



# Public Health Assessment for

**PCB CONTAMINATED SEDIMENT  
IN THE LOWER FOX RIVER AND GREEN BAY  
NORTHEASTERN WISCONSIN  
EPA FACILITY ID: WI0001954841  
MARCH 14, 2006**

**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
PUBLIC HEALTH SERVICE**

Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PCB Contaminated Sediment  
in the Lower Fox River and Green Bay

Final Release

**PUBLIC HEALTH ASSESSMENT**

PCB CONTAMINATED SEDIMENT IN THE LOWER FOX RIVER AND GREEN BAY

NORTHEASTERN WISCONSIN

EPA FACILITY ID: WI0001954841

Prepared by:  
Wisconsin Department of Health and Family Services  
Division of Public Health

Prepared for:  
The Citizens of Northeastern Wisconsin and the  
Agency for Toxic Substances and Disease Registry

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## Foreword

The Wisconsin Department of Health and Family Services (DHFS) has prepared this public health assessment in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This public health assessment was prepared in accordance with methodologies and guidelines developed by ATSDR.

This final document was first issued as a public comment release in December of 2001. The public comment document included recommendations for actions to reduce PCBs in fish tissue in the Fox River and Green Bay. Following the release of the draft document, the Wisconsin Department of Natural Resources (DNR) and the U. S. Environmental Protection Agency (USEPA) have adopted a plan for cleanup for the river system, and the companies involved began implementing the cleanup plan and are removing contaminated sediments from the river.

The 2001 public comment public health assessment also included recommendations for increasing public awareness of fish consumption advisories. Some work has been done to increase public awareness in the region, but the need is still great and becoming an increasing challenge. This final document responds to public comments made on the public comment release and contains updated information from the December 2001 public health assessment. Portions of the public comment document pertaining to cleanup recommendations were removed and do not appear in this final version. More focus in the final version is now placed on increasing awareness of fish consumption advisories, and a section has been added to discuss comments received on the public comment release.

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## SUMMARY

The Lower Fox River from Lake Winnebago down stream to the bay of Green Bay, in Lake Michigan, contains sediments contaminated with polychlorinated biphenyls (PCBs). PCBs were released into the river from seven pulp and paper companies located along its banks. The pulp and paper industries stopped releasing PCBs into the river in the early 1970's. However, much of the PCB contamination remains in the river today. PCBs that have been diluted in the environment have re-concentrated in the aquatic food chain. Fish consumption advisories have been issued for fish in the Fox River and Green Bay since they were first monitored in the 1970s.

Long term exposure to PCBs by people has been associated with a wide variety of health problems including some types of cancer, impaired intelligence, and problems with the physical development and behavior in young children. Many of the non-cancer health effects have been associated with human exposure to contaminated fish in the diet.

The Lower Fox River and Green Bay are used in many ways by the residents living in northeastern Wisconsin. However, eating fish from these waters is the primary use that poses a *public health hazard*. Direct exposure to contaminated sediments from other uses, such as swimming and wading, is a *no apparent public health hazard*. The Wisconsin Department of Health and Family Services (DHFS) has recommended that cleanup actions be taken in the Lower Fox River to reduce the amount of PCBs accumulating into the aquatic food chain. The overall cleanup plans for the Lower Fox River have been finalized and removal of PCB contaminated sediment began in 2004.

Environmental monitoring conducted during cleanup activities in 2004 and 2005 has shown that contaminated sediment removal is being done without an appreciable release and downstream loss of PCBs. Due to precautions taken during handling, transport, and disposal, the cleanup activities themselves are not causing unsafe exposures to PCBs or other contaminants.

Since 1976, fish consumption advisories had some success in reducing exposure to PCBs for many anglers using the Lower Fox River and Green Bay. In spite of continued efforts, many people still are not aware of the advisory. Language and cultural barriers have made it even more difficult to raise awareness of the advisories among minority and immigrant populations. Even with an aggressive cleanup of the river sediments, PCB levels in fish tissue will remain above safe eating levels for many years. The fish consumption advisories will continue to serve as the major risk management and public health function during this period. The public health implications of PCB exposure are most severe for women, children, and minorities. Several studies have shown that these groups are least likely to be aware of fish consumption advisories. DHFS has been and will continue to work with other agencies and community groups to increase advisory awareness.

Additional health information about PCBs can be found on the DHFS Web Site at:  
[http://www.dhfs.state.wi.us/dph\\_beh/Env\\_Health\\_Resources](http://www.dhfs.state.wi.us/dph_beh/Env_Health_Resources)

## **PURPOSE AND HEALTH ISSUES**

The purpose of this public health assessment is to describe the existing health issues related to PCB-contaminated sediments in the Lower Fox River and Green Bay, and to recommend actions to reduce risks to human health. The health effects of concern from fish consumption exposures to PCBs include, but are not limited to, cancer, reproductive and endocrine effects, impaired physical and mental development in young children. Children are the most sensitive to many of the non-cancer health effects associated with PCB exposures. Awareness of the issue influences exposure to contamination. Women and minorities are least likely to be aware of fish consumption advisories and are thus placed at greater risk of exposure. The public comment version of this final public health assessment, released to the public in December of 2001, recommended that the Wisconsin Department of Natural Resources (DNR) and the U.S. Environmental Protection Agency (EPA) take actions to reduce PCBs in the system in order to ultimately reduce the risks to the public from eating contaminated fish. Since the release of that document, the DNR and EPA have worked with the companies responsible for the contamination to select cleanup plans, and have begun cleanup activities.

The primary public health issues are related to PCB contamination in the fish people eat. This public health assessment includes information from the 2001 document, but also provides an update on activities related to increasing awareness of fish consumption advisories

While cleanup activities are underway to reduce PCB levels in fish tissue, the public health action plan for this project continues to focus on promoting healthier fish consumption habits among families who eat fish from the Lower Fox River and Green Bay.

## BACKGROUND

### *History and Description of the Project Area*

The Lower Fox River flows from Lake Winnebago to the northeast, 39 miles to its mouth at the base of Green Bay. The river's watershed is more than 6,330 square miles and is Wisconsin's largest tributary to Lake Michigan (TRCC, 2002a).

