Frank Horvath, U.S. FWS, personal communication, 2000).

Therefore, a total overhead rate of 38.84% is used by the Co-trustees to estimate indirect costs.

Summary

Table 3.18 presents an example of the estimated overall average unit costs for each cost component of the four types of restoration actions. Many factors may affect the actual unit costs at the time of final plan implementation, including exact project location, attitudes of current landowners, and the specific restoration and maintenance actions required. The values shown in Table 3.18 are intended to represent reasonable estimates of the overall average costs for each of the cost elements.

Table 3.18. Examples of estimated overall average unit costs.

	Direct costs ($/acre)						Indirect costs ($/acre)	
	Land acquisition (per acre)							
Restoration action	**Land value**	**Transaction costs (20%)**	**Restoration actions**	**Project maintenance (present value)**	**Contingency on restoration actions (10%)**	**Monitoring (5%)**	**Co-trustee overhead (38.84%)**	**Total costs ($/acre)**
Wetland restoration	3,000	600	2,600	590	260	340	2,900	$10,300
Wetland preservation — coastal wetlands	1,300	260	n/a	590	n/a	110	880	$3,100
Wetland preservation — coastal uplands	1,600	320	n/a	n/a	n/a	100	780	$2,800
Wetland preservation — other high quality natural areas	1,000	200	n/a	590	n/a	90	730	$2,600
Wetland preservation — wetlands in more populated areas	1,300	260	n/a	590	n/a	110	880	$3,100
Conservation tillage	n/a	n/a	90	n/a	n/a	5	40	$140
Vegetated buffer strips	500	100	240	1,100	20	100	800	$2,900

3.2.9 Combining restoration projects in the preferred alternative

The final component of the Co-trustees' restoration plan is defining the amounts of the different general classes of restoration actions that will, together, constitute the preferred alternative. This section describes the Co-trustees' overall approach to defining the preferred mix of project types, and provides representative examples of total restoration costs for different possible combinations. The final mix of project types will be defined in the post-award restoration plan.

The Co-trustees' TVE study is used to assist in defining the scale of restoration required to compensate the public for natural resource injuries and service losses through different possible combinations of the three general project categories (increasing wetland acreage, reducing nonpoint source pollution, and improving existing park facilities). Through these three types of restoration actions, the public can be made whole for the continuing and future PCB injuries to natural resources. The Co-trustees considered the following factors in determining the relative amount of the three restoration project types that constitute the preferred alternative:

- *Natural resource restoration is preferred over outdoor recreational facility improvements.* Park improvements scored much lower against the Co-trustees' criteria than resource-based actions of wetlands preservation/restoration and nonpoint source pollution reduction. This preference is also supported by the results of the TVE study, which demonstrate the public's preference for natural resource actions over outdoor recreational enhancements.

- *A mix of project types is preferred*. Co-trustees prefer a mix of natural resource restoration actions to provide a broad array of natural resource services throughout the Lower Fox River and Green Bay Environment and to enhance a select group of outdoor recreational activities that have benefits to local communities. Thus, a variety of natural resource and public goals are supported, rather than just one type of goal. Selecting a mix of project types allows for more flexibility to develop a cost-effective restoration plan, and may be necessary to provide the full amount of services of equal value to those lost under some PCB remediation scenarios.

- *There are technical limitations on the maximum amount of each restoration type that is reasonably possible to implement.* The preceding sections describe the limits on the maximum amount of TSS and phosphorus loading reductions that are possible through conservation tillage and buffer strip installation. There are also limits on the total wetland acreage available for preservation, and on the extent to which existing park facilities can be improved.

- *The scale of restoration required affects the project mix.* The less extensive the response agencies' PCB cleanup, the larger the magnitude of restoration required to compensate the public for losses (because service flow losses will continue longer). The relative mix of project types selected may change as the overall amount of restoration changes, because of practical limits on implementation of specific project types or because of cost considerations.

- *Cost-effectiveness.* The TVE study observed diminishing marginal value with increasing levels of any one type of restoration (other than PCB removal), indicating that a mix of actions is preferred to cost-effectively produce service flow benefits. Furthermore, the cost-effectiveness of actions to reduce nonpoint source runoff may decrease as the amount of the actions increases (since the most cost-effective watersheds and sites will be addressed first).

Table 3.19 lists illustrative examples of mixes of restoration actions, including different combinations of preserving and restoring wetlands, increasing water clarity through conservation tillage and buffer strips, and improving existing park facilities. These examples illustrate the types of combinations that will be considered by the Co-trustees under different possible remediation scenarios and timeframe of continuing injury. Estimated costs for each of the combinations are also provided. The table shows that if intensive remediation is conducted and baseline levels are achieved within 20 years, restoration costs are less than if intermediate remediation is conducted and PCB injuries continue for 40 years. The examples shown in the table are illustrative only to demonstrate the types of project mixes and associated costs that will be considered by the Co-trustees as part of the post-award restoration plan. However, as described previously, cost is not the only factor in selecting the mix of project types to be implemented.

The combinations of wetland preservation, wetland restoration, reduced nonpoint source runoff through improved tillage practices and riparian buffer strips, and improved park facilities will provide a broad array of environmental benefits, from improving habitat for birds, fish, and other biota to increasing bay water clarity to enhancing recreational opportunities. These actions will compensate for the resources and services lost because of PCB injuries by providing valuable environmental benefits to the Lower Fox River and Green Bay Environment.

Table 3.19. Illustrative examples of project mixes and total restoration costs under different time periods of injury.

Nonpoint source runoff reduction			Wetlands			
Vegetated buffer strip (acres)	Cropland converted to conservation tillage (acres)	Resulting water clarity (inches, from 20 inches initially)	Acres preserved	Acres restored	Percent improvement in park facilities	Total cost (millions)
For PCB injuries from 0 to 20 years into the future (intensive remediation)						
5,500	106,000	22.0	8,700	2,900	10	$111
12,000	254,000	24.0	7,800	2,600	5	$133
23,500	477,000	26.0	6,900	2,300	5	$191
For PCB injuries from 0 to 40 years into the future (intermediate remediation)						
12,000	254,000	24.0	9,900	3,300	10	$158
23,500	477,000	26.0	9,000	3,000	10	$216
23,500	852,000	28.0	8,700	2,900	10	$268

3.3 Compensable Value Determination

The Co-trustees conducted an assessment of the compensable values of recreational fishing service flow losses to the public (referred to as recreational fishing damages) as a result of releases of PCBs into the waters of Green Bay. The assessment was based on existing literature and data, as well as data from a new survey of recreational anglers, to identify and quantify impacts of the PCB contamination on recreational fishing through time. A report detailing the approach, methods, results, and conclusions of the assessment was published in November 1999 (U.S. FWS and Stratus Consulting, 1999f). A summary of the report is provided here.

The assessment determines total recreational fishing damages, including damages for both past interim losses and current and future losses. However, as described in Section 3.1 of this RCDP, the Co-trustees have selected the compensable values from recreational fishing losses for use in calculating only the past interim damages, and current and future damages will be calculated as restoration costs. Nevertheless, the current and future damages for recreational fishing losses that were determined in the Co-trustees' assessment are included here to provide a comparison with the results of the TVE study that addresses current and future losses of all services (Appendix A).

3.3.1 Methods

Area addressed

The recreational fishing damages assessment assessed losses for all waters of Green Bay, including the bays within Green Bay (e.g., Little and Big Bays de Noc, Sturgeon Bay), and all rivers feeding into Green Bay up to the first dam or obstruction, including the Lower Fox River from the dam at De Pere to Green Bay. The entire waters of Green Bay are included because there are PCB fish consumption advisories (FCAs) for the entirety of Green Bay, including its tributaries. Thus, the PCBs released into the Lower Fox River result in service losses, and therefore damages, throughout the waters of Green Bay. While PCBs from the Lower Fox River are transported to the waters, sediments, and natural resources of Lake Michigan, this assessment does not address any recreational fishing service flow losses from the release of PCBs into Lake Michigan outside of the waters of Green Bay.

Types and measures of service flow losses considered

The assessment estimates the value of recreational service flow losses (e.g., damages) resulting from the imposition of FCAs in response to PCB contamination in the assessment area. While fish populations may be injured by PCBs, resulting in recreational fishing service flow losses through reduced catch rates, these injuries have not been quantified and are not included in the valuation of recreational service losses. However, the assessment methods and results are designed to compute the value of service flow benefits from increased catch rates if increasing catch rates is part of a restoration package.

The recreational fishing service flow losses from FCAs can be classified into the following four categories:

1. ***Reduced enjoyment from current Green Bay fishing days.*** Anglers active at the assessment site may enjoy their days at the site less because of concerns about health, and safety and displeasure with catching contaminated fish. These concerns can result in changes in fishing locations within the waters of Green Bay, changes in target species type and size, and changes in behavior regarding keeping, preparing, and consuming fish.

2. ***Losses by Green Bay anglers from fishing at substitute sites.*** Because of FCAs, anglers who fish the waters of Green Bay may substitute some of their fishing days from the waters of Green Bay to other fishing sites that, in the absence of FCAs in the waters of Green Bay, would be less preferred sites.

3. ***Losses by Green Bay anglers who take fewer total fishing days.*** Because of FCAs, anglers who fish the waters of Green Bay may take fewer total fishing days than they would otherwise. For example, an angler may still take the same number of days to other sites, but take fewer days to the waters of Green Bay to avoid the FCAs.

4. ***Losses by other anglers and nonanglers.*** Because of FCAs, some anglers may completely forego fishing the waters of Green Bay, in one year or many years. Other individuals who would fish the waters of Green Bay if it did not have FCAs may completely forego fishing.

The approach employed in the Co-trustees' assessment measures the value of service losses in categories 1 and 2, but not in categories 3 and 4. As a result, the calculations understate recreational fishing damages. The magnitude of this omission is unknown, although survey results indicate that losses in category 4 are not inconsequential, because the number of anglers who would be active in Green Bay fishing in the absence of FCAs may be as much as 30% larger than occurs with the current FCAs.

Consistent with the Department regulations for conducting NRDAs, the assessment measures the value of service flow losses through measuring recreational WTP for changes in FCA levels [43 CFR § 11.83 (c)].

Time period

Compensable damages are computed for interim services lost to the public resulting from PCB contamination from the date of CERCLA enactment (December 1980) or CWA amendments (1976) until the service flows are restored to baseline [43 CFR § 11.80 (b)]. For purposes of this determination, which concerns the value of losses to recreational anglers, the service flows are considered to be returned to baseline when there are no longer FCAs. Interim damages thus include: (1) damages for past service flow losses starting in 1981 or 1976 through 1999, and (2) damages for future service flow losses beginning in 2000 until FCAs are removed. Future damages are computed under alternative remediation and restoration scenarios.

Primary data collection and benefits transfer

The assessment focuses on primary data collection and analysis to estimate open-water recreational fishing damages for a target population of anglers who purchase Wisconsin fishing licenses in eight Wisconsin counties near Green Bay and who fish in Green Bay. Data collection focuses on the Wisconsin waters of Green Bay because PCB loadings and the resultant FCAs are more severe for the Wisconsin waters of Green Bay than for the Michigan waters of Green Bay, and because the recreational fishing activity in the Wisconsin waters of Green Bay is much larger than in the Michigan waters of Green Bay. Therefore, recreational fishing losses are expected to be greater in the Wisconsin waters than in the Michigan waters. The population of anglers who purchase licenses in eight counties near Green Bay was targeted because they account for most of the anglers and fishing days in the Wisconsin waters. Thus, damages associated with many, but not all, Green Bay anglers who live out of state are included. Data collection focuses on open-water fishing (e.g., non-ice fishing) because it accounts for almost 90% of all fishing on the waters of Green Bay.

The assessment was designed to collect and combine data on actual fishing activities under current conditions (e.g., days fishing in the Wisconsin waters of Green Bay and elsewhere), referred to as revealed preference data, with stated preference data on how anglers would be willing to trade off changes in fishing characteristics, including catch rates, FCAs, and costs, and on how many days anglers would fish Green Bay under alternative conditions for the waters of Green Bay. This combination of data allows the benefits of both types of data to be realized. For example, Green Bay is a unique resource, and substitute sites similar to Green Bay without FCAs do not exist. Therefore, stated preference data were necessary to assist in determining angler preferences for resource characteristics that do not currently exist.

Stated preference data were collected using choice questions, which is a method related to conjoint analysis. The revealed preference and stated preference data, along with site-specific and individual-specific data, were combined in random utility models of recreation demand to estimate damages. These economic methods are recognized in the NRDA regulations at 43 CFR § 11.83 and at 15 CFR Part 990 Preamble Appendix G, and are well established in the literature.