Approximately 270,000 people live in communities along the river. The river flows through portions of Winnebago, Outagamie, and Brown Counties. Land use along the river is both urban and rural and includes industrial, commercial, agricultural, and residential properties. Several large and small communities are found along the shores of the river, including: Neenah, Menasha, Appleton, Kimberly, Little Chute, Combined Locks, Kaukauna, Wrightstown, De Pere, Ashwaubenon, and Green Bay. Many more communities line the shores of Lake Michigan's Green Bay.

The minority population has grown rapidly in Fox Valley communities. From 1990 to 2000 Green Bay has had the largest increase in Hispanic or Latino population of any City in Wisconsin (470%). The Hispanic or Latino population has grown from 906 in 1980, to 1,525 in 1990, to 8,698 in 2000. The Hmong population in Green Bay increased by 90.5%; to 2,629 people between 1990 and 2000. In 2000 11.3% of the population of Green Bay report that a language other than English is spoken at home (UW, 2000a,b,c).



**Figure 1:** Location of the Lower Fox River between Lake Winnebago and Green Bay in Northeastern Wisconsin.

The Lower Fox River has a long history of industrial use and has the highest concentration of pulp and paper mills in the world. As a result of recycling carbonless copy paper, area mill operations discharged polychlorinated biphenyls (PCBs), contaminating sediments in the Lower Fox River. The Lower Fox River is the largest source of PCBs found in Lake Michigan. Between 1957 and 1971, approximately 600,000 pounds of PCBs were released, contaminating 11 million tons of sediment. An estimated 160,000 pounds of PCBs have already left the Lower Fox River and entered Green Bay and Lake Michigan, and on average, 300 to 500 additional pounds are flushed from the Lower Fox River sediments each year. Each flood flushes additional thousands of pounds into the bay. Once PCB-contaminated sediments reach Green Bay and Lake Michigan, they are extremely difficult to remove (TRCC, 2002a).



### *Polychlorinated Biphenyls(PCBs)*

PCBs are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs. PCBs appear as either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don't burn easily and are good insulators. The PCBs in the Lower Fox River came primarily from the production and recycling of carbonless copy paper at local paper mills. PCBs resist breaking down, instead they concentrate in the environment and the food chain. Through a process called biomagnification, PCB levels in top predators, such as bald eagles and lake trout, can be millions of times higher than levels found in surface water.

Concentrations in top predator fish are high enough to cause adverse health effects when eaten by humans, other fish, and wildlife. Because of these dangers, the U.S. Congress banned the manufacture of new PCBs in 1976, and PCBs still in use are strictly regulated (ATSDR, 2000).

### **Fox River Sediments**

The Lower Fox River varies in character as it moves from Lake Winnebago to its mouth at Green Bay. Shortly after it leaves Lake Winnebago through the Neenah and Menasha Channels, the river widens to form Little Lake Butte des Morts, an impoundment controlled by the Upper Appleton Dam. Because the river slows in this area, fine grained sediments have deposited on the bottom. From Appleton to the De Pere Dam the river is generally narrow, faster flowing, and sediment deposits are sandier. Approximately 90% of the PCB mass and a large percentage of the most heavily contaminated sediments are found in the final stretch of river from the De Pere Dam downstream to the mouth at Green Bay. From the De Pere dam to its mouth, the Lower Fox River is channelized and wider. From the mouth to three miles up the river, the channel is maintained to allow commercial navigation.

### **Sedimentation**

The sediment in a river is the result of solid material washed into the river from erosion, waste water discharges, and other materials carried with rainfall runoff. Sediment is composed largely of soil, decaying vegetation and other organic matter. The faster a river flows the more energy it has to carry sediment downstream. As a river slows, the heavier sediment (sand and gravel) fall to the bottom and are no longer moved downstream. The slower it moves, the smaller the sediments that are dropped out and deposited on the bottom. These smallest sediment particles consist of the fine grains of silt and clay, and often contain most of the organic material as well. Because the flow in any river is complex there are both major sediment deposits where the whole river slows, and more discrete deposits where only a part of the river slows (e.g. behind a bend or man made structure in the river). Changes in water flow from rainfall or snow melt changes the pattern of deposition of sediments and re-mobilize existing deposits.

### **Distribution of Contaminants in Sediment**

Chemicals released into a river behave in a variety of ways. Some chemicals are very water soluble and will move down stream with the water. Some chemicals evaporate easily and move from the river into the air. Other chemicals, such as PCBs, are less water soluble and bond to the sediments. These chemical contaminants move downstream with the sediments to which they've bonded. The fine grained sediment containing the greatest amount of organic material tends to have the highest contaminant levels. Contaminated sediment locations are determined by where the chemicals enter the river and then by where the rivers current slows. A very small fraction of the PCBs will dissolve in the water and concentrate in the food chain.

Samples of water, sediment, and fish tissue have been collected throughout the Lower Fox River for more than the past 30 years. More than 300,000 analyses have been done of Fox River sediments and other media including surface water and fish tissue. Many more samples have been taken from sediments in Green Bay as well. These sediment samples were collected as part of several individual investigations. The sediment sample results are summarized in Table 1. A more detailed review of the sample results for all media can be found in the remedial investigation report for the site on the DNR Fox River Cleanup website (<http://www.dnr.state.wi.us/org/water/wm/lowerfox/index.html>).

Many other chemicals have been found in Lower Fox River surface water, sediments, and even in fish tissue over the years. However, the ecological and human health risks were the greatest from PCBs and became the basis of public health concerns for environmental contamination in the Lower Fox River. In the draft baseline human health risk assessment issued for the Lower Fox River in 1999, other contaminants of potential concern were evaluated and found not to contribute a significant adverse health risk relative to that posed by PCBs. Many of the contaminants remaining in the sediments share similar properties to PCBs and are found in the same areas. Some of the other contaminants identified in the sediments of the river include: dioxin and furan, dichlorodiphenyltrichloroethane (DDT), dieldrin, mercury, lead, and arsenic. For this reason, addressing the sediments with the highest PCB levels also serves to address some of the highest concentrations of other contaminants (TRCC, 2002b). These contaminants are from non-specific sources. The potential health implications of their presence in the sediments was considered in the risk assessment but is not addressed in this public health assessment.