Based on the damages in the Wisconsin waters of Green Bay, we employ benefits transfer methods [43 CFR § 11.83 (c)(2)(vi)] to compute damages for fishing days in the Michigan waters of Green Bay, and for ice-fishing days in the Wisconsin waters of Green Bay. This provides a high-quality benefits transfer because it applies to the same water body, and to the same or similar fish species and fishing activities.

Focus on Green Bay fishing by Green Bay anglers

The primary data collection is from a sample of the target population of anglers who currently fish the Wisconsin waters of Green Bay and focuses on the valuation of changes in fishing conditions in the Wisconsin waters of Green Bay. Through this approach, the extent and value of service flow losses with a large sample of anglers who are specifically knowledgeable of the resources and injuries of interest are estimated, and the survey is designed so that the valuation questions are relevant to respondents. Respondent familiarity and relevant questions specific to the site and conditions of interest, combined with the real world nature of the questions, enhance response accuracy and the applicability of the results to the valuation of service flow losses and the determination of compensable values.

A three-step procedure was used to collect data from a random sample of individuals in the target population of anglers who purchased licenses in eight counties near Green Bay and who are active in fishing the Wisconsin waters of Green Bay. First, a random sample of anglers was drawn from lists of 1997 license holders in the county courthouses in the eight counties near the Bay of Green Bay: Brown, Door, Kewaunee, Manitowoc, Marinette, Oconto, Outagamie, and Winnebago. This population includes residents of these counties, residents of other Wisconsin counties, and nonresidents who purchased their Wisconsin fishing licenses in these eight counties.

Second, a telephone survey was completed in late 1998 and early 1999. The telephone numbers were obtained from the courthouse sample, and a telephone contact was attempted for a 69% response rate. The telephone survey collected data on the number of total days fished in 1998, how many days were in the waters of Green Bay, and attitudes about actions to improve fishing. Anglers who participated in open-water fishing in the Wisconsin waters of Green Bay in 1998 were recruited for a followup mail survey: 92% of the recruited anglers agreed to participate. Data from the telephone survey allow comparisons of anglers who were and were not active in fishing the Wisconsin waters of Green Bay, as well as a comparison of those anglers who completed the mail survey versus anglers who did not complete the mail survey.

Third, a mail survey was used to collect data for estimating damages associated with PCB contamination and the resultant FCAs. The survey focuses on FCAs and catch rates for four species that account for about 90% of the Green Bay fishing activity, and on fishing costs. Interviews with anglers indicate that they are most concerned with changes in these site characteristics, and much less concerned with changes in most other site characteristics such as improving recreational facilities. By focusing on the key target species and key site characteristics, site conditions were efficiently presented, resulting in a cost-effective assessment that had limited cognitive burden on survey respondents.

The core of this mail survey is a series of eight choice questions used to assess damages for reductions in enjoyment for current open-water fishing days in the Wisconsin waters of Green Bay. In each question, respondents are provided two alternatives (A and B), each with different levels of fishing characteristics for the waters of Green Bay, and asked to choose Alternative A or Alternative B. Fishing characteristics include catch rates and FCA levels for yellow perch, trout and salmon, walleye, and smallmouth bass, and an angler's share of a daily fee. By varying the levels of the characteristics across alternatives and questions, the survey provides input data for computing the amount of money the anglers would be willing to pay (or the increases in fish catch rates the anglers would be willing to give up) to reduce or eliminate FCAs, as well as the amount of money the anglers would be willing to pay for increased catch rates.

After each choice question, a followup question asks how often the respondent would fish the Wisconsin waters of Green Bay under the alternative they select. This followup question allows the estimation of damages associated with substituting days from the waters of Green Bay to other fishing sites because of FCAs. The mail survey also updates the angler's fishing activity profile for 1998 by asking how many fishing days occurred since the telephone survey; collects attitude, opinion, and socioeconomic data; and collects additional data to evaluate the choice question responses. Of the 820 anglers mailed the survey, 647 (79%) completed and returned the survey.

Based on an evaluation of the sampling plan and available data, adjustments to the sample estimate of average days fished per angler are made to obtain a target population estimate accounting for potential recall, sampling, and nonresponse biases. Further, the sample can be expected to account for on the order of 90% of recreational fishing days on the Wisconsin waters of Green Bay and to be reasonably representative of the mix of resident and nonresident anglers.

3.3.2 Results

Advisory awareness

Eighty-five percent of the anglers active in the Wisconsin waters of Green Bay had heard or read about the FCAs. Generally, the anglers' perceptions of the specific advisory levels (i.e., how often one could eat fish of each species) are generally consistent with the published FCAs, although perceptions tend to understate the actual FCA severity for smallmouth bass.

The majority of the anglers rate the advisories as somewhat to very bothersome to their Green Bay fishing. Seventy-seven percent of the anglers identify behavioral responses to the FCAs, and 30% of active anglers report that they spend fewer days fishing the Wisconsin waters of Green Bay because of the FCAs. Over half the anglers have changed the species or size of fish they keep to eat, and over half have changed the way the fish they keep are cleaned, prepared, or cooked. For most anglers, improving catch rates is rated as less important than removing PCB contamination from Green Bay.

Total recreational fishing damages

The present value of all interim recreational fishing losses are summarized in Table 3.20. Damage estimates were found to be robust and highly statistically significant over different specifications of the statistical model.

Damages for past service flow losses are computed from 1981 or 1976 and are continued through 1999. Fishing activity through time is based on WDNR and MDNR estimates for the waters of Green Bay. Damages are scaled through time to reflect changes in FCAs through time. Generally, the FCA levels were the same or less in the past (as a result, anglers may have experienced the same or less loss of enjoyment but experienced increased health risks in the past, which is not included in the damage estimates). In Michigan, however, the FCAs were more restrictive in some past years. Also note that the number of fishing days in the past was often larger than in 1998. Total damages for past service flow losses starting in 1981 are estimated to be about $64.5 million, with about 69% of these damages in the Wisconsin waters of Green Bay.

Damages for future recreational fishing service flow losses are computed starting in 2000. The duration and levels of the FCAs depend on the level of remediation efforts to address PCB contaminated sediments, which have not been selected. The assumed levels of remedial efforts used to calculate the numbers shown in Table 3.20 are the same as those used to report the results of the Co-trustees' TVE study (Appendix A). For all future years we assume that fishing effort remains constant at 1998 levels for all fishing considered. The assumption of current fishing activity levels into the future may or may not be conservative because fishing effort in the waters of Green Bay was at a decade low level in 1997 and 1998. Fishing effort may or may not

Table 3.20. Present values for recreational fishing service losses for the waters of Green Bay resulting from fish consumption advisories for PCBs (millions 1998$, present value to 2000).[a,b]

	(A) Wisconsin waters of Green Bay		(B) Michigan waters of Green Bay	(C) All waters of Green Bay (A + B)
	Open-water fishing	Open-water plus ice	All fishing	All fishing
Damage category	Primary study	Primary + transfer	Benefits transfer	Primary + transfer
1. Present value of past losses:				
a. 1981-1999	37.8	44.3	20.2	64.5
b. 1976-1981	5.4	6.3	5.8	12.1
2. Present value of future losses[c]				
a. intensive remediation[d]	30.7	36.2	5.3	41.5
b. intermediate remediation[e]	43.2	51.0	7.5	58.5
c. no additional remediation[f]	62.3	72.9	10.2	83.2
3. Present value of total damages from 1976 to baseline (1+2)				
a. intensive remediation	68.5	80.5	25.5	106.0
b. intermediate remediation	81.0	95.3	27.7	123.0
c. no additional remediation	100.2	117.3	30.4	147.7

a. Rounded to the nearest $100,000. Totals may not equal sum of elements due to rounding.

b. Values for Wisconsin open-water fishing include reduced quality of current days plus substitution of days to other sites. Values for Wisconsin ice fishing and Michigan fishing include only reduced quality of current days.

c. Present values computed adjusting for changes in FCAs through time, assuming an average fishing activity at 1998 levels, and a 3% discount rate.

d. 20 years of damages = 10 years sediment removal plus 10 years of declining FCAs.

e. 40 years of damages = 10 years sediment removal plus 30 years of declining FCAs.

f. FCAs decline to zero over 100 years due to natural recovery.

remain depressed, most likely depending on the future catch rates, changes in FCAs and other water quality measures, and changes in the population of northeast Wisconsin.

Damages for future recreational fishing service losses range from $41.5 million (with intensive remediation) to $83.2 million (with no additional remediation). Total damages for past and future service losses range from $108 million (with intensive remediation) to $148 million (with no additional remediation).

A 3% discount rate is used to escalate past damages and to discount future damages to the year 2000. A 3% discount rate is consistent with the average real 3-month Treasury bill rates over the last 15 years (Bureau of Economic Analysis, 1998; Federal Reserve, 1998) and is consistent with Department recommendations (U.S. DOI, 1995) for NRDAs under CFR § 11.84(e). The present value of past and future service flow losses varies with the discount rate. For example, increasing the discount rate to 6% increases the value of past service flow losses but decreases the value of future service flow losses. The value of the total of past and future service flow losses would increase by about 15% under Scenario 1, increase by about 7% under Scenario 2, and decrease by about 6% under Scenario 3. Decreasing the discount rate to 2% would decrease the value of past and future service flow losses in Scenario 1 by about 3%, increase the value in Scenario 2 by less than 1%, and increase the value in Scenario 3 by about 9%.

3.3.3 Conservative design features

These compensable value estimates are conservative. The computations exclude:

- damages to anglers and nonanglers who do not fish Green Bay at all because of the FCAs
- damages from reduced total fishing days by Green Bay anglers
- damages due to injuries to Oneida tribal waters
- damages that could result from potential fish population injuries.

The understatement of estimates may be caused by other factors as well. For example, the computations use very conservative assumptions about FCA levels in Green Bay; that is, the damages are based on FCA levels that understate current FCA levels for every one of the species. Additionally, damages for other fishing categories, such as subsistence fishing, have been omitted or limited.

3.4 Preparing a Final Claim

The Co-trustees' final claim for damages includes the following components [43 CFR § 11.15(a); 43 CFR § 11.80(b)]:

- the cost of resource restoration, as described in Section 3.2

- the compensable value of lost recreational fishing services because of PCB fish consumption advisories, as described in Section 3.3

- the reasonable and necessary costs of the Co-trustees' assessment.

Section 3.1 described how, to avoid possible double counting, compensable values from recreational fishing losses and restoration costs may be combined in the final claim. The Co-trustees will apply the recreational fishing damages determination to quantify compensable values for past interim loss damages, whereas the restoration planning analysis is applied to current and future losses. All recovered damages will be applied to resource restoration, with the compensable value damages being applied to conduct restoration that directly enhances recreational fishing services and/or provides additional restoration similar to that being conducted to address future injuries.

The magnitude of future losses, and therefore the amount and cost of restoration that may be required, is dependent on the extent of PCB cleanup that will be conducted under the response agencies' remedial action. The more extensive the PCB cleanup, the less resource restoration is necessary. The exact mixture of projects that will constitute restoration may also be affected by the extent of PCB cleanup that will be conducted, as described in Section 3.2.9. Therefore, the final claim will be prepared following selection of a remedy.

Table 3.21 presents the claim components of compensable values for past interim loss damages and potential restoration costs for present and future losses under several different assumed PCB cleanup scenarios and combinations of restoration projects. The values shown in the table do not include the reasonable and necessary costs of the Co-trustees' assessment. The restoration costs shown in the table are from several illustrative examples of different mixes of restoration project types that the Co-trustees may consider. The costs are not intended to serve as the costs that will be used in the final claim.

Table 3.21. Potential damages under different remediation scenarios[a] (millions).

Remediation scenario	Past interim damages (recreational fishing losses)[b]	Present and future damages (restoration costs)[c]	Total
Intensive PCB cleanup (baseline achieved in 20 years)	$65	$111-191	$176-256
Intermediate PCB cleanup (baseline achieved in 40 years)	$65	$158-268	$223-333

a. Table does not include the reasonable and necessary costs of conducting the assessment, which will be included in the final claim.

b. From column C of Table 3.20 (all waters of Green Bay, open-water plus ice fishing, 1981-1999).

c. From Table 3.19. Values are from illustrative mixes of restoration project types and are not intended to represent the costs that will be used in the final claim.

Through compensable damages for past interim losses (which will be applied to resource restoration) and restoration actions to address continuing and future injuries, the public will be compensated for the injuries to natural resources caused by PCB releases into the Lower Fox River.