**Table 1. PCB Distribution in Sediments of the Lower Fox River (DNR, 2001)**

<b>Location</b>	<b>Low Level (ppb)</b>	<b>High Level (ppb)</b>	<b>PCBs Mass (Kg)*</b>	<b>Sediment volume (cubic yards)</b>	<b>% PCBs in River</b>
Lake Winnebago (background)	ND	36	NA	NA	NA
Little Lake Butte des Morts	2.0	222,722	1,849	2,200,400	5.4
Appleton to Little Rapids	ND	185,560	109	339,200	0.2
Little Rapids to De Pere Dam	3.0	54,000	1,250	3,030,100	3.5
De Pere Dam to mouth of River	4.0	710,000	26,647	8,491,400	90.9

\* Estimates based on sediments with over 50 parts per billion (ppb) total PCBs  
 NA - Not Applicable  
 ND - Not Detected

## PCBs Levels in Fish of the Lower Fox River

In 1976, the Wisconsin Department of Health and Social Services and Department of Natural Resources issued fish consumption advisories on the Lower Fox River, Green Bay, and Lake Michigan. This was in recognition of the unsafe levels of PCBs found in fish tissue in those waters (Hagler, 1998).

PCB levels in Lower Fox River and Green Bay fish have declined significantly since the late 1970s. However, levels have not shown a significant decline since the late 1980s. PCB levels may be dropping by 50% in some fish every 10-30 years. If these rates of decline were to continue, it would take from 50 to more than 100 years for PCB levels to decline to a level so that fish could be safely eaten. However, recent evaluations of some Great Lakes' fish show that PCB levels may no longer be declining (MWL, 2001).

PCB water levels at the mouth of the Lower Fox River have not declined since 1989 and are from 100 to 10,000 times greater than safe levels set by the State to protect human and ecological health. In this case the human health criteria are based on bioaccumulation in sport fish.

**Table 2**  
Summary of Fish Consumption Advisories for the Lower Fox River  
Recommendations for Limiting Exposure Based on Fish Species and Size (DHFS, 2005)

Section of the Lower Fox River	PCB Level 0.05 to 0.2 ppm — Eat no more than 1 meal per week or 52 meals per year.	PCB Level 0.2 to 1.0 ppm — Eat no more than 1 meal per month or 12 meals per year.	PCB Level 1.0 to 1.9 ppm — Eat no more than 1 meal every 2 months or 6 meals per year.	PCB Level >1.9 ppm — Do Not Eat
Little Lake Butte des Morts downstream to the dam at DePere		Northern Pike* Smallmouth Bass* Walleye* White Bass*  White Perch*Yellow Perch*		Carp*
DePere Dam downstream to the mouth		Black Crappie* Bluegill* Northern Pike < 33" Rock bass* Sheepshead <10" Smallmouth bass* Walleye <16" Yellow Perch*	Northern pike >33"  Sheepshead 10-13"  Walleye 16-22" White Perch* White Sucker*	Carp Channel Catfish Sheepshead >13" Walleye >22" White bass*

Note: \* - All sizes of this species fall under this category

Wisconsin's sport caught fish consumption advisories for PCBs are set to be protective of non-cancer health effects. Following the intake recommendations reproduced in Table 2, exposure would fall between the reference doses for Aroclors 1254 and 1016 (two common groupings of

PCBs). This exposure also represents a theoretical increased cancer risk of about one in ten thousand. These estimates are based on exposure by a 70 Kg adult eating a half a pound of fish at each fish meal. For comparison, the risk assessment for the Lower Fox River estimated that people who eat a lot of fish from the River and Bay could eat as many as 130 fish meals per year (Anderson, 1993)(TRCC, 2002b).

## **PRIOR EFFORTS TO INCREASE COMMUNITY AWARENESS**

Due to PCB contamination and human health concerns, fish consumption advisories have been in-place for the Lower Fox River and Green Bay since 1976. Some species and sizes of fish (i.e., large walleye, crappie, small mouth bass, and channel catfish) are not to be eaten at all or only a few meals per year. These advisories, published regularly by the Wisconsin Department of Natural Resources (DNR), warn residents to limit or eliminate locally-caught fish from their diet. They also provide tips on how to properly clean and cook fish to reduce the risk of PCB exposure. However, not all people follow the fish consumption advisories.

In 1997, DHFS conducted a study of health advisory awareness in the Great Lakes region. Approximately fifty percent of anglers who had eaten sport caught fish were aware of the consumption advisories on those fish. However, there was a wide discrepancy in awareness between men and women and between white and minority anglers. Sixty percent of women were unaware of the advisories while only forty percent of men were unaware. Likewise, only twenty-two percent of minority anglers were aware of the advisories compared to fifty-two percent of white anglers. These findings have directed consumption advisory promotion efforts over the past several years towards women and minority populations (Tilden, 1997).

### *Fish Consumption Advisory Promotion*

DHFS has worked with DNR since the mid-1970s to develop recommendations for consumption of sport-caught fish. Almost every year, a state-wide advisory is printed with information on all bodies of water that have mercury and PCB advisories. The booklet is available as a separate document from the fishing regulations booklet. In 1998, 40,000 advisories were printed and 1.25 million licenses were sold. There are approximately 47,000 licensed anglers in the counties bordering the Lower Fox River. These same booklets have been posted on the DNR web site over the past few years as well (Hagler, 1998)(DHFS, 2005).

DHFS provided advisories, informational brochures (English, Spanish, and Hmong), and offered a poster to primary care physicians in Green Bay. DHFS staff wrote articles for newsletters intended for health professionals who serve women, infants, and children in the Green Bay area. The Brown, Outagamie, and Winnebago County Health Departments are engaged in providing health advisories and support for promotion of the advisory in the Fox River Valley (Steenport, 2000).

### *Medical Grand Rounds*

In the mid 1990s, DHFS gave medical education presentations to physicians in Green Bay and Appleton. Medical grand rounds were again presented on this topic in Green Bay and Appleton in 1999. The subject of those medical education presentations pertained to the importance of taking an environmental health history. By assessing lifestyle environmental factors, the

physician is better able to make recommendations for reduction of exposure and more accurately treat the illnesses that may be the result of exposure to environmental contaminants.

### *Minority Involvement*

DHFS has developed relationships with American Indian and Southeast Asian populations in the Fox River Valley while assessing this and other environmental health hazards. In 1993 and 1994, DHFS participated in public meetings regarding the Fort Howard Sludge Lagoons (also a PCB problem).