4. Assessment Planning and Coordination

4.1 Coordination of the Co-trustees' Assessment with the Public

The Co-trustees place a high priority on public values and attitudes, public access to the assessment, and transparency of the assessment to ensure that the assessment is credible, understandable, and in the public interest. Therefore, the Co-trustees have endeavored to ensure public input on the NRDA and provide full disclosure of all assessment results. The Service maintains a public reading room in Green Bay (1015 Challenger Court, Green Bay, WI 54311, 920-465-7407) and an Internet site of assessment plans, assessment determinations, and indexes (http://www.fws.gov/r3pao/nrda). The Co-trustees hold formal public comment periods and formal public meetings. The Co-trustees meet with local agencies and organizations that have expertise or represent the public, coordinate with other potential trustees and response agencies, and are members of the Intergovernmental Partnership. Finally, the Co-trustees coordinate and negotiate with the potentially responsible parties. These efforts are described in greater detail below.

4.1.1 Public comment periods and meetings

In addition to the 45-day public comment period for this RCDP, the Co-trustees have conducted four formal public comment periods for all of the administrative assessment planning documents used in the Fox River/Green Bay NRDA (Appendix B). These public comment periods ensure that the public can express its preferences on how the site should be assessed, and provide relevant information that may not have been considered by the Co-trustees.

In addition, including the public meeting for this RCDP, the Co-trustees have held five formal public meetings to present the results of the assessment as they become available (Appendix B). These public meetings ensure that the public is aware of the results of the assessment being conducted on their behalf. It also provides the public, including the scientific community, an opportunity to react and provide additional relevant information and input to the Co-trustees.

4.1.2 Public surveys

Public surveys provide information of direct relevance to determining the appropriate type and scale of restoration required to make the public whole. In addition, these surveys provide information about public preferences and values which would not be available through public meetings and the Co-trustees' normal coordination with the public.

The Co-trustees have conducted three economic studies that surveyed the public to determine public values relevant to the assessment. The first was a limited pilot study of subsistence fishing along the Lower Fox River. This study was not completed, but the preliminary results (Hutchison, 1999) were forwarded to the WDNR and the EPA for potential use in the human health risk assessment. This study showed that subsistence fishing is a significant consideration for cleanup and restoration of the Lower Fox River. The second study was a valuation of recreational fishing damages due to fish consumption advisories (see Section 3.3 and U.S. FWS and Stratus Consulting, 1999f). The third survey was part of a total value equivalency study, which is described in Section 3.2.4 and Appendix A of this RCDP. This study showed that cleanup is the most important environmental program for the Lower Fox River and Green Bay Environment, followed by habitat and nonpoint source control. The study also determined the appropriate scale of these programs to make the public whole.

Several other studies have been conducted for Green Bay to determine the importance and value of environmental resources to the general public. While none of this literature is as applicable as the Co-trustees' studies for selecting and scaling restoration options, the literature shows considerable consistency in that residents are aware of and concerned about environmental programs and place a high priority and value on cleaning up contaminated water resources, and cleanup of pollution is a high priority among alternative natural resource management actions that may be taken. Stoll (1999) conducted a 1997 repeat mail survey of the general population to estimate benefits of contaminated sediment remediation in the Fox-Wolf River basin. Johnsen et al. (1992) also examined public perceptions and attitudes toward environmental rehabilitation of the lower Green Bay watershed. Further, the St. Norbert College Survey Center conducted a 1999 survey (Campbell, 1999; St. Norbert College Survey Center, 1999) that summarizes current attitudes of nearby Brown County residents about Fox River health concerns.

Other studies have focused on Great Lakes areas outside of the assessment area. Katz and Schuler (1995) surveyed public knowledge and opinions about Great Lakes issues in general. Finally, a study was done to learn about environmental awareness and attitudes about Lake Erie and the Ashtabula River by surveying random samples of Ashtabula County voters in Ohio (Lichtkoppler and Blaine, 1999). All of these surveys and studies are described in greater detail in Appendix A.

4.1.3 Coordination with agencies and groups with expertise relevant to the NRDA

In addition to formal public comment periods, formal public meetings, and scientific public surveys, the Co-trustees have also conducted extensive public outreach with key constituents and expert agencies relevant to the Lower Fox River and Green Bay Environment. Since 1992, the Service has led presentations and discussions relevant to the Fox River and Green Bay at

43 meetings with key constituents and agencies with important expertise. A complete listing of these meetings is provided in Appendix B.

4.1.4 Coordination with the WDNR experts

The Service has been coordinating its NRDA program and/or the Fox River/Green Bay NRDA with the WDNR since 1989 (Appendix B). In addition, the Co-trustees have consulted directly with WDNR experts on all aspects of the Fox River/Green Bay NRDA. WDNR experts that have collaborated with the Co-trustees include aquatic toxicologists, terrestrial toxicologists, ecologists, fishery managers, wildlife managers, economists, PCB fate and transport modelers, chemists, data managers, NRDA experts, real estate experts, park managers, endangered species experts, water quality experts, and engineers from divisions and offices throughout the WDNR.

4.2 Co-Trustee Coordination with the Response Agencies for the Lower Fox River and Green Bay Environment

4.2.1 Intergovernmental Partnership Memorandum of Agreement purpose and summary

On July 11, 1997, the Co-trustees, the EPA, and the WDNR, collectively the Intergovernmental Partnership (IGP), entered into a Memorandum of Agreement (MOA). The MOA was designed to coordinate response and restoration activities undertaken by the IGP. The MOA was also designed to coordinate negotiations by the IGP with the potentially responsible parties. Since the signing of the MOA, the Co-trustees have participated in all of EPA's and WDNR's deliberations on the RI/FS, have sought Co-trusteeship with the WDNR, and have refrained from unilateral settlement negotiations with the potentially responsible parties. In addition, the Co-trustees have participated in IGP public relations efforts through the Fox River Current and IGP public meetings.

4.2.2 Formal comments

To ensure consistency between the Co-trustees' NRDA and the response agencies RI/FS, the Co-trustees are members of EPA's Biological Technical Advisory Group for the Fox River and Green Bay NRDA. In addition, the Co-trustees have provided data, analyses, draft language, and written comments to the EPA, the WDNR, and the WDNR's consultants on 38 occasions since February 1998. Examples of key changes made in the RI/FS based on the Co-trustees' information and comments include 1) incorporation of Green Bay into the RI/FS; 2) inclusion of ecological risk endpoints other than population endpoints; 3) incorporation of assessment data, analyses, and determinations into the RI/FS; and 4) incorporation of PCB fate and transport model documentation into the RI/FS.

4.3 Coordination of the Co-Trustees' Assessment with the Potentially Responsible Parties

In addition to coordinating with processes influenced by the potentially responsible parties, such as the Fox River Coalition and the State/Company Agreement, the Co-trustees have sought meaningful coordination with the potentially responsible parties directly. Therefore, the Co-trustees invited the potentially responsible parties to participate in a collaborative assessment in 1994 when the assessment was launched, and again in 1996 when the assessment plan was published. However, the PRPs elected to enter into an agreement for a collaborative assessment with WDNR.

Even though the potentially responsible parties have neither funded nor participated in the Co-trustees' assessment, the Co-trustees have sought input from the potentially responsible parties. The Co-trustees have received multiple comments on the assessment from the potentially responsible parties, and the Co-trustees will provide a responsiveness summary of all formal comments in the Report of Assessment soon after the EPA issues its cleanup decision in the ROD. Furthermore, the Co-trustees have participated in the potentially responsible parties' RI/FS peer reviews and have analyzed and used data produced by the potentially responsible parties, including chemical data, habitat data, and economics data.

References

Allen, P., J. Sullivan, and L. Persson. 1987. Toxic Substances Management Technical Advisory Committee Report: Lower Green Bay Remedial Action Plan. PUBL-WR-166 87. Wisconsin Department of Natural Resources.

Author Unknown. 1994. Green Bay Habitat Restoration Workshop: Summary. Sponsored by the Lower Green Bay and Fox River Remedial Action Plan. Holiday Inn Center, Green Bay, WI. April 13-14.

Author Unknown. 1995. Menominee Reservation Lake Sturgeon Management Plan.

Bardecki, M.J. 1998. Wetlands and Economics: An Annotated Review of the Literature, 1988-1998 with Special Reference to the Wetlands of the Great Lakes. Prepared by Environment Canada. May.

Bertrand, G., J. Lang, and J. Ross. 1976. The Green Bay Watershed: Past/Present/Future. University of Wisconsin Sea Grant College Program Technical Report #229. January.

Bierman, V.J., J.V. DePinto, T.C. Young, P.W. Rodgers, S.C. Martin, R. Raghunathan, and S.C. Hinz. 1992. Development and Validation of an Integrated Exposure Model for Toxic Chemicals in Green Bay, Lake Michigan. Draft Final Report. Prepared by U.S. EPA, Large Lakes and Rivers Research Branch. September 1.

Blankenship, J. 1992. Calculation of Project Costs Provided to the Corps of Engineers or Bureau of Reclamation for Service Work Performed; ES Instructional Memorandum No. 53. From Assistant Regional Director, U.S. Fish and Wildlife Service, U.S. Department of the Interior, Fort Snelling, MN. March..

Brazner, J.C. 1997. Regional, habitat, and human development influences on coastal wetland and beach fish assemblages in Green Bay, Lake Michigan. *Journal of Great Lakes Research* 23(1):36-51.

Brewer, R., G.A. McPeak, and R.J. Adams. 1991. The Atlas of Breeding Birds of Michigan. Michigan State University Press, East Lansing.

Brinson, M.M. 1993. A Hydrogeomorphic Classification for Wetlands. U.S. Army Corps of Engineers Wetlands Research Program Technical Report WRP-DE-4. August.

Brown, J.F. and R.E. Wagner. 1990. PCB movement, dechlorination, and detoxication in the Acushnet Estuary. *Environmental Toxicology and Chemistry* 9:1215-1233.

Bureau of Economic Analysis. 1998. Summary, 1929-97. *http://www.bea.doc.gov/bea/pubs.htm*. Released August 1998.

Campbell, S. 1999. Most residents back Superfund cleanup: Survey on Fox River finds health concerns. Press-Gazette. October 21.

Colborn, T.E., A. Davidson, S.N. Green, R.A. Hodge, I.C. Jackson, and R.A. Liroff. 1990. Great Lakes: Great Legacy? The Conservation Foundation, Washington, DC.

Curtis, J.T. 1959. The Vegetation of Wisconsin. University of Wisconsin Press, Madison.

Cushing, B.S. 1999. State of Current Contaminated Sediment Management Practices. Prepared for Sediment Management Work Group. *http://www.smwg.org*.

D'Avanso, C. 1990. Long-Term Evaluation of Wetland Creation Projects. In *Wetland Creation and Restoration: The Status of the Science*. J.A. Kusler and M.E. Kentula (eds.). Island Press, Washington, DC.

DePinto, J.V. 1994. Role of mass balance modeling in research and management of toxic chemicals in the Great Lakes: The Green Bay Mass Balance Study. *Great Lakes Research Review* 1(1):1-8.

DePinto, J.V., V.J. Bierman, and T.C. Young. 1994. Recalibration of GBTOX: An Integrated Exposure Model for Toxic Chemicals in Green Bay, Lake Michigan.

Erdman, T.C. and J.P. Jacobs. 1991. Birds of Brown County. Richter Natural History Museum, Research Report No. 3. University of Wisconsin-Green Bay.

Erickson, M.D. 1997. Analytical Chemistry of PCBs. Second edition. Lewis Publishers, New York.

Federal Reserve. 1998. The Federal Reserve. Treasury Bills 3-month constant maturities. *http://www.bog.frb.fed.us/releases/H15/data.htm*. Updated April 1999.

Fitzpatrick, J.J. and M.B. Myers. 2000. Development of a Coupled Eutrophication and Sediment Carbon Model for Green Bay. Draft. Prepared for Limno-Tech, Inc.

Flanagan, W.P. and R.J. May. 1993. Metabolite detection as evidence for naturally occurring aerobic PCB biodegradation in Hudson River sediments. *Environmental Science and Technology* 27(10):2207-2212.

Fox River Global Meeting Participants. 1997. Fox River Global Meeting Goal Statement. Meeting at U.S. EPA Region 5 Offices, Chicago, IL. October 27.

Gilliam, J.W., D.L. Osmond, and R.O. Evans. 1997. Selected Agricultural Best Management Practices to Control Nitrogen in the Neuse River Basin. North Carolina Agricultural Research Service Technical Bulletin 311, North Carolina State University, Raleigh. *http://www.soil.ncsu.edu/lockers/Gilliam_J/bmps/*. [Accessed October 16, 2000.]