Early in the 1990s, DHFS recognized a particular need to provide information to Hmong residents of the state. Many Hmong people use fish as a major source of food and have more than average difficulty obtaining understandable information. The majority of Hmong in Wisconsin immigrated to this country in the last 20 years, and many speak only their native language. Because their written language was only recently developed (1960s), many Hmong adults over age 40 cannot read Hmong. In response to their need, staff worked with other agencies to provide unique educational workshops for Hmong communities.

Staff first contacted the local Hmong associations regarding the fish advisory in 1992. Then later, in 1995, a workshop was held to verbally communicate the fish advisory (in Hmong) to Green Bay residents. The workshop included presentation of the concepts of good nutrition that includes fish, bioaccumulation of chemicals, fish identification, the fish advisory, and cooking and cleaning fish to reduce contaminants. To reinforce the messages in the workshop, DHFS produced with DNR a simple color-coded map showing advisory waters, single issue cards for individual water bodies, and translated advisories.

Staff worked with the Appleton Hmong Association to obtain an EPA Environmental Justice Grant to produce a fish consumption video in 1999. The purpose was to give the same type of information as the workshop in a 10-15 minute video. The video is now available for use throughout the state with a number of Hmong communities. It may be shown in community centers, in homes, and on cable access television.

Since 1991, workshops have been conducted for Hmong communities in Green Bay, Sheboygan, Menomonie, Eau Claire and Manitowoc. Each workshop consists of a discussion about chemicals, food chain, fish identification, fish consumption recommendations, cooking methods, and filleting.

In 2003 DHFS began giving workshops on fish consumption advisories and proper fish cleaning methods to "English as a Second Language" classes of primarily Hispanic immigrants in the Green Bay area. This type of activity has been a productive method of reaching people who eat fish from the river. Due to the rapid increase in the Hispanic immigrant population in the Fox River Valley, DHFS is planning to increase this type of outreach activity in future years.

Additional advisory promotion activities have included developing a clear and simple public health message for fish consumption. This message was created to address both PCB and mercury contamination issues. The message and some recognizable graphics have been printed on the following: growth charts, sippy cups, stadium cups, T-shirts, coffee mugs, bandage

dispensers, refrigerator magnets, and grocery list note pads. These materials were distributed to local WIC (Women Infants and Children Program) clinics, health fairs, and local health departments.

### *Posting Signs*

During the summer of 2000, signs were posted in English, Spanish, and Hmong at popular fishing locations on the Lower Fox River. These signs were made of plastic and the printed information was no longer legible after a year of outdoor exposure. In 2004 DHFS created aluminum signs with durable color images and text. These signs were developed to rely largely upon images to relate the fish consumption advisory concepts. English, Spanish and Hmong translations are included on each sign, rather than having separate signs for each language. DHFS worked with local health departments along the Lower Fox River to post these signs at popular fishing locations. Following minor revisions to the advisories in 2005, DHFS created durable replacement decals to keep the signs current for each stretch of the river, and once again worked with local health departments to have them placed on the signs.

## **COMMUNITY HEALTH CONCERNS**

A few residents were concerned that the notifications of fish advisories were inadequate and too slow. They said the state's fish advisory slogan, "Hook into healthy fish," was confusing. They also said the slogan leads people to believe there are a lot of healthy fish in the river. Some disagreed with that line of thought. Residents also said the fish advisory signs along the river were not properly maintained. In some areas, the signs were missing. They assumed anglers would believe the water is clean and the fish are safe to eat. In addition, they thought the fish advisory signs should be in three "languages": English, Spanish and pictures. Others said no one really knows about the fish advisories. Another resident asked how long the fish advisories would/could last. On the other hand, a resident said people were aware of the fish advisories. Another person said he/she "couldn't imagine people fishing the river and eating the fish."

Some people were concerned about the health of the Hmong and other ethnic populations that fish along the river. They were aware of the Hmong culture to eat most every part of the fish they catch. They said there should be an outreach effort to the Hmong that is respectful of their culture and also make them aware of the fish advisories. Several people said they do not fish the Lower Fox River but have observed Hmong do so.

One resident was concerned that the contamination from the river affected the health of area residents. He/she observed children requiring physical therapy and "lots of kids with problems." He/she wondered if their difficulties could be linked to the river. The resident believed an epidemiology study of the area was needed. He/she said people worry about cancer, but there were other problems of which to make the public aware: developmental and pregnancy issues.

In 1998, DHFS worked with the US Environmental Protection Agency (EPA) to conduct community involvement interviews. To further understand community health concerns. The following list of health concerns were expressed in the interviews and during interaction with citizens at public meetings:

- **Some anglers complained that they were not notified sooner about PCB-contaminated fish in the Lower Fox River and are worried that their families are being slowly poisoned as they eat contaminated fish.** DNR and DHFS began telling the public about the health concerns of contaminated fish in the Lower Fox River when we first learned of the problem. The health risks, while unacceptable, do not warrant significant fear about past exposures. While the target levels of acceptable exposure are not being met, the risks presented by exposure to these levels, while unacceptable, should not have have noticeable impact on daily life. Nonetheless, efforts should move forward to reduce exposure to more protective levels, particularly improving awareness. Once people are aware of the advisory, they can take control over unnecessary future exposures.
- **Some residents expressed frustration in a cultural sense that recommendations to avoid eating the entire fish, and to only eat fillets, conflicted with their cultural traditions.** Unfortunately for some, the most effective cleaning methods for reducing PCB exposures involve removal of some parts of the fish that had been eaten in the past.
- **Some residents believe that the health risks of eating PCB-contaminated fish from the Lower Fox River have been over stated.** DNR and DHFS have always stressed that while the health risks of eating PCB-contaminated fish are unacceptable, those risks warrant cleanup rather than alarm. In any project like this, it is not possible to control the health information that is passed among community members. There are many sources of health information available to residents. Some information sources advocate on the behalf of particular groups or organization, and their associated perspective. This report provides what State and Federal health officials believe is a balanced discussion of the risks from PCB exposures.
- **Concerns were expressed that the health effects demonstrated by PCB studies on animals and people from outside the Fox River area may not be applicable to the Fox River system.** No health studies will perfectly match this or any other site. However, many of the most compelling studies are of people demonstrating health effects associated with eating contaminated fish (very relevant to this project). DHFS relied on a large number of studies and considered the weight of evidence from those studies before developing the health recommendations in this document.
- **There was a sense that the health of everyone in the lower Fox River Valley was at risk because of the PCB contamination in the river.** This was a common concern raised at both interviews and public meetings. The health risks from the PCB-contaminated sediments are primarily related to fish consumption. DHFS will continue to work to make people aware of this and the fact that they can take control of their risks by following the fish consumption advisory.
- **Concerns were raised regarding the algae and associated odors in Lake Winnebago that seem to be getting worse in recent years.** Algae problems on Lake Winnebago are not related to the PCB contamination on the Lower Fox River and Green Bay. These algae problems have been the result of nutrient runoff problems in combination with

unusual weather events. This is a separate project within DHFS, DNR, and local health agencies. These agencies have been working cooperatively to address these concerns and have provided information to the public.

In addition to the community involvement interviews, DHFS has participated in several public meetings over the past year related to the contaminated sediments in the Fox River. During those meetings, a number of health questions have been raised. The following questions are some that were posed that were not mentioned in the previously presented interview questions:

- **Several concerns were raised about the safety of landfill disposal of dredged sediments as part of a cleanup option. These concerns were echoed by physicians from the Winnebago County Medical Society who formally opposed the landfill disposal of PCB-contaminated sediments.** A section has been added to this report describing the safety built into the landfill disposal of PCB contaminated sediments.
- **Some residents expressed concerns that PCBs would volatilize during dredging and disposal activities and that the public would be exposed to unsafe levels of PCBs. In addition to their own exposure, some people were concerned that, through volatilization, some PCBs could end up in the milk coming from area dairy farms.** Extensive air sampling was done during the demonstration projects which confirmed that PCB releases were minimal and would not result in a risk to public health. Additional discussion has been added to the section “*Managing PCBs During Cleanup*” later in this document.
- **Residents who live on the Fox River were concerned because they and their children occasionally swim in the river.** The possible exposures from swimming in affected portions of the lower Fox River have been evaluated and found not to pose a health hazard. DHFS is now providing that information to people to maintain the focus on the primary exposure pathway of fish consumption.
- **People who live around the river are concerned about the health effects from coming in direct contact with PCBs in river sediments.** There are a wide variety of ways that people use the river; uses that involve the most contact with the sediments were evaluated. Health professionals considered recreational activities such as wading, swimming, and water skiing. They also considered nearby residents’ breathing the air, drinking river water, and workers involved in actively moving the sediments. Other than eating contaminated fish and wildlife, none of the remaining exposure pathways represent a significant exposure to PCBs.



## DISCUSSION

Several exposure pathways were evaluated as part of the risk assessment conducted by DNR with assistance from DHFS and EPA in early 1999, as well as in other evaluations in the past. Of all the exposure pathways with the greatest potential for PCB exposure in the Lower Fox River, only fish consumption pose a *public health hazard*. Exposure to PCB-contaminated sediments, surface water, or air also poses a *no apparent public health hazard* (TRCC, 2002b)(WDOH, 1997).

### *Pathways Evaluation*

#### **Exposures to Contaminated Sediments**

PCBs can enter a person's body in a number of ways: when the person swallows materials contaminated with PCBs (such as eating contaminated fish); when the person breathes in volatilized PCBs from the air or that are attached to dust particles in the air; or when the person comes in skin contact with the PCBs, a very small amount of PCBs could be absorbed into the body. Absorption through the skin is the least likely route of exposure for PCBs to enter a person's body at the Lower Fox River. Only a very small amount of PCBs in contact with the skin will be absorbed, and the PCBs attached to sediments are unlikely to be released. In this case significant inhalation exposures are also unlikely because the amount of PCBs expected to volatilize is extremely low. Therefore, ingestion or swallowing contaminated material is the remaining route of exposure to the PCB contaminated sediments. This route is plausible because while swimming a person may stir up sediments and accidentally swallow water containing suspended sediments. The amount of contaminated sediments that would actually be ingested would still be quite low (TRCC, 2002b).

People may come in contact with PCB-contaminated sediments in the Lower Fox River in a variety of ways. The risk assessment conducted by DNR and their contractor considered both swimmers and boaters using the river frequently during the summer months and marine construction workers who may have more infrequent, yet high opportunity for exposure. The nature of these activities and the contaminated sediments is such that exposure frequency, duration of exposure, and dose would be too low for a direct contact with affected sediments to result in an increased health risk. DHFS concurs with the findings of this risk assessment, and concludes that human direct-contact exposures to PCB-contaminated sediments in the Lower Fox River pose a *no apparent public health hazard*. Other uses of the river involving direct contact with contaminated sediments (e.g., wading) would result in even lower exposures to PCBs (TRCC, 2002b).

## **Exposure to Multiple Contaminants in Fish**

Because sediments in the Lower Fox River contain multiple chemicals that can accumulate in fish tissue the risks from exposure to each individual contaminant were considered. Using conventional risk assessment methods, the potential for combined or synergistic effects of the group of chemicals were also considered. The relative risk from PCBs in fish is so much higher than that of the other contaminants, that including the other contaminants does not substantially change the risk estimates.

A potentially important exception to this statement exists in the concurrent presence of mercury in fish. Mercury levels in fish from the Lower Fox River and Green Bay are not remarkably higher than in many other water bodies in the state. However, even these levels are high enough to warrant fish consumption advisories. Of particular concern are the similar child development health effects of both mercury and PCBs. Research on the potential interaction of effects from exposure to these contaminants is on-going (Roegge, 2004).

## **The Toxicological Implications of PCBs in the Lower Fox River**

ATSDR and the USEPA have conducted extensive reviews of the hundreds of health studies involving PCB exposures. A comprehensive summary of this review can be found on the following web site: [www.atsdr.cdc.gov/DT/pcb007.html](http://www.atsdr.cdc.gov/DT/pcb007.html).

This web site contains more information on each of the human health effects discussed in this section (Johnson, 1999). EPA also has a thorough summary of the health effects associated with PCB exposures at: [www.epa.gov/opptintr/pcb/effects.html](http://www.epa.gov/opptintr/pcb/effects.html).