Habitat Restoration Workgroup. 1997a. Final Project Summaries of the Habitat Restoration Workgroup.

Habitat Restoration Workgroup. 1997b. Potential Habitat Restoration Projects Identified by GBMSD: From Municipal Sources for the Habitat Restoration Workgroup. October 20, 1997.

Hutchison, R. 1999. Impacts of PCB Contamination on Subsistence Fishing in the Lower Fox River. Prepared by ERH Associates for Stratus Consulting and U.S. Fish and Wildlife Service. Revised August 1.

HydroQual. 1999. Hydrodynamics, Sediment Transport and Sorbent Dynamics in Green Bay. Prepared by Hydroqual Inc. for Remediation Technologies Inc. and WDNR. March.

Johnsen, P.K., G.J. Knapp, and L.J. Smith. 1992. Public perceptions and attitudes toward environmental rehabilitation of the Lower Green Bay watershed. *Coastal Management* 20:9-23.

Katz, E.F. and S. Schuler. 1995. Baseline Survey: Eight Great Lakes States' Public Knowledge and Opinions about Great Lakes Issues, Final Report. Prepared for the U.S. Environmental Protection Agency, Great Lakes National Program Office.

Kittle, B. 1999. Buffer Strips Help Protect Watershed's Health. UCSC CASFS Newsletter Winter/Spring 1999. *http://zzyx.ucsc.edu/casfs/Newsletter2/bufferstrips2.html*.]Accessed Oct. 16, 2000.]

Lichtkoppler, F.R. and T.W. Blaine. 1999. Environmental awareness and attitudes of Ashtabula County voters concerning the Ashtabula River Area of Concern: 1996-1997. *Journal of Great Lakes Research* 25(3):500-514.

Linscombe, G., N. Kinler, and R.J. Aulerich. 1982. Mink (*Mustela vison*). In *Wild Mammals of North America: Biology, Management, Economics*. J.A. Chapman and G.A. Feldhamer (eds.). The Johns Hopkins University Press, Baltimore, MD. pp. 629-643.

LTI Environmental Engineering. 1999. Fox River and Green Bay PCB Fate and Transport Model Evaluation Technical Memorandum 2c: Compilation of Internal Solids Loads in Green Bay and the Fox River. Final. Prepared by LTI, a Division of Limno-Tech, Inc. February 12.

Manchester, J.B. 1993. The Role of Porewater in the Remobilization of Sediment-Bound Polychlorinated Biphenyl Congeners. PhD Dissertation for the Department of Chemistry, University of Wisconsin, Madison. Ann Arbor, Michigan: UMI Dissertation Information Service.

Mountain Whisper Light Statistical Consulting and ThermoRetec Consulting. 2000. Time Trends in PCB Concentrations in Sediment and Fish: Lower Fox River, Wisconsin. Prepared for WDNR by Mountain Whisper Light Statistical Consulting and ThermoRetec Consulting Corporation. August 22.

NRCS, 2000. Buffer Strips: Common Sense Conservation. National Conservation Buffer Initiative. Natural Resources Conservation Service, U.S. Department of Agriculture. *http://www.nhq.nrcs.usda.gov/CCS/Buffers.html*. [Accessed October 21, 2000.]

Patterson, D., X. Zhang, P. Jopke, and J.J. Steuer. 1994. The Green Bay Mass Balance Project, Historical Perspective and Future Projections. Authored by Employees of the WDNR and the United States Geological Survey.

Robbins, S.D. 1991. Wisconsin Birdlife. Population and Distribution Past and Present. The University of Wisconsin Press, Madison.

Shideler, G.L. 1992. Critical Coastal Wetland Problem Areas along the Michigan-Wisconsin Shoreline of Lake Michigan, and their Prioritization for Further Study. U. S. Geological Survey Open-File Report 92-22.

St. Norbert College Survey Center. 1999. 1999 Fox River Public Opinion Survey. Prepared by St. Norbert College.

Steuer, J., S. Jaeger, and D. Patterson. 1995. A Deterministic PCB Transport Model for the Lower Fox River between Lake Winnebago and Depere, Wisconsin. WDNR PUBL WR 389-95.

Stoll, J. 1999. Chapter 20: Results of a Contingent Valuation Survey of the Benefits of Remediation in the Green Bay Area of Concern, Draft. University of Wisconsin, Green Bay Working Paper (September). Research conducted for the Great Lakes Protection Fund.

Stow, C.A., L.J. Jackson, and S.R. Carpenter. 1999. A mixed-order model to assess contaminant declines. *Environmental Monitoring and Assessment* 55:435-444.

Stow, C.A., S.R. Carpenter, L.A. Eby, J.F. Amrhein, and R.J. Hesselberg. 1995. Evidence that PCBs are approaching stable concentrations in Lake Michigan fishes. *Ecological Applications* 5(1):248-260.

Temple, S.A. and J.R. Cary. 1987. Wisconsin Birds. A Seasonal and Geographical Guide. The University of Wisconsin Press, Madison.

The Nature Conservancy. 1999. Great Lakes Ecoregional Plan: A First Iteration. Great Lakes Ecoregional Planning Team, The Nature Conservancy, Great Lakes Program, Chicago IL. December.

ThermoRetec Consulting and Natural Resource Technology. 1999. Draft Remedial Investigation: Lower Fox River, Wisconsin. Prepared for by ThermoRetec Consulting Corporation, Seattle, WA, and Natural Resource Technology Inc., Pewaukee, WI. February.

ThermoRetec Consulting and Natural Resource Technology. 2000. Draft Remedial Investigation: Lower Fox River and Green Bay, Wisconsin. Prepared for WDNR by ThermoRetec Consulting Corporation, Seattle, WA, and Natural Resource Technology Inc., Pewaukee, WI. May.

Toweill, D.E. and J.E. Tabor. 1982. River Otter (*Lutra canadensis*). In *Wild Mammals of North America: Biology, Management, Economics*. J.A. Chapman and G.A. Feldhamer (eds.). The Johns Hopkins University Press, Baltimore, MD. pp. 668-703.

University of Wisconsin-Green Bay. 1993. The State of the Bay: A Watershed Perspective. Produced by the UWGB Institute for Land and Water Studies.

U.S. Army Corps of Engineers and U.S. EPA. 2000. A Guide to Developing and Documenting Cost Estimates during the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-075. July.

U.S. DOI. 1995. The Appropriate Discount Rate of Social Policy Analysis: Discussion and Estimation. Issue paper 11/22/95. U.S. Department of Interior.

U.S. EPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA: Interim Final. Prepared by U.S. EPA Office of Emergency and Remedial Response, Washington, DC. October.

U.S. EPA. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. Office of Water. EPA-840-B-93-001c. January. *http://www.epa.gov/OWOW/NPS/MMGI/*. [Accessed October 21, 2000.]

U.S. EPA. 1997. Phase 2 Report — Review Copy. Further Site Characterization and Analysis. Volume 2C — Data Evaluation and Interpretation Report. Hudson River PCBs Reassessment RI/FS. U.S. Environmental Protection Agency, Washington, DC. February.

U.S. EPA and Environment Canada. 1995. The Great Lakes: An Environmental Atlas and Resource Book. Chicago, IL: U.S. Environmental Protection Agency.

U.S. FWS. 1980. Habitat Evaluation Procedures (HEP). Prepared by Department of the Interior, Division of Ecological Services. ESM 102. Washington, DC. March 31.

U.S. FWS. 1993. Atlas of Green Bay Coastal Wetlands Influenced by Lake Level Changes: Green Bay Special Wetlands Inventory Study. Prepared for the U.S. EPA by the Green Bay Field Office of the U.S. FWS.

U.S. FWS. 1994. Preassessment Screen and Determination: Lower Fox River and Green Bay, Wisconsin. Prepared by U.S. Fish and Wildlife Service, Fort Snelling, MN, U.S. Department of Justice, U.S. Department of the Interior.

U.S. FWS. 1998. Maps Showing Locations of Walleye Tag Returns from Fish Tagged in Michigan Waters of Green Bay.

U.S. FWS. 2000. Third Assessment Plan Addendum: Lower Fox River/Green Bay NRDA. Prepared by U.S. Fish and Wildlife Service, Fort Snelling, MN, U.S. Department of Justice, U.S. Department of the Interior. May.

U.S. FWS and Hagler Bailly Consulting. 1996. Assessment Plan: Lower Fox River/Green Bay NRDA. Prepared by Hagler Bailly Consulting Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of Justice, U.S. Department of the Interior. August.

U.S. FWS and Hagler Bailly Services. 1997. Assessment Plan Addendum: Lower Fox River/Green Bay NRDA. Prepared by Hagler Bailly Services Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of Justice, U.S. Department of the Interior. October.

U.S. FWS and Hagler Bailly Services. 1998. Lower Fox River/Green Bay NRDA: Initial Restoration and Compensation Determination Plan. Prepared by Hagler Bailly Services Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of Justice, U.S. Department of the Interior. September.

U.S. FWS and Stratus Consulting. 1998. Fish Consumption Advisories in the Lower Fox River/Green Bay Assessment Area: Final Report. Prepared by Stratus Consulting Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of Justice, U.S. Department of the Interior. November 24.

U.S. FWS and Stratus Consulting. 1999a. Association between PCBs, Liver Lesions, and Biomarker Responses in Adult Walleye (*Stizostedium vitreum vitreum*) Collected from Green Bay, Wisconsin. Prepared by Stratus Consulting Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of the Interior, U.S. Department of Justice. April 13.

U.S. FWS and Stratus Consulting. 1999b. Injuries to Avian Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment. Prepared by Stratus Consulting Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of the Interior, U.S. Department of Justice. May 7.

U.S. FWS and Stratus Consulting. 1999c. Injuries to Fishery Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment. Prepared by Stratus Consulting Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of the Interior, U.S. Department of Justice. November 8.

U.S. FWS and Stratus Consulting. 1999d. Injuries to Surface Water Resources, Lower Fox River/Green Bay Natural Resource Damage Assessment. Prepared by Stratus Consulting Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of Interior, U.S. Department of Justice. November 8.

U.S. FWS and Stratus Consulting. 1999e. PCB Pathway Determination for the Lower Fox River/Green Bay Natural Resource Damage Assessment. Prepared by Stratus Consulting Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of the Interior, U.S. Department of Justice. August 30.

U.S. FWS and Stratus Consulting. 1999f. Recreational Fishing Damages From Fish Consumption Advisories in the Waters of Green Bay. Prepared by Stratus Consulting Inc., Boulder, CO, for U.S. Fish and Wildlife Service, U.S. Department of Justice, U.S. Department of Interior. November 1.

WDNR. 1988. Lower Green Bay Remedial Action Plan for the Lower Fox River and Lower Green Bay Area of Concern.

WDNR. 1993. Lower Green Bay Remedial Action Plan: 1993 Update for the Lower Green Bay and Fox River Area of Concern. September.

WDNR. 1999a. Model Evaluation Workgroup Technical Memorandum 2d: Compilation and Estimation of Historical Discharges of Total Suspended Solids and PCBs from Lower Fox River Point Sources. Madison, WI. February 23.

WDNR. 1999b. Model Evaluation Workgroup Technical Memorandum 2e: Estimation of Lower Fox River Sediment Bed Properties. March 31.

WDNR. 1999c. Model Evaluation Workgroup Technical Memorandum 2g: Quantification of Lower Fox River Sediment Bed Elevation Dynamics. April 23.

WDNR. 2000. Letter from Secretary George Meyer to William Hartwig, Regional Director, U.S. FWS. September 8.

WDNR and Bureau of Watershed Management. 1997. Polychlorinated Biphenyl (PCB) Contaminated Sediment in the Lower Fox River: Modeling Analysis of Selective Sediment Remediation. PUBL-WT-482-97. Madison, WI. February.

WDNR, Wisconsin Department of Agriculture, Trade and Consumer Protection, Brown and Calumet County Land Conservation Departments, Bay Lake Regional Planning Commission, and Brown County Planning Commission. 1993. Nonpoint Source Control Plan for the East River Priority Watershed Project. The Wisconsin Nonpoint Source Water Pollution Abatement Program. Publication #WR-274-93. March.

WDNR, Wisconsin Department of Agriculture, Trade and Consumer Protection, Outgamie County Land Conservation Department, Brown County Land Conservation Department, and Oneida Nation Planning Department. 1997. Nonpoint Source Control Plan for the Duck, Apple, and Ashwaubenon Creeks Priority Watershed Project. The Wisconsin Nonpoint Source Water Pollution Abatement Program. Publication WT-493-97. June.