PCBs cause a variety of adverse health effects. They have been shown to cause cancer in animals. PCBs have also been shown to cause a number of serious non-cancer health effects in animals, including effects on the immune system, reproductive system, nervous system, endocrine system and other health effects. Studies in humans provide evidence for potential carcinogenic and non-carcinogenic health effects due to PCB exposures. The different health effects of PCBs may be interrelated, as alterations in one system may have significant implications for the other systems of the body. The potential health effects of PCB exposure are discussed in greater detail below (Johnson, 1999).

### **Cancer**

Health and environmental officials use a weight-of-evidence approach in evaluating the potential carcinogenicity of environmental contaminants. This allows the results of individual studies to be viewed in the context of all of the other available studies. PCBs are one of the most widely studied environmental contaminants, and many studies in animals and human populations have been performed to assess the potential carcinogenicity of PCBs. Studies in animals provide conclusive evidence that PCBs cause cancer. Studies in humans raise further concerns regarding the potential human carcinogenicity of PCBs, but are less conclusive than animal studies. Taken together, the data strongly suggest that PCBs can cause cancer in humans.

USEPA's peer reviewed cancer reassessment conducted in 1996 concluded that PCBs are probable human carcinogens. USEPA is not alone in its conclusions regarding PCBs. Other agencies concluding that PCBs are human carcinogens include: ATSDR, the International Agency for Research on Cancer, the National Toxicology Program, and the National Institute for Occupational Safety and Health. The reassessment concluded that the types of PCBs likely to be bioaccumulated in fish and bound to sediments are the most carcinogenic PCB mixtures (EPA, 1996)(EPA, 2006).

In addition to the animal studies, a number of epidemiological studies of workers exposed to PCBs have been performed. Results of human studies raise concerns for the potential carcinogenicity of PCBs. Studies of PCB workers found increases in rare liver cancers and malignant melanoma. The presence of cancer in the same target organ (liver) following exposures to PCBs, both in animals and in humans and the finding of liver cancers and malignant melanomas across multiple human studies, adds weight to the conclusion that PCBs are probable human carcinogens (ATSDR, 2000).

Some studies in humans have not demonstrated an association between exposures to PCBs and disease. However, epidemiological studies share common limitations that can affect their ability to find and measure important health effects even when they are present. Epidemiological studies may not be able to detect small increases in cancer over background unless the cancer rate following contaminant exposure is very high or the exposure produces an unusual type of cancer. However, studies that do not demonstrate an association between exposure to PCBs and disease should not be characterized as negative studies. These studies are most appropriately viewed as inconclusive. Limited studies that produce inconclusive findings for cancer in humans do not mean that PCBs are safe (EPA, 2006).

### **Non-Cancer Effects**

A variety of other non-cancer effects of PCBs have been reported in animals and humans, including dermal and ocular effects in monkeys and humans, and liver toxicity in rodents. Elevations in blood pressure, serum triglyceride, and serum cholesterol have also been reported with increasing serum levels of PCBs in humans.

### *Developmental and Reproductive Effects*

Most of the studies of health effects of PCBs in the general population examined children of mothers who were exposed to PCBs. The most sensitive subpopulation to the effects of PCBs is children. Their developing bodies are more sensitive to harm than those of adults. PCBs are stored in the bodies of women who eat a lot of contaminated fish. When these women get pregnant, the PCBs are released into their blood and may reach and enter the developing baby. When children eat fish themselves, they are also exposed to PCBs. This exposure may cause children to learn and grow more slowly, as well as cause them to have behavioral problems. The developmental and learning difficulties children have early in life, can have significant impacts throughout their lives. Women exposed to relatively high levels of PCBs in the workplace or who ate large amounts of fish contaminated with PCBs had babies that weighed slightly less than babies from women who did not have these exposures. These babies also showed abnormal responses

in tests of infant behavior. Some of these behaviors, such as problems with motor skills and a decrease in short-term memory, lasted for several years. Other studies suggest that the immune system was affected in children born to and nursed by mothers exposed to increased levels of PCBs. There are no reports of structural birth defects caused by exposure to PCBs nor of health effects of PCB exposures in older children. The most likely way infants will be exposed to PCBs is from breast milk. However, in most cases, the benefits of breast-feeding outweigh any risks from exposure to PCBs in mother's milk (ATSDR, 2000)(EPA, 1996).

Potentially serious effects on the reproductive system were seen in monkeys and a number of other animal species following exposures to PCB mixtures. Most significantly, PCB exposures were found to reduce the birth weight, conception rates and live birth rates of monkeys and other species and PCB exposure reduced sperm counts in rats. Effects in monkeys were long-lasting and were observed long after exposure to PCBs occurred. Studies of reproductive effects have also been carried out in human populations exposed to PCBs. Children born to women who worked with PCBs in factories showed decreased birth weight and a significant decrease in gestational age with increasing exposures to PCBs. Studies in fishing populations believed to have high exposures to PCBs also suggest similar adverse health effects on children (ATSDR, 2000).

#### *Effects on the Immune System*

The immune system is critical for fighting infections, and diseases of the immune system have very serious potential implications for the health of humans and animals. The immune system effects of PCB exposure have been studied in Rhesus monkeys and other animals. It is important to note that the immune systems of Rhesus monkeys and humans are very similar. Studies in monkeys and other animals have revealed a number of serious effects on the immune system following exposures to PCBs. These effects included rates of Epstein-Barr infection and an associated increase in non-Hodgkins lymphoma (EPA, 2006).

In humans, a recent study found that individuals infected with Epstein-Barr virus had a greater association of increased exposures to PCBs with increasing risk of non-Hodgkins lymphoma than those who had no Epstein-Barr infection. This finding is consistent with increases in infection with Epstein Barr virus in animals exposed to PCBs. Since PCBs suppress the immune system and immune system suppression has been demonstrated as a risk factor for non-Hodgkin's lymphoma, suppression of the immune system is a possible mechanism for PCB-induced cancer. Adverse effects on the immune system were also noted in humans who experienced exposure to rice oil contaminated with PCBs, dibenzofurans and dioxins.

#### *Neurological Effects*

Proper development of the nervous system is critical for early learning and can have potentially significant implications for the health of individuals throughout their lifetimes. Newborn monkeys exposed to PCBs showed persistent and significant deficits in neurological development, including visual recognition, short-term memory and

learning. Some of these studies were conducted using the types of PCBs most commonly found in human breast milk. Studies in humans have suggested effects similar to those observed in monkeys exposed to PCBs, including learning deficits and changes in activity associated with exposures to PCBs.

#### *Effects on the Endocrine System*

PCBs have been demonstrated to suppress thyroid hormone levels in animals and humans. Thyroid hormone levels are critical for normal growth and development, and alterations in thyroid hormone levels may have significant implications. PCB exposures decrease thyroid hormone levels in rodents, and these lowered levels resulted in developmental deficits in the animals, including deficits in hearing. PCB exposures have also been associated with changes in thyroid hormone levels in infants in studies conducted in the Netherlands and Japan. Additional research will be required to determine the significance of these effects in the human population.

#### **Fish Consumption Advisories**

When properly prepared, fish provide a diet high in protein and low in saturated fats. Many doctors suggest that eating a half-pound of fish each week is helpful in preventing heart disease. Almost any kind of fish may have real health benefits when it replaces a high-fat source of protein in the diet. Wisconsin's fish consumption advisories are based on the work of public health, water quality, and fisheries experts from eight Great Lakes states and the Canadian province of Ontario. Based on the best available scientific evidence, these scientists have determined how much fish is safe to eat. In developing the recommendations presented in the Great Lakes Consortium fish advisory, health officials considered a range of possible health risks linked to contaminants, but placed the most weight on reproductive and child development effects (DHFS, 2005).

A fact sheet covering the current fish consumption advisories for the Lower Fox River and Green Bay, along with a picture identification chart of the fish included in those advisories, is available on the DHFS web site. The advisories are different for the different parts of the water bodies. There is a separate advisory covering the segment from Little Lake Butte des Morts to the DePere dam; the segment from the DePere dam to the mouth of the river at Green Bay; and for the bay of Green Bay from the mouth of the Fox River to the northern end of the bay.

#### *Fish Consumption Advisory Awareness*

A number of surveys have been done of anglers who fish the Lower Fox River and Green Bay in order to get a better understanding of the amount of fish people actually eat. Still other studies have been conducted to find out how effective the fish consumption advisories have been. The conclusions of these studies indicate that many people are aware of the fish consumption advisories and have adjusted their behavior appropriately. However, these same studies have identified some groups of people who nevertheless eat a lot of sport caught fish from these waters and because of cultural and language reasons, are not aware of the fish consumption advisories (Tilden, 1997)(Hutchison, 1994)(Fiore, 1989).

As part of the process of conducting this public health assessment the DHFS Great Lakes Fish program assessed exposure with an angler survey on the Lower Fox River. The study titled "Fish Consumption Habits and Advisory Awareness Among Fox River Anglers" was published in the November, 2000 issue of the Wisconsin Medical Journal. The study consisted of a face-to-face survey administered to 104 anglers fishing along the Fox River. It indicates that 17% of anglers eat some or all of the fish they catch and that 83% practice "catch and release." Almost none of the anglers were familiar with Wisconsin's fish advisory booklet but many had heard of the health risks from their local newspaper and TV. As a follow-up, a health advisory brochure specific to the Fox River was developed. The study also found that there continues to be a discrepancy between white and minority anglers in their awareness of consumption advisories. A full copy of the published report is included at the following internet site of the Wisconsin Medical Journal: <http://www.wismed.org/wmj/nov2000/fish.html> (Steenport, 2000).

A similar survey was conducted in July and August of 1997 by the US Fish and Wildlife Service. Of 102 anglers surveyed, 70 were identified as Southeast Asian (Hmong or Laotian), 25 as white (non-Hispanic), and 7 as African-American or Hispanic. Over 50% of anglers reported eating fish included in the fish consumption advisories. Only 20% of Hmong and Laotian anglers reported not eating fish from the river, 88% of white anglers did not eat the fish, and 28% of the African-American and Hispanic anglers reported not eating fish from the river. All of the white anglers reported hearing of contamination problems. While 68% of Laotian and Hmong, and only 28% of African-American or Hispanic anglers knew about contamination problems (Hutchison, 1999).

#### *Managing PCBs During Cleanup*

During the dredging, de-watering, handling, and disposal of contaminated sediments, very small amounts of PCBs may evaporate or volatilize, enabling PCBs to return to water ways. Once back in water, they might once again enter the food chain. The very small amount of PCBs that could potentially volatilize during dredging and disposal would not be measurable in the air and would not contribute to an increased health risk. An evaluation of the risks from volatilization was done by DNR air experts and toxicologists in DNR to answer these questions. In addition, during the remediation of a large sediment deposit in the City of Green Bay, an extensive air monitoring project was conducted. The monitoring project confirmed that exposure to PCBs in air during remediation activities (dredging, dewatering, transport, and disposal) is not a significant source of health risk. During that same period, the water quality was monitored to demonstrate that contaminated sediments would not be re-suspended and carried downstream of a dredge project (DNR, 1999)(DNR, 1998a)(DNR, 1998b)(FJC, 2001).

Monitoring of air and surface water quality during cleanup activities since they began in the fall of 2004 has confirmed that these activities in themselves do not result in unsafe exposures to PCBs. More information about the ongoing cleanup activities and the environmental monitoring work is posted on the DNR website for the Fox River Project at: <http://dnr.wi.gov/org/water/wm/foxriver/>.

### **Child Health Considerations**

Wisconsin's fish consumption advisory was developed specifically to discourage high level exposure to PCBs in fish, and thus to protect pregnant women and children from these risks. The advisory awareness strategy summarized in the *Public Health Action Plan* section of this document focuses a great deal of attention at reducing the unsafe exposures of children.

### **CONCLUSIONS**

- Exposure to PCBs from eating contaminated fish from the Fox River and Green Bay poses a *public health hazard*.
- The existing fish consumption advisories have reduced the rate that many residents eat PCB-contaminated fish from the Lower Fox River and Green Bay.
- Pregnant women and children are particularly sensitive to the effects of PCB exposures. Women and ethnic minority populations are least likely to be aware of fish consumption advisories.
- Although cleanup activities are proceeding, it will be many years before PCB levels in fish no longer warrant consumption advisories.
- Exposures to contaminated sediments from other uses of the river and Green Bay (swimming, boating, etc.) pose *no apparent public health hazard*.

### **RECOMMENDATIONS**

- DHFS recommends that state and local health departments continue to promote awareness of the fish consumption advisories, with special emphasis on women and minority groups.
- DHFS recommends increased attention be given to evaluate and improve methods of communicating fish consumption advisories.
- DHFS recommends continued monitoring of PCB levels in fish from the Lower Fox River and Green Bay. DHFS will work with DNR to adjust the advisory accordingly.

### **PUBLIC HEALTH ACTION PLAN**

DHFS has developed a public health action plan for addressing the health hazards related to environmental contamination that affects the safety of Wisconsin's sport fishery. Contamination in the Lower Fox River and bay of Green Bay has been a primary reason for developing this plan. The plan provides a conceptual framework for public health involvement with the management of this and similar water resources.

It is the goal of DHFS to reduce risks posed to families from eating contaminated sport fish in Wisconsin. The following is a summary of what DHFS has done in the past, is currently doing, and plans to do in the future to achieve this goal.

*Actions Undertaken*

- DHFS has worked with the DNR since the 1970s to develop and issue the fish consumption advisories for the Lower Fox River and Green Bay.
- DHFS has conducted studies of health advisory awareness in the Great Lakes region and Fox River Valley since the 1990s.
- DHFS has provided advisories, informational brochures (English, Spanish, and Hmong), and offered a poster to primary care physicians to promote fish consumption advisory awareness in the region.
- DHFS staff have written articles for newsletters intended for health professionals who serve women, infants, and children in the Green Bay area.
- DHFS has given medical education presentations to physicians in Green Bay and Appleton. DHFS has also given lectures to nursing students in the region on topics that include advisories for the Fox River.
- DHFS has participated in public meetings to address community health concerns on a variety of health issues related to this project.
- DHFS staff have provided educational workshops for Hmong communities in the region.
- DHFS has given workshops on fish consumption advisories and proper fish cleaning methods to “English as a Second Language” classes in Green Bay.
- DHFS has created and distributed a variety of promotional items containing advisory promotion messages to sensitive or particularly at risk populations in the region.
- DHFS and local health departments has created and posted multilingual advisory awareness signs along stretches of the Fox River and Green Bay.

*Actions Under way*

- DHFS and local health departments are currently working on increased streamside display “kiosks” to increase advisory awareness and provide educational information about the cleanup project.
- DHFS and local health departments are working on developing multilingual public service announcements to provide to a variety of local media in order to increase advisory awareness in the region.



- DHFS and local health departments are currently developing a pocket guide summary of the fish advisories and safe cleaning tips for the project area.

#### *Actions Planned*

- DHFS and local health departments are interested in increasing the effectiveness of current advisory promotion activities through a variety of evaluation methods. DHFS considers this process of evaluation, improvement and adaptation to be an ongoing need for the project until advisories are no longer needed.
- In the future DHFS intends to continue to conduct several of the previously listed activities, including: revising fish consumption advisories, producing and distributing promotional materials, presenting information to health care providers, posting and maintain shoreline signs, and evaluating the effectiveness of these activities.

#### **Report Author**

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#### **Response to Public Comments**

Two sets of public comments were received on the draft public health assessment. These sets of comments were detailed, and in stark contrast with one another other.

#### *Characterization of Public Health Risk*

One commenter suggested that the public health assessment document understates the level of public health threat posed by PCBs. The commenter provided examples of studies that support that assertion. Another commenter suggested that the document overstates the public health threat posed by PCBs and also provides examples of toxicity and epidemiologic studies to support their assertion.

Additional background information about health effects of PCB exposures was added to the document, though perhaps not at the the level of detail requested by the first commenter. These comments point out an important aspect of public health toxicology. The study of direct human exposure to contaminants in the environment is extremely complicated. There are many hundreds of studies of the toxicity of PCBs. In this public health assessment document, DHFS chose to present the characterization of risk developed by both the USEPA and ATSDR. The process used by these agencies to arrive at the currently accepted risk characterization involved peer review and comment by hundreds of internal and external agency scientists. DHFS does not have the resources to unnecessarily duplicate this process. However, we recognize that there are some that would come to a different conclusion after reviewing the same information.

*Critique of Human Health Risk Assessment and Selected Cleanup Plan*

Both sets of comments dispute the references in the public health assessment to risks derived in the human health risk assessment conducted as part of the remedial investigation for this project. Again these comments were opposed to one another with one suggesting that the risk assessment used too conservative an approach and ultimately overstates risks, while the other asserting that risks are understated due to exposure assumptions that are not protective enough. Each commenter requests that DHFS dispute the findings of the risk assessment for those reasons. They also request that DHFS advocate for a more stringent and less stringent cleanup respectively.

However, DHFS recommendations were solicited by DNR and USEPA during the development of the Risk Assessment and also during selection of remedial action alternatives for the project. The risk assessment reflects the recommendations made by DHFS during its development, and DHFS supported the selected remedy because the agency was involved on a routine basis during its development.

*Comment on Fish Consumption Advisories*

One comment suggested that current fish consumption advisory promotion activities are inadequate and that more work is needed to evaluate the effectiveness of these activities. DHFS agrees with this assertion and is continually working to improve both the activities and their evaluation.

*Comments on Issues Specific to DNR and USEPA*

Many additional comments were provided that were directed more to DNR and USEPA decisions. DHFS forwarded copies of those comments to those agencies when they were received.

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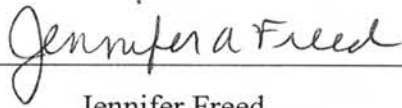
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**CERTIFICATION**

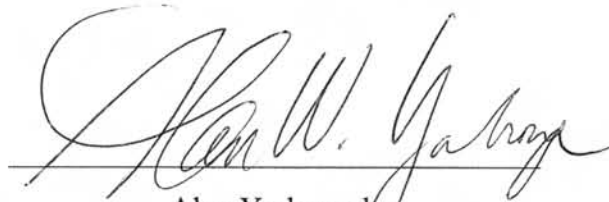
The Wisconsin Department of Health and Family Services prepared this Public Health Assessment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry. It followed approved methodology and procedures existing at the time it began. The Cooperative Agreement Partner completed editorial review.



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The Division of Health Assessment and Consultation, ATSDR, has reviewed this health assessment, and concurs with its findings.



